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The Commercialization of POLB Off Road Technology (C-PORT) Demonstration Final Report

G16-DEMO-03 • Prepared for the California Air Resources Board

PORT OF LONG BEACH

C-PORT Final Report

August 19, 2021

Port of Long Beach
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C-PORT (The **C**ommercialization of **P**OLB **O**ff-Road **T**echnology **D**emonstration) is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment — particularly in disadvantaged communities.

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Glossary

AC – Air Conditioning
ACT Expo – Advanced Clean Transportation Exposition
AGL – Port of Long Beach Academy of Global Logistics Program at Long Beach Unified School District’s Cabrillo High School
AHJ – Authority Having Jurisdiction
ANSI – American National Standards Institute
AQIP – Air Quality Improvement Program
ASAP – As Soon As Possible
awg – American Wire Gauge
Bombcart - a trailer upon which a cargo container is placed and is moved by a terminal tractor
BYD – BYD Motors Inc.
CAAP – San Pedro Bay Ports Clean Air Action Plan
CARB – California Air Resources Board
CCI – California Climate Investments
CCR – Code of California Regulation
CEC – California Energy Commission
CEQA – California Environmental Quality Act
CFR – Code of Federal Regulations
CHE – Cargo Handling Equipment
CITT – The Center for International Trade and Technology at California State University, Long Beach
CNHTC – China National Heavy Duty Truck Group Co.
CO – Carbon Monoxide
CO2 – Carbon Dioxide
CPORT – “C-PORT”: The Commercialization of POLB Off-Road Technology Demonstration Project
CRADA – Cooperative Research and Development Agreement
CSULB – California State University, Long Beach
DAC – Disadvantaged Communities
eCHE – Electric Cargo Handling Equipment
ECM – Engine Control Module
ECU – Electronic Control Unit
EFM – Electronic Flow Measurement
EPA – Environmental Protection Agency
ESS – Electric Storage System
EVSE – Electrical Vehicle Supply Equipment
FY – Fiscal Year
FOPS – Falling Object Protective Structure
GFCI – Ground-Fault Circuit Interrupter
GGRF – Greenhouse Gas Reduction Fund
GHG – Greenhouse Gas
GPS – Global Positioning System
HD – Heavy Duty
HDP – Harbor Development Permit
HEM – Hydraulics + Electrical + Mechanical
IAPH – International Association of Ports and Harbors
ICU – Inverter Charger Unit
ILWU – International Longshore and Warehouse Union
ISO – International Organization for Standardization
ITSDF – Industrial Truck Standards Development Foundation
Kalmar – Kalmar Global
kcmil – Thousands of circular mils
Knot – Nautical mile per hour (1 knot = 1.15 miles per hour)
kW – Kilowatt
kWh – Kilowatt hour
LBCC – Long Beach City College
LBCT – Long Beach Container Terminal
LBUSD – Long Beach Unified School District
LED – Light-Emitting Diode
LLC – Limited Liability Company
MJ – Megajoule
MT – Metric Tonne
NEMA – National Electrical Manufacturers Association
NFPA – National Fire Protection Association

NOx – Oxides of Nitrogen
NRTL – Nationally Recognized Testing Laboratory
OBC – On-Board Charger
OEMs – Original Equipment Manufacturers
OSHA – Occupational Safety and Health Administration
PAMS – Portable Activity Measurement System
PEM – Proton Exchange Membrane
PEMS – Portable Emissions Measurement Systems
PM – Particulate Matter
PM10 – Course Particulate Matter
PMP – Port Master Plan
PMSM –Permanent Magnet Synchronous Motor
POLB or Port – Port of Long Beach (City of Long Beach Harbor Department)
Q1 – Quarter 1 (January-March)
Q2 – Quarter 2 (April-June)
Q3 – Quarter 3 (July-September)
Q4 – Quarter 4 (October-December)
QA/QC – Quality Assurance/Quality Control
R&D – Research and Development
ROG – Reactive Organic Chemicals
RPM – Revolutions Per Minute
SCAQMD – South Coast Air Quality Management District
SCE – Southern California Edison
SCR – Selective Catalytic Reduction
SOC – State of Charge
t/y – Tons per Year
TAP – The Technology Advancement Program, a CAAP initiative
Taylor – Taylor Machine Works International
TEU – Twenty-Foot Equivalent Unit
THC – Total Hydrocarbon
TransPower – Transportation Power, Inc.
TUV – Technischer Überwachungsverein English translation: Technical Inspection Association
TWIC – Transportation Worker Identification Credential
UCR – University of California, Riverside
UCR CE-CERT – University of California, Riverside, College of Engineering, Center for Environmental Research and Technology
UL – Underwriter Laboratories
UQM – UQM Technologies
V – Volts (alternating current)
Vdc – Volts, Direct Current
VIN – Vehicle Identification Number
VP – Vice President
ZE – Zero-Emission
ZLC – Series of Taylor Top Handler

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Executive Summary

Background

On April 18, 2018, The California Air Resources Board (CARB) awarded the City of Long Beach Harbor Department (Port of Long Beach, POLB, or Port) $5,339,820 through its Off-Road Advanced Technology Demonstration Project grant program.[1] The Port's application — *"C-PORT": The Commercialization of POLB Off-Road Technology Demonstration* — was designed to fund the demonstration of the first ever zero-emission (ZE) human-operated cargo-handling equipment (CHE) at the Port of Long Beach (Port).

Project Partners

Figure 1: C-PORT major project partners

To complete the project, the Port organized a cohesive set of project partners (Figure 1), including: BYD Motors (BYD); California State University, Long Beach's (CSULB) Center for International Trade and Transport (CITT); China National Heavy Duty Truck Group Co. (CNHTC); Green Education, Inc. (Green Education); the International Longshore & Warehouse Union (ILWU); Kalmar Global (Kalmar); Long Beach City College (LBCC); Long Beach Container Terminal

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[1] Funds were made available through CARB's Air Quality Improvement Program (AQIP) and Low Carbon Transportation Greenhouse Gas Reduction Fund (GGRF) Investments, as identified in the Fiscal Year (FY) 2016-17 Funding Plan approved by CARB in June 2016, available at http://www.arb.ca.gov/msprog/aqip/fundplan/fundplan.htm

(LBCT); Long Beach Unified School District (LBUSD) Cabrillo High School's Academy of Global Logistics (AGL); Loop Energy, Momentum (formerly Grant Farm), SSA Marine, South Coast Air Quality Management District (SCAQMD), Taylor Machine Works International (Taylor); Transportation Power, Inc. (TransPower) — later acquired by Meritor Electric Vehicles, LLC (Meritor); Tetra Tech; and University of California, Riverside, College of Engineering, Center for Environmental Research and Technology (UCR CE-CERT).

Goals and Objectives

C-PORT's overarching goals, and ultimate successes, were to:

1. Advance the economic viability of two types of pre-commercial, ZE CHE toward widespread commercialization and adoption in California and beyond.
2. Demonstrate ZE CHE under tough duty cycles in a rigorous seaport setting.
3. Achieve significant greenhouse gas (GHG) and air pollutant emission reductions.
4. Communicate the benefits of a ZE transformation in the Port community and meaningfully benefit Disadvantaged Communities (DAC).

To these ends, the C-PORT team pursued the following objectives:

1. Design, manufacture, and deploy three battery-electric top handlers across two Port terminals.
2. Design, manufacture, and deploy one battery-electric yard tractor (also known as a yard truck, yard goat, or yard hostler) and one hydrogen fuel cell yard tractor in head-to-head operations at a single Port terminal (the latter piece of equipment was ultimately removed from the demonstration due to safety concerns associated equipment design, not any fault of the fuel cell technology).
3. Install sufficient electric charging infrastructure to support operation of the ZE units in revenue service.
4. Demonstrate the proposed equipment in revenue service for at least six months and collect real-world data on equipment performance.

CHE Technologies Demonstrated

C-PORT resulted in the deployment of three battery-electric top handlers, manufactured as a collaboration between Taylor (Original Equipment Manufacturer [OEM]) and BYD (technology developer) and one battery-electric yard tractor, manufactured as a collaboration between Kalmar (OEM) and TransPower/Meritor (technology developer). Two of the top handlers were demonstrated at SSA Marine's Pier J location, and one battery-electric top handler and the battery-electric yard tractor were demonstrated at LBCT's Pier E location. The two terminals operate quite differently, which was an interesting component of C-PORT. LBCT is a mostly autonomous ZE terminal that used the demonstration units against rail-limited ad hoc operations, whereas SSA Marine is more of a typical seaport container terminal, requiring CHE to operate two full shifts entirely.

Deployed vehicles are shown in Figure 2 and Figure 3.

Figure 2: Taylor and BYD battery-electric top handler at LBCT (left) and at SSA Marine (right)

Figure 3: Kalmar and TransPower/Meritor battery electric yard tractor at LCBT (left), and CNHTC/Sinotruck and Loop Energy fuel-cell yard tractor at LBCT (ultimately removed from the demonstration) (right)

Infrastructure Deployment

To support the ZE CHE, C-PORT required the installation of four charging stations and the deployment of one mobile hydrogen refueling station. Three 200 kW BYD chargers were installed — one for each top handler — and one 200 kW TransPower charger for the battery-electric top handler. Ultimately, one BYD charger and one TransPower charger were deployed at LBCT, and two BYD chargers were deployed at SSA Marine (Figure 4). The fuel-cell yard tractor was to be refueled by a permitted HF-150 mobile hydrogen refueler manufactured by Air Products; however, this equipment was not ultimately deployed.

Figure 4: A top handler Charging unit at SSA Marine

Port staff designed and constructed the infrastructure to support the four required charging units in-house, with the aid of a consultant. These were the first ZE CHE charging stations and associated infrastructure that the Port has deployed. Traditionally, a project of this magnitude would go through a typical Port design, bid, build process; however, due to the grant-imposed time constraints, the Port internal program management and engineering team, with support by consultants, deployed a more dynamic process —adjusting to new information as it became available from the OEM and technology providers and doing much of the work in-house. This project — and the ability to adapt and the flexible approach taken — is considered an enormous success by Port Engineering staff for testing and vetting new technologies. Overall, C-PORT was a 38-month long project, beginning with the Kickoff Meeting in June of 2018 and culminating in the equipment demonstration and data collection ending in July of 2021.

> *"The Green Prize Festival was a huge success … we appreciate Green Education's effort to bring this wealth of information to District 7 and to Westside residents."*
>
> *– District 7 Councilmember Roberto Uranga*

Community Education

C-PORT also included important educational and workforce development aspects. Green Education led the effort to proactively engage and educate residents of nearby DACs. To promote interest in ZE Port technologies, Green Education organized the 2018 Green Prize

Festival, developed educational materials, and conducted presentations at 10 citywide community workshops, with approximately 340 residents in attendance (Figure 5).

Figure 5: Green Education's March 23, 2019 workshop in Silverado Park (left); April 17, 2019 workshop with the Wilmore Neighborhood Association (center); and the 2018 Green Prize Festival booth (right)

Workforce and Student Development

To promote early education of ZE port technologies, the Port collaborated with LBCC and the Port-funded, award-winning AGL Program at Cabrillo High School — located in a DAC in West Long Beach — to develop and execute a capstone project designed to promote critical thinking around the ZE transformation at the Port.

AGL is a partnership between LBUSD and CSULB and combines academic curriculum with industry-relevant training and information to support academic and career development. The Academy introduces high school students to career opportunities in global trade and logistics, preparing them for such careers through a wide range of training and educational programs including certificates, certifications, and degrees offered by LBCC and CSULB.

The AGL Program Senior capstone project invited students to participate in addressing some of the Port's most challenging environmental problems, centered around the following prompt: "*The Port of Long Beach has set an ambitious goal to transition its terminals to ZE by 2030. How can the Port achieve this goal without disrupting its position as a major economic engine and job generator for Long Beach?*" (Figure 6). In small teams, students developed approaches that addressed critical matters including technology development and commercialization, financing, community outreach, and workforce development.

Figure 6: The C-PORT team with the AGL students and faculty who worked on the capstone project

Project Outcomes

C-PORT was a 38-month long project, beginning with the Kickoff Meeting in June of 2018 and culminating in the equipment demonstration and data collection ending in July of 2021. A timeline of major milestones is presented in Figure 7. During this demonstration, the Port and its stakeholders were significantly impacted by the COVID-19 global pandemic — impacting terminal operations, labor availability, disrupting manufacturer supply chains, and delaying local equipment service. The Port worked diligently with CARB to track and monitor these impacts to the project schedule and identify solutions that maintained personnel safety as the top priority.

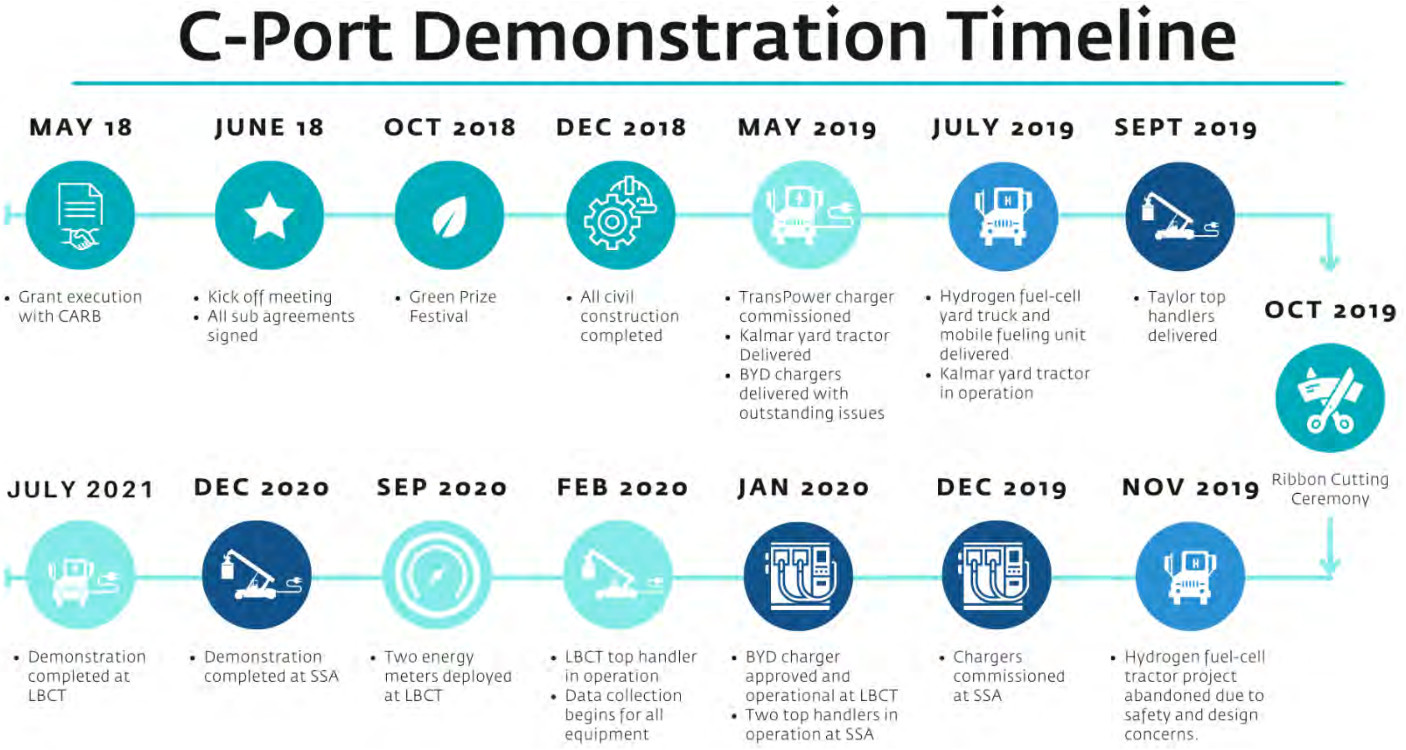

Figure 7: High-level project execution timeline

Through the successful project completion, the Port has accomplished its goals to advance two new types of pre-commercial ZE CHE toward commercialization while achieving significant GHG, criteria pollutant, and toxic emission reductions — which benefit DACs, the labor force, and the region. Over the demonstration period, operators tested and became familiar with ZE CHE units, resulting in realized system and process improvements for future equipment models by the OEMs and technology providers. Overall, the ZE battery-electric top handlers and yard tractor were found to have operated at levels relatively comparable to the baseline diesel equipment in operation across the Port complex. As no two marine port terminals are the same, the experiences, expectations, and differing duty cycles of the two terminals provided invaluable feedback; what proved sufficient for LBCT operations did not quite meet SSA Marine's heavy-duty cycle. C-PORT is considered a great success, with valuable lessons were gleaned along the way, including:

- OEMs and technology vendors developed better ***understanding of Port equipment duty cycles and best practices for design elements*** to better suit the needs of seaport terminals.
- Equipment operators were able to ***experience first-hand the benefits and capabilities of ZE equipment***, including greatly reduced noise, vibration, odor, and emissions.

- The technology demonstrations provided avenues for thoughtful and critical engagement that ***resulted in streamlined processes that will expedite future technology deployments***.
- Data collected during the demonstration phase ***provided critical insights into electricity consumption, the potential for opportunity charging, and the impacts on the grid*** that could be used for the Port's master planning efforts.
- The ***importance of flexibility for new and innovative technologies*** that come with inherent uncertainty, as all parties are learning at each step. The Port's approach to design, engineering, and construction allowed for maximum flexibility by implementing an in-house dynamic infrastructure process that prepared staff for future ZE deployments using more traditional construction procedures.
- The importance of a shared collective and educational experience. While deploying new technologies can require great resources and be time intensive, ***all participants are unified in the effort to support the same ultimate outcome***. Dedicating time and effort to celebratory and collaborative events — such as the ribbon cutting ceremony — remind each partner of the historic nature of the endeavor.

The completion of C-PORT is not the culmination of the ZE transformation journey at the Port of Long Beach. Several other demonstrations are already underway, applying early learning from C-PORT and building upon institutional knowledge and best practices. The Port is appreciative of the two terminal operator project partners — LBCT and SSA Marine — for participating in the project and being the first to aid in the design and demonstration of these new technologies. These first-generation CHE units have laid the groundwork for all future ZE deployments at the Port of Long Beach; for ports across the state, nation, and globally; and for the OEMs. The learned lessons — by Port staff, terminal operators, OEMs, and technology vendors alike — have already resulted in improved equipment model design, pushed technology advancements for both equipment and infrastructure, and provided an integral foundation for the Port to feasibly and economically pursue its ambitious 2017 **Clean Air Action Plan** (CAAP) Update[2] ZE goals.

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[2] http://www.cleanairactionplan.org

1 Introduction

The planning process for the Port's ZE future commenced in 2005 when the Port laid out its Green Port Policy. The latest strategy is the 2017 CAAP Update, an ambitious roadmap outlining the required technology, planning, and advancements needed to accomplish the monumental ZE goal.

The Port has pioneered policies and funded technologies, including infrastructure, that allows ocean-going vessels to switch off fossil fuel engines at berth, launched hybrid diesel-electric tugboats in the harbor, implemented a renowned Clean Trucks Program that transformed a 17,000-vehicle drayage truck fleet in a few short years, and incentivized the world's ocean carriers to slow down for cleaner air and wildlife safety in Long Beach waters.

The Port's environmental initiatives, such as the Green Port Policy and the San Pedro Bay Ports CAAP, have made dramatic and documented gains in cutting air pollution. These initiatives have helped restore water quality in the harbor, protect wildlife and natural habitats, and nurture groundbreaking clean technologies that are a model for ports around the world in how to reduce the impacts of their operations.

On April 18, 2018, CARB awarded the Port $5,339,820 from the Off-Road Advanced Technology Demonstration Project grant for the C-PORT demonstration. The grant funded ZE CHE project was planned at two Port terminals to demonstrate a battery-electric yard tractor, fuel cell yard tractor and three battery electric operated top handlers. These were the first ZE CHE of their kind to be demonstrated at any port and some of the first units deployed by manufacturers in the United States. Ultimately, due to the unsuitable design and safety specifications of the fuel cell yard tractor, the scope was reduced, and a total of $5,249,820 from CARB was used to fund the project, with the Port providing an additional $2,534,266.74 in match funding — along with a portion contributed by the SCAQMD. The project's scope included efforts for grant management and administration; project design, engineering, and construction for infrastructure installation; equipment commissioning; at least six months of equipment; emissions and activity data collection; and community outreach and engagement.

Funding under this solicitation supported projects that accelerated the introduction of advanced ZE technologies on the cusp of commercialization into the California marketplace. Target technologies were selected based on the potential for widespread commercialization and significant transformation of the industry while achieving GHG, criteria pollutant, and toxic emission reductions benefitting DACs. For heavy-duty off-road equipment used in freight operations, such as CHE, these advanced technology demonstration projects were expected to expand the type and quantity of ZE CHE deployed in off-road operations, facilitating the opportunity for technology transfer from other applications, such as on-road. C-PORT was assembled to reduce GHG emissions and provide economic, environmental, and public health co-benefits to disadvantaged communities while synergistically demonstrating the practicality and economic viability of widespread adoption of advanced off-road technologies in a marine port setting.

For the project, the Port's overarching goals, and many ultimate successes, were to:

1. Advance the economic viability of two types of pre-commercial ZE CHE toward widespread commercialization and adoption in California and beyond.
2. Demonstrate ZE CHE under tough duty cycles in a rigorous seaport setting.
3. Achieve significant GHG and air pollutant emission reductions.
4. Communicate the benefits of a ZE transformation in the Port community and meaningfully benefit DACs.

To these ends, the C-PORT team pursued the following objectives:

1. Design, manufacture, and deploy three battery-electric top handlers across two Port terminals.
2. Design, manufacture, and deploy one battery-electric yard tractor and one hydrogen fuel cell yard tractor in head-to-head operations at a single Port terminal.
3. Install sufficient infrastructure to support operation of the ZE units in revenue service.
4. Demonstrate the proposed equipment in revenue service for at least six months and collect real-world data on equipment performance.

The Port, LBCT, and SSA Marine collaborated with the OEMs and technology project partners to design, manufacture, and deploy five ZE CHE units. Four of these units were ultimately deployed in revenue service across two marine port terminals: LBCT, Pier E and SSA Marine, Pier J (Figure 8).

Figure 8: A map of the terminals and the equipment that was demonstrated at each location

Two battery-electric top handlers were demonstrated at SSA Marine, and one battery-electric top handler (Figure 9), one battery-electric yard tractor, and one fuel cell yard tractor (which was ultimately removed from the project prior to demonstration) were deployed at LBCT (Figure 10).

Figure 9: Taylor and BYD battery-electric top handlers at LBCT (left) and at SSA Marine (right),

Figure 10: Kalmar and TransPower/Meritor battery-electric yard tractor at LCBT (left), and CNHTC/Sinotruck and Loop Energy fuel-cell yard tractor at LBCT (ultimately removed from the demonstration) (right)

The hydrogen fuel cell yard tractor — manufactured through a partnership with CNHTC/Sinotruk (OEM), Loop Energy (technology developer) — was delivered to LBCT. In October 2019, the Port and terminal, in consultation with CARB, made the decision to not proceed with the hydrogen fuel cell yard tractor commissioning and demonstration due to many concerns, most prominently, deficient engineering documentation, safety issues and design concerns. *The fuel cell technology itself was not inherently responsible for any of the issues* — the challenges were unique to this specific vehicle's design.

The Port installed four electric charging stations and accompanying infrastructure to support the battery-electric ZE equipment deployments (Table 1).

Table 1: Equipment types deployed and the respective stakeholders

User	OEM	Vendor	Equipment	Quantity	Infrastructure
LBCT	Taylor	BYD	Battery-Electric Top Handler	1	200 kW
	Kalmar	TransPower/ Meritor	Battery-Electric Yard Tractor	1	200 kW
	CNHTC	Loop Energy	Fuel-Cell Electric Yard Tractor	1	Mobile fueler
SSA Marine	Taylor	BYD	Battery-Electric Top Handler	2	2 x 200 kW

2 Project Planning

The Port — as the grant awardee — entered into a formal contract with CARB on April 19, 2018, with an official start date of May 1, 2018. The Port executed subgrant agreements with CHE OEMs Taylor, Kalmar, and UQM Technologies (UQM), on behalf of CNHTC. The OEMs contracted directly with technology providers BYD, TransPower, and Loop Energy, respectively. Data collection partner Tetra Tech was also a subgrantee who directly contracted with UC Riverside to obtain its technical emission testing services. Existing relationships or agreements already in place were leveraged for the remaining partners on the project, such as AGL, Green Education, and Momentum.

C-PORT is the first grant-funded endeavor to deploy human-operated ZE CHE at the Port of Long Beach. Because yard tractors and top handlers represent approximately 60% of the CHE used at the Port, deploying ZE alternatives to traditionally diesel-powered machines would significantly reduce the Port’s overall emissions. For this reason, these specific types of CHE were targeted for demonstration. These equipment types are vital to moving cargo and port terminals require intense usage, as top handlers move cargo vertically, on and off trains and ships, while yard tractors move cargo around the terminals.

To organize this project, the Port worked closely with its terminal operators to select the technologies for this demonstration. Taylor and Kalmar are two of the largest OEMs for marine terminal equipment and were in a position to demonstrate their technologies within the timeframe of the grant. Multiple ZE top handlers were selected to test operations at two different terminals and to evaluate variability within the technology. The planned comparison between the battery-electric and fuel-cell yard tractors at LBCT was to provide information about head-to-head performance of the two predominant ZE configurations.

The Port utilized skilled staff members to manage the process and subcontracted with vetted and proven manufacturers and vendors to successfully deploy the technology in a real-world application. Kalmar and Taylor, well-known manufacturers of diesel CHE in the San Pedro Bay Complex, were approached to design the units and deploy appropriate charging infrastructure in collaboration with technology vendors BYD and TransPower. The specific terminals were selected based on interest, operations, as well as known electrical capacity that had been installed as part of the grid upgrades needed to support shore power electricity requirements. This capacity was expected to more efficiently and cost-effectively complete the project on time.

To educate and inform the community, the Port leveraged its existing strong relationships with DAC groups and educational institutions to include novel components to the equipment demonstration, creating a well-rounded, inclusive project that will support a ZE future for all. These novel components — including participation at the Green Prize Festival and a ZE Transformation Capstone Project for seniors in Cabrillo High School’s Academy for Global Logistics — were paired with traditional outreach to community groups and neighborhood associations to maximize the outreach efforts throughout the region, across various demographics.

2.1 Key Stakeholders and Project Partners

To complete the project, the Port brought together a network of industry-leading partners. C-PORT participants (Figure 11) included AGL, LBUSD Cabrillo High School, BYD Motors, CITT at Long Beach State University, CNHTC, Green Education, ILWU, Kalmar Global, Loop Energy, LBCC, LBCT, Momentum, SSA Marine, SCAWMD, Taylor, Tetra Tech, TransPower/Meritor and UCR's CE-CERT.

Figure 11: Project team participants for the completion of C-PORT

The specific roles and responsibilities of the participants, partners, and key stakeholders are summarized in Table 2.

Table 2: Project Team roles and capabilities

Team Member	Focus Area	Project Role
The Port of Long Beach	Applicant, Grant Management	Grant and project management/administration, reporting, project oversight
LBCT	Terminal Operators and CHE Demonstrators	Demonstrated one battery-electric top handler, one battery-electric yard tractor, and one fuel-cell yard tractor
SSA Marine		Demonstrated two top handlers
ILWU	Vehicle Operators	Provided labor for all demonstration CHE units
Taylor	Battery-Electric Top Handlers	Top handler OEM
BYD		Electrification technology provider
Kalmar	Battery-Electric Yard Tractor	Yard tractor OEM
TransPower/Meritor		Electrification technology provider
CNHTC/Sinotruk	Fuel-Cell Yard Tractor	Yard tractor OEM
Loop Energy		Fuel cell technology provider
Green Education	Community Outreach	Local community/DAC outreach provider
LBUSD	Workforce and Student Development	AGL partner, curriculum development
CITT		
LBCC		
Momentum (Formerly Grant Farm)	Grant Administration	Grant administration and reporting support
Tetra Tech	Data Collection	Data collection and analysis
UCR CE-CERT		Emissions testing

2.2 Project Management Partners

The Port of Long Beach: The Port is one of the nation's foremost seaports — a pinnacle of goods movement and environmental leadership and coined as "The Green Port." The Port has extensive experience managing grants and has worked with leading and innovative OEMs and technology providers through prior technology demonstrations, grant programs, and workforce development. The Port is a global leader in the development and implementation of environmental policies, such as the groundbreaking Green Port Policy and the San Pedro Bay Ports CAAP. The CAAP targets include:

- Reduce GHGs from port-related sources to 40% below 1990 levels by 2030.

- Reduce GHGs from port-related sources to 80% below 1990 levels by 2050.
- By 2023, reduce port-related emissions levels by 59% below 2005 levels for NOx, 93% below 2005 levels for SOx and 77% below 2005 levels for DPM.

In pursuit of these ambitions goals, the Port has extensive experience overseeing major strategies and projects that demonstrate advanced technology across the goods movement sector, reducing climate and community air quality health impacts. These efforts have proven very successful with the latest Annual Emissions Inventory, published in 2019,[3] with two of the three pollutants already surpassing the 2023 goals (Table 3).

Table 3: 2019 emission reductions compared to San Pedro Bay CAAP goals

Pollutant	2019 Actual Reductions	2023 Emission Reduction Standard
DPM	88%	77%
NO_x	58%	59%
SO_x	97%	93%

Momentum: Based in Sacramento, California, Momentum has a global reach, delivering strategic planning, fund development, project management, communication, and commercialization services across the country and around the world. Since 2005, Momentum has raised approximately $1 billion in grants, loans, and other incentives for companies working on transformative advanced energy, water, transportation, and manufacturing projects. For this project, Momentum provided strategic project management services to the Port of Long Beach for the duration of the grant.

2.2.1 Marine Terminal Operators

Marine terminal operators at the Port are tenants that lease real estate to conduct business, such as moving and sorting cargo. These tenants understand that the transition to a ZE future at the Port is well underway. By participating in these kind of demonstration projects, the terminal operators gain the opportunity to work hands-on with OEMs and technology providers to design and improve upon electric vehicle technology so that future models meet their operational and functional needs in a marine port setting. The participating terminal project partners who demonstrated the advanced CHE are as follows:

Long Beach Container Terminal: Long Beach Container Terminal (LBCT) comprises 105 acres and eight structures. Further, it is undergoing a major expansion that will make it one of the world's most technologically advanced and environmentally sustainable port terminals, estimated to handle twice the amount of cargo while cutting air emissions by more than half. The terminal features battery-electric yard equipment, including some of the world's most sophisticated automated guided vehicles, and shoreside electricity for ships at berth. Although most of the equipment at the terminal are automated ZE units, LBCT also operates

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[3] Available for download here: https://polb.com/environment/air/#emissions-inventory

approximately 20 human-operated diesel yard tractors. These yard tractors are used primarily for rail operations but also for ancillary work related to the yard and vessel moving containers that do not go through their standard yard handling. LBCT has a deep commitment to eliminating emissions and improving the environment. For C-PORT, LBCT demonstrated —with ILWU labor — a ZE top handler and yard tractor.

SSA Marine: With operations across five continents and a vast network of interconnected transportation solutions, SSA Marine opens new opportunities that accelerate the growth and pace of global business. Improving the customer experience is at the heart of everything the company does, so it makes purposeful investments in people, facilities, and technical innovations that deliver the greatest customer value. Its highly skilled workforce handles more than 14 million marine TEUs annually. SSA Marine provides its employees with proprietary training to maximize productivity across its operations. SSA Marine has made substantial investments in cleaner technologies to date, including deployment of ZE and hybrid rubber-tire gantry cranes and shore power infrastructure, and is an integral partner on two additional grant-funded, ZE CHE projects managed by the Port. For C-PORT, SSA Marine demonstrated — with ILWU labor — two ZE top handlers.

2.2.2 Technology Providers and OEMs

BYD (Technology Vendor): BYD Motors Inc. (BYD) is an American company based in California. Its parent company, BYD Company Ltd, is based in China and is the world's largest manufacturer of rechargeable batteries, specializing in battery technologies. Backed up by its core Iron-Phosphate battery technology, BYD Motors Inc. focuses on Electrified Transportation, including automobiles, buses, trucks, and utility vehicles. BYD's electric clean air technology is silent, efficient, and usable anywhere there is standard AC power. BYD collaborated with Taylor to design and provide components for three electric battery-powered top handlers, and associated infrastructure, for this demonstration.

CNHTC/Sinotruck (OEM): CNHTC or Sinotruk Group, is a Chinese state-owned truck manufacturer headquartered in Jinan, Shandong province. It is currently the third largest truck manufacturer in Mainland China. It is known for developing and manufacturing China's first on-road heavy-duty truck, "Huanghe" (黄河, lit. Yellow River) JN150. CNHTC coordinated with the Port through UQM, an American subsidiary. For this project, CNHTC designed and built a hydrogen fuel cell yard tractor, with Loop Energy.

Kalmar (OEM): Kalmar Global (Kalmar) offers a wide range of cargo handling solutions and services to ports, terminals, and distribution centers and to heavy industry. Kalmar is one of the industry forerunners in terminal automation and in energy-efficient container handling, with one in four container movements around the globe being handled by a Kalmar solution. The Kalmar product range includes ship-to-shore cranes, rubber-tired and rail-mounted gantry cranes, straddle and shuttle carriers, reach stackers, empty container handlers, terminal tractors, forklift trucks, and automated guided vehicles. For C-PORT, Kalmar designed, built, and deployed one ZE battery-electric yard tractor.

Loop Energy (Technology Vendor): Based in Vancouver Canada, Loop Energy (Loop) benefits from an R&D and management team with over 75 combined years of direct fuel cell sector experience. At the core of Loop Energy's technology is eFlow® — a fuel cell design that maximizes power, efficiency, and durability through optimized airflow inside the fuel cell. Loop Energy collaborated with CNHTC/Sinotruck to design and deliver one hydrogen fuel cell yard tractor.

Taylor (OEM): Taylor, located in Louisville, Mississippi, is one of the only privately held manufacturers of industrial lift trucks operating in America today. Taylor builds quality forklifts and yard tractors for steel mills, concrete yards, wood mills, and port operations around the world. Taylor manufactures the majority of the essential components for its lift trucks and can respond to changing needs in the industries it serves – including developing ZE equipment. For C-Port, Taylor demonstrated three battery-electric top handlers at two locations.

TransPower/Meritor (Technology Vendor): TransPower, a California-based company, was founded in 2010 for the express purpose of manufacturing components for ZE heavy-duty vehicles. TransPower was acquired by Meritor Electric Vehicles, LLC (Meritor) in January of 2020. TransPower/Meritor has established itself as an industry leader in adapting ZE technologies to port vehicles such as drayage trucks, yard tractors, and reach stackers. Meritor is a leading supplier of drivetrain, mobility, braking, and aftermarket solutions focused on on-highway applications. TransPower/Meritor collaborated with Kalmar to design and provide components for the ZE battery-electric yard tractor, and associated infrastructure, for this demonstration.

2.2.3 Data Collection Partners

Tetra Tech: Tetra Tech is a leading provider of consulting, engineering, program management, construction management, and technical services worldwide. They over saw the efforts for data collection and analysis by the UCR CE-CERT laboratory and research team.

UCR CE-CERT: UCR CE-CERT is located at the University of California Riverside, is a nonprofit government entity, and is classified as a Minority Serving Institution (MSI). UCR is a national and international leader in the activity and emissions measurement and analysis and has worked extensively with CARB on both vehicle activity and vehicle and equipment emissions. This includes recent research programs in which UCR are data logging over 200 heavy-duty vehicles for activity data to understand after treatment effectiveness and the potential for aerodynamic devices. UCR also conducted many of the groundbreaking on-road studies and measurements to develop and quantify the procedures for the use of portable emissions measurement systems (PEMS) as part of the Measurement Allowance program conducted by the U.S. Environmental Protection Agency (U.S. EPA), CARB, and the heavy-duty engine and truck manufacturers. UCR also has a Cooperative Research and Development Agreement (CRADA) with the U.S. EPA for the measurements of in-use vehicle activity and emissions. Under this CRADA, UCR has access to U.S. EPA PEMS and portable activity measurement system (PAMS). The UCR CE-CERT team conducted the emissions and activity data collection and analysis effort for this project.

2.2.4 DAC and Equity Partners

As ZE technology continues to be developed, demonstrated, and ultimately commercialized, it is crucial that near-port, environmentally-impacted communities and social equity efforts are included in innovative projects. As C-PORT deployed ZE technology that eliminated emissions and harmful environmental impacts in the communities surrounding the Port, this project engaged social equity partners and community members by conducting high-profile events as well as outreach activities to educate local students about the project and engage them in meaningful conversations around sustainability, equity, and the Port, including good paying jobs.

DAC outreach partners included the AGL, a Port-sponsored academy at LBUSD Cabrillo High School in West Long Beach, operated by CITT and Long Beach State University. CITT's research portfolio features policy analysis in the areas of trade and transportation as well as workforce development. Its outreach programs include educational forums, including the nationally recognized State of the Trade and Transportation Town Hall series, research conferences such as the International Urban Freight Conference, and media-based efforts including podcasts and web-based programming that engage the broader community in the discussion surrounding international trade and transportation. AGL combines academic curriculum with industry-relevant training and information to support academic and career development. The Academy builds on the Long Beach College Promise by introducing high school students to career opportunities in global trade and logistics and showing them how to prepare for those careers through a wide range of training and education programs including certificates, certifications, and degrees offered by LBCC and CSULB. LBCC provided guidance and materials to AGL and the students' capstone efforts.

Green Education: Green Education is a local community-based organization that partners with stakeholders to educate, revitalize, and transform communities into green sustainable neighborhoods, creating healthy and energy-efficient homes, buildings, and schools in the process. For this project, Green Education communicated the goals of C-PORT to surrounding disadvantaged communities, community-based organizations, nonprofits, and other stakeholders. Green Education developed educational materials, maintained a social media presence, held the Prize Festival, and completed community workshops.

2.3 CEQA Permitting

Prior to CEQA review, the Port of Long Beach prepared an application for a Harbor Development Permit (HDP) pursuant to the California Coastal Act of 1976 and Section 1215 of the City of Long Beach Charter, which requires that the Long Beach Board of Harbor Commissioners issue an HDP under the certified Port Master Plan (PMP) for any "groundbreaking activity" including construction, alteration, improvement, erection, remodeling, or repair within the Port's Harbor District. The HDP — a discretionary permit — automatically triggers a review consistent with the State's CEQA Guidelines.[4]

Prior to the submission of the grant application, the Port prepared an HDP application, #HD-17-519 for internal processing. The HDP application was submitted on August 7, 2017, and approved on August 14, 2017. A copy of the HDP was provided in the grant application. Because the CARB-funded project included construction at two terminals — Pier J and Pier E — the Port (lead agency) evaluated the proposed charging station construction activities and found the construction efforts to be Categorically Exempt, per 14 Code of California Regulation (CCR) Section 15303. The exemption is specifically designed in support of the installation of small new equipment and facilities in small structures. The Notice of Exemption documents were filed on January 29, 2018, and open to public comment until February 28, 2018. No comments were filed. The Notice of Exemption documents were provided to CARB on March 7, 2018.

2.4 COVID-19 Impacts

C-PORT was impacted by the novel COVID-19 global pandemic — affecting terminal operations and labor availability, disrupting manufacturer supply chains, and delaying local equipment service. COVID impacted the Port beginning in approximately March of 2020 and included:

- Delays to the data collection and PEMS testing schedule due to the inability to safely access the logging equipment on-site.
- Energy metering deployment and data collection delays, including staff and data collector consultant training to accurately download data.
- Supply chain disruptions, resulting in delayed receipt of components and parts required to repair the CHE units.
- Delayed and limited access for service technicians and vendors who needed to visit the terminal(s) to perform routine and emergency maintenance safely, due to in-person and travel limitations.
- Delays to personnel travel that particularly impacted BYD's staff abilities to travel from China to the United States for on-site diagnostics.

2.5 Overall Lessons Learned and Best Practices

Of substantial value to a demonstration project is that the lessons learned that can be used to inform future equipment design, demonstrations, and deployments. Following are some of the larger lessons learned as a result of C-PORT:

- Demonstration projects are often complex and technical; building strong working relationships and clear communication chains with and between project partners and stakeholders will ease challenges faced. It is critical that all project partners and stakeholders understand their roles and responsibilities and to set up a clear chain

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[4] http://files.resources.ca.gov/ceqa/docs/2019_CEQA_Statutes_and_Guidelines.pdf

of command early in the project so that communications, questions, and issues are addressed as soon as possible.

- Legally binding agreements need to be developed with every project stakeholder, including partners who are not receiving grant dollars but are instrumental to project success.
- Demonstration projects typically operate on a truncated timeline and yet these types of projects need significant more time for design, sometimes bid, and build than a commercialized deployment. Additionally, data collection is a required component of almost any demonstration and challenges almost always arise when testing new technology, exacerbating the timeline. It's important that all stakeholders are committed to working within aggressive timelines and the granting agency remains as flexible as possible to support overall program success.
- All partners should be brought to the table early on for efficient and appropriate design and development. It is important that all field situations are made known to the manufacturers and technology providers, such as differing sizes of bombcarts, also known as terminal chassis, and all unique end user requirements. A bombcart is a trailer upon which a cargo container is placed and is moved by a terminal tractor. The manufacturers should acquire exact equipment specs from the terminals. This will lessen costly alterations required when a unit is ultimately tested. Additionally, any pertinent safety requirements for the equipment or infrastructure should be articulated upfront during the design phase.
- For out-of-country project partners, provide clear written information about the required American standards, especially for infrastructure components.
- Make it very clear that factory testing to the greatest extent possible is required along with proof that all engineering standards and other regulatory and permit obligations are met. This will reduce the likelihood that equipment will have to be returned for upgrades after deliver and avoiding extra transportation costs.
- Account for long lead-times on permits or certifications, or potentially development of a new permit/certification process, if applicable.
- To the extent available, it's important that the Port and project partners gather as much information on equipment specifications as possible early in the project, understanding that the equipment may be still under development and will continue to evolve as the project progresses. Finalized specifications are critical to successful design and deployment of infrastructure. For this reason, OEMs and technology developers must share all manuals and specifications for equipment and charging infrastructure before installation or delivery.
- Validate that power meters are installed correctly and calibrated to a known time period, so no data will be lost. Without proper calibration, data is collected and attributed to an irrelevant date, making it hard to understand what time period was recorded.
- Engage data collection team early in the process with terminal operators and the technology providers to validate that data logging equipment will operate

appropriately. Confirm, prior to contracting, that all grant required data points are possible with the services data collectors provide.

- Continue to build in time and funding for activities which highlight project successes and foster relationships amongst project partners, including the granting agency, and community and workforce development organizations, such as the AGL and ribbon cutting activities that were a part of C-PORT.

3 Project Infrastructure

Infrastructure is a vital component of any ZE equipment deployment project, supporting the vehicles that rely on it for safe, reliant adequate charging or fueling. C-PORT represents the first ZE infrastructure project at the Port for CHE. The execution of this process catalyzed new processes and procedures within the Port's Engineering department, which traditionally focuses on conventional civil and electrical infrastructure projects. ZE infrastructure presents unique challenges, specifically because the equipment is being developed and modified in real time. These charging units are in early to late-stage development, and have not completed all the traditional safety and quality certifications for electrical equipment. In addition, there is no current industry standard for this type of equipment to reference. The data collected through this project will provide real-world measurements that could be used during future planning efforts, including the development of a ZE master plan, as described in the Port's EV Blueprint.[5]

To manage this highly dynamic engineering project, the Port's Project Management and engineering group oversaw the design, engineering, and installation of the charging infrastructure component, with support from a consultant. This portion of C-PORT involved finalizing the engineering design of needed infrastructure upgrades, including conduits, stub-outs, and the charging units themselves — all of which required extensive field construction. For a conventional civic and electrical infrastructure project of this magnitude, these activities would traditionally go through a typical Port design, bid, build process with clearly defined project scopes. Because the engineering specifications and project requirements were being documented and developed in real time and there were grant-imposed time constraints, the Port's engineering team was best equipped to provide the flexibility needed to iterate throughout the dynamic project development cycle. This experience provided valuable hands-on lessons that the Port's engineering staff have been able to successfully implement in subsequent demonstration projects across the Port. As the Port becomes more familiar with these new technologies, it will be able to better utilize its traditional design, bid, build process to accelerate the pace of infrastructure deployment.

> *The dynamic way the C-Port infrastructure component was approached is considered a great success by Port staff and a model for future ZE projects.*

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[5] The Port Community EV Blueprint can be downloaded at https://polb.com/environment/our-zero-emissions-future/#program-details

Due to the truncated nature of a grant project, Port engineers proved creative and dynamic, completing many activities under a separate construction project contract at the terminals, using Port funds. The group also supported the hydrogen unit infrastructure permitting process.

When the infrastructure component was completed in May of 2019, Port engineers hosted a barbeque for the entire team to celebrate the first ZE infrastructure deployment in the Port and show appreciation for a job well done (Figure 12). The C-PORT infrastructure project, and the dynamic way it was approached and developed, is considered a great success by Port staff.

Figure 12: Port staff enjoying a celebratory BBQ lunch after completing construction of the first ever CHE charging infrastructure, hosted by Port Engineer Fred Patricio.

When the infrastructure component was completed in May of 2019, Port Engineers hosted a barbeque for the entire team involved to celebrate the first ZE infrastructure deployment in the Port and show appreciation for a job well done (Figure 12). The C-PORT infrastructure project, and the dynamic way it was approached and developed, is considered a great success by Port staff and a model for projects utilizing innovative and new technologies.

3.1 Overview of the Port Design, Engineering, Installation, and Commissioning Process

Each of the five ZE charging units (four electric chargers and one mobile hydrogen storage system) required its own design, construction, and supporting infrastructure. C-PORT was the first time *any* of the project partners deployed this type of infrastructure at an active container terminal environment, and the Port was the first seaport to do so. The deployed charging/refueling infrastructure included:

- One 200-kW, 3-phase 480V charger provided by TransPower to support the battery-electric yard tractor at LBCT.
- Three 200-kW, 3-phase 480V chargers provided by BYD to support the battery-electric top handlers at LBCT (one) and SSA Marine (two). Each charging unit was equipped with two charging cables, each capable of providing 100kW. The top handler has an on-board charger, which rectifies and charges the on-board Vdc batteries.

To complete the ZE electric charging infrastructure buildout, the engineering staff followed a 10-step approach:

1. Conduct site evaluations for each of the project locations.
2. Perform an engineering evaluation to determine necessary electrical infrastructure upgrades.
3. Prepare scaled site design plans, specifications, and estimates along with a charging profile for each project location.
4. Implement quality control procedures and perform necessary quality control reviews and risk assessments throughout the design review submission process.
5. Obtain all necessary permits for the charging stations.
6. Accept the ZE charging units from the technology vendors.
7. Complete supporting infrastructure, including trenching and running conduit to prepare for equipment installation.
8. Install the charging stations at the completed stub-outs.
9. Field test and certify the equipment to UL or Technischer Überwachungsverein (TUV, English translation: Technical Inspection Association).
10. With the technology provider, OEM, contractors, City of Long Beach, and Port of Long Beach, commission the charging equipment.

By January 30, 2019, Port engineers and approved contractors completed construction on all the charging infrastructure at the two sites. In February of 2019, the Port completed all necessary infrastructure tasks, including securing the necessary permits, construction, validation testing results, a sign-off by the City of Long Beach, and full commissioning. Reference the *Commissioning Report* (Appendix A) for additional details of this effort as well as the items below.

The infrastructure that was not deployed, through no fault of the fuel or infrastructure itself, included a mobile hydrogen refueling trailer (HF-150), to be provided by Air Products, to support the fuel cell hydrogen yard tractor at LBCT.

3.2 Infrastructure and Construction for TransPower Charging Unit Deployment (LBCT)

3.2.1 Design and Engineering Process

The process was originally designed around the 200-kW chargers selected for the project, which represented the fastest EVSE charging units available at the time that would successfully charge the batteries on the Yard Tractor. Due to the specific windows of time available to charging, it was important to have the greatest charging capacity available to maximize up-time for the unit. The Port worked closely with the terminal operators to evaluate locations for the charging unit, considering the site’s current layout, traffic flows, proximity to electrical infrastructure, and overnight parking of the equipment. Because this was a first-of-its-kind design, the Port and the terminal operators evaluated locations suitable for cost-effectively charging the equipment, as related to electrical availability. As this was a small-scale demonstration, it was understood that the identified sites may not ultimately be the locations where the terminal would prefer to locate charging stations if the entire CHE fleet was transitioned to ZE.

The engineering efforts to complete the required civil construction work and installation of the charging unit was formally approved by the Port's Board of Harbor Commissioners, a standard practice for any such project, on September 24, 2018. The project-related construction permits and tenant site access agreement were secured soon thereafter using a prior project contract at the same terminal of the Port, a creative solution the Port implemented to allow a truncated grant process. This enabled the construction to begin on schedule at LBCT in November of 2018. Construction at LBCT (for both the yard tractor and top handler) included the installation of two 400A circuit breakers in existing switchboard, pulling wires (#500 kcmil copper and #2 awg copper) to the new charging units, and the installation of two concrete pedestals with an electrical grounding system. By the end of 2018, all civil construction work was completed, and the electrical work was completed in May of 2019 (Figure 13 and Figure 14).

Figure 13: TransPower ZE charging unit prior to delivery. The full unit (left) and the connector (center and right) are shown.

Figure 14: Infrastructure completion, ahead of delivery, at LBCT to prepare for the installation of the TransPower unit, including a closeup of the concrete pad and stub-out (left) and the same pad showing the breaker and its proximity to the safety bollards and necessary transformer (right)

3.2.2 Infrastructure Installation, Certification, and Commissioning

At the end of 2018, the TransPower EVSE unit was delivered on-site and installed by Q1 of 2019. However, prior to delivery, in October of 2018, the Port identified that the TransPower charger unit was not UL certified, a safety certification required by the City of Long Beach. UL certification is a standard practice for the Port, many other cities, and many industries as they certify products, facilities, processes, or systems based on industry-wide accepted standards. To address this challenge, the Port and TransPower agreed to pursue third-party testing by a nationally recognized testing laboratory (NRTL). To address this challenge, TransPower agreed to pursue third-party testing by a nationally recognized testing laboratory (NRTL). TransPower coordinated with UL to provide the third-party field evaluation, which could not commence until the yard tractor was delivered. Once the Kalmar yard tractor was delivered in May of 2019, UL was able to conduct the certification testing and passed inspection (Figure 15). This inspection specifically evaluated whether the unit was in compliance with UL 508A, Standard for Industrial Control Panels, 3rd Edition, Revised 07/03/2018, and NFPA 70, National Electrical Code – 2017, First Edition. The field evaluation report details each safety standard and is provided as part of Appendix A.

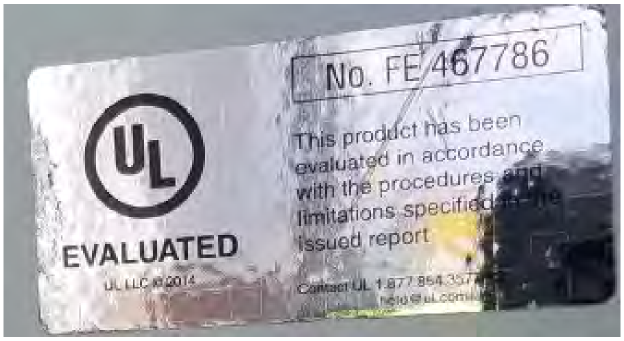

Figure 15: UL inspection sticker showing that the equipment passed the in-field UL evaluation

Upon passing the final inspection, UL submitted a report to the City in May of 2019, demonstrating the charging unit's compliance with the relevant codes. Upon acceptance of this report, the TransPower charging unit was approved for use by the City. Note, that while the full LBCT Pier E City Commissioning was granted in January of 2020 to include both technology vendors charging units, the TransPower charging unit (Figure 16) was granted an approval ticket by the City, such that the unit could be utilized by the Kalmar battery electric yard tractor at that time.

Figure 16: TransPower EV charging station at LBCT to support the battery-electric Kalmar yard tractor

3.2.3 Lessons Learned and Best Practices

As with any major project — especially one that requires civil construction work at an active site — the project team identified some areas of improvement around the design, construction, and ultimate deployment of the TransPower charging infrastructure. Some of the key main takeaways include:

- The terminal operator requirements should be understood at the very beginning design phase, specifically regarding safety and clearance requirements (such as K-Rail) for the terminal layout and preference of charging unit location.
- Identify tenant, City, and Federal requirements when determining the viability of the pre-commercial charging equipment, which is critical to making sure that the chargers would safely function. In this case, there was limited information about the EVSE units because of how new the technology was, which caused issues and delays with commissioning and the UL certification.
- Sometimes, the conceptual design of an untested charging unit is not practical in a real-world setting, and creative solutions are required. For example, the charging cable was considered too heavy to be ergonomically safe and was also a potential tripping hazard, so the team added a support mechanism while the demonstration was underway.
- The charging unit was located over a mile away from where the unit was primarily used, which caused slight logistical issues when needing to charge, as well as with transferring the operator to the unit at the beginning of each shift. For this demonstration, the charging units were placed close to the existing electrical infrastructure to minimize installation costs and likely not reflective of locations for infrastructure associated with a broader deployment.

3.3 Infrastructure and Construction for BYD Charging Unit Deployments (LBCT and SSA Marine)

3.3.1 Design and Engineering Process

As with the TransPower infrastructure deployment, the process was originally designed around the 200-kW chargers selected for the project. These represented the largest chargers available at the time. Due to the specific windows of time available to charge, it was important to have the greatest charging capacity available to maximize up-time for the equipment. The Port worked closely with the terminal operators to evaluate locations for the chargers based on the site's current layout, traffic flows, proximity to electrical infrastructure, and overnight parking of the equipment. Because this was a first-of-its-kind design, the Port and the terminal operators evaluated locations suitable for cost-effectively charging the equipment, as related to electrical availability. As this was a small-scale demonstration, it was understood that the identified sites may not ultimately be the locations where the terminal would prefer to locate charging stations if the entire CHE fleet was transitioned to ZE.

The engineering efforts to complete the required civil construction work and installation of the charging unit was formally approved by the Port's Board of Harbor Commissioners, a standard practice for any such project, on September 24, 2018. The project-related construction permits and tenant site access agreement were secured soon thereafter using a prior project contract at the same terminal of the Port, a creative solution the Port implemented to allow a truncated grant process. This enabled the construction to begin on schedule at LBCT in November of 2018 and in October of 2018 at SSA Marine. As described above, construction at LBCT (for both the yard tractor and top handler) included the installation of two 400A circuit breakers in existing switchboard, pulling wires to the new charging station, and the installation of two concrete pedestals with an electrical grounding system. Construction at SSA Marine included the installation of two 400A circuit breakers in an existing switchboard, excavation of pavement to install duct bank, pulling wires (#500 kcmil copper and #2 awg copper) to the charging stations, pavement restoration, construction of two concrete foundation pedestals with a grounding system, and the installation of four K-Rail and pins on both sides of each charging station. By the end of 2018, all civil construction work was completed, and the electrical work was completed in May of 2019 (Figure 17).

Figure 17: Stub-out completion at SSA Marine for the two BYD chargers to support the top handlers

The BYD component of C-PORT experienced significant hurdles. At the beginning of the project, in July of 2018, the Port — as well as the Port of Los Angeles that was acquiring BYD charging units for its own demonstrations — met with BYD executives and staff to address several outstanding engineering items, including issues relating to the charging units, UL certification approval, and matching charging receptacles.

Over the next year and a half, the Port and BYD were able to address each of the issues to satisfaction so that the three charging units were successfully commissioned, though issues occurred during the demonstration period, such as unexplained tripping.

During the Taylor and BYD top handler design process, Port staff recognized that the charging cable length of three meters installed from the BYD charger would not be enough to reach the top handler, given the orientation of the charging port on the equipment, the required spacing between the charger and the safety bollards and K-rail, and the parking orientation. To address this, a five-meter cable length had to be manufactured for each unit.

3.3.2 BYD Infrastructure Installation, Certification, and Commissioning

The three BYD charging units were delivered to the terminals in May of 2019 with many concerns to be rectified before commissioning could occur, including the incorrect three-meter cable length, material quality concerns, and the entire unit and cables not being UL or TUV listed.

TUV, an NRTL that BYD preferred to work with and the Port signed off on, was chosen to conduct the required safety inspection and certification. TUV, similar to UL, tests and certifies a product's safety, quality, and sustainability attributes. TUV specifically evaluated the product against NFPA 70: 2017 National Electric Code, UL 2594 Standard for Safety Electric Vehicle Supply Equipment, ANSI/UL 508A Standard for Industrial Control Panels, ANSI/UL 50E Standard for Enclosures for Electrical Equipment, Environmental Considerations, and ANSI/UL 891 Deadfront Switchboards. During inspection by TUV, multiple other areas of non-conformance were identified:

- Insufficient dead front protection from live uninsulated components
- Incorrect ventilation for the enclosure type
- Insufficient enclosure design for outdoor applications
- Inadequate charging cable strain relief bushings
- Insufficient protections to deenergize the cable in the event of a short circuit caused by cable strain, when uncoupling from the vehicle, or in a state conducive to electric back-feed
- Vehicle coupler was not UL or TUV listed
- Charging cables were improperly sized
- Signal wires were not low-voltage, low-energy circuits
- Insufficient spacing between the internal circuitry and the enclosure
- Insufficient spacing between the busbars
- Insufficient barriers and segregation between the 24 Vdc and 480 Vac circuits
- Incorrect overcurrent protection for branch circuits
- Circuit breakers were no UL or TUV listed
- Insufficient labeling of the insulation materials
- Insufficient equipment labeling
- Inadequate/inaccessible lockable disconnect

After the initial inspection, the BYD chargers (Figure 18) were removed from the terminal for the critical upgrades, modifications, and repairs. In August of 2019, the charging units were delivered back to the terminals and installed, as TUV confirmed that all identified concerns had been addressed through modifications to the equipment or through provision of sufficient objective evidence.

Figure 18: Images of the BYD charging station at SSA Marine during TUV field inspections

The TUV report for the two SSA Marine BYD chargers was submitted to the City in September of 2019. A resubmittal was required by the City due to minor administrative errors (such as incorrect addresses) and submitted in October of 2019. The TUV Field Evaluation details each safety standard and is provided as part of Appendix A. Final inspection of the SSA Marine BYD charging units was completed by the City in November of 2019. The City approved the SSA Marine infrastructure in December of 2019. Shortly after, one of the BYD chargers at SSA Marine was found to have a circuit breaker issue that allowed the charger to complete only 30 minutes of charging. Adjustments to the power setting on the charger resolved the issue.

The LBCT BYD TUV inspection report was submitted to the City in December of 2019. Because BYD had gained experience with obtaining TUV certification for the SSA Marine top handlers by this point, the process went much more smoothly, and the City approved the LBCT BYD infrastructure in January of 2020 (Figure 19).

Figure 19: BYD charging stations at SSA Marine (left and center) and LBCT (right)

3.3.3 BYD Infrastructure Lessons Learned and Best Practices

Due to the major hurdles with the BYD charging units, there were many lessons learned. These included:

- Discuss safety certification requirements at the very beginning so all stakeholders are aware of the expectations. In some cases, safety standards may not yet exist, or a legal mandate does not exist. However, for the purpose of permitting and user acceptance, it is critical that both the Port and the technology developer/OEM understand the state of standard development, what will be required for permitting purposes, and whether the end users require that their equipment meets an optional safety standard. Companies which would like to do business at the Port of Long Beach, or within many cities in the State of California, or the U.S., should plan and fund any modifications to meet mandated, or commonly accepted, safety standards.
- Provide written documentation about required American standards, particularly for any companies based, or main experience is, out of the country.
- Quality assurance is an important aspect of any project and should be considered during the design phase, and verified before accepting delivery of any equipment. In addition, some OEMs/technology developers have implemented a practice of dropping off prototype units or the diesel equivalent unit for terminal operators to test before finalizing design specifications. This allows the operator to provide early feedback to support the development of a final product that meets their expectations.
- The design of the equipment should not change mid-project without approval of the grant manager, in this case the Port, and the terminal, such as LBCT. In this project, this became an issue when BYD changed the short-circuit rating of the charger without notifying the Port.
- Understandably, project team members may turn over when a person exits a company to pursue a new opportunity. It is critical to project success that a new team member is identified expeditiously, and the evolution of the project is documented to support speedy knowledge and context transfer.
- Port engineers identified that communication with the City electrical inspectors during the design process helps to mitigate delays down the road by communicating the appropriate requirements prior to any delivery of a product.
- The nature of projects such as C-PORT is dynamic. These technologies are new, and the manufacturers are developing and redesigning as they go, meaning things can change very quickly. Project teams should be nimble and prepared for major pivots. An example of an unexpected challenge was the need to develop a five-meter cable (originally three meters). The project team evaluated multiple options, including moving the location of the charger on the equipment. Ultimately BYD produced a new, longer cable.
- Ports are highly regulated and secure areas, and inspectors and technology provider staff should have the required clearance identification — such as Transportation Worker Identification Credential (TWIC) cards — so they can perform their job duties. Contractors and vendors required additional time to obtain TWIC cards for entering and

exiting terminal gates. This delay could have been avoided if contractors had coordinated with the terminals early to communicate this requirement.

- The nature of projects such as C-PORT is dynamic. These technologies are new, and the manufacturers are developing and redesigning as they go — meaning that things can change very quickly. Project teams should be nimble and prepared for major pivots. As part of the BYD charger installation, this happened multiple times — including a different short-circuit rating change and with the TUV field evaluation findings.

3.4 Infrastructure for Air Products Fueler (LBCT)

The Port contracted directly with Air Products to provide hydrogen fuel through an on-site mobile fueling trailer to support the fuel cell Sinotruk yard tractor at LBCT. While in the deployment phase of the yard tractor, the Port and LBCT — in consultation with CARB — made the decision not to proceed with completing the project, because the yard tractor was deemed infeasible and unsafe to operate, due in *no part* to its fuel. See Section 4.3 for additional details.

3.4.1 Design and Engineering Process

The Port worked with Air Products and the City, to identify a prime location for the chosen mobile SmartFuel™ fueler trailer s (Figure 20). Minor engineering work was suggested by Air Products, as the hydrogen provider, such as a stable concrete platform, which the Port was prepared to deploy.

Figure 20: Air Products Mobile Fueler

3.4.2 Infrastructure Commissioning

Due to detailed engineering requirements of the City of Long Beach, the permitting authority, Air Products was tasked in summer 2019 to prepare the permit package at additional, unbudgeted cost. On September 18, 2019, the Port approved an HDP for the installation. The mobile fueling trailer was ultimately permitted through the City in October of 2019. However, the project team, including CARB, decided to not move forward with the project on November 25, 2019, and the hydrogen C-PORT component ended. For additional details, reference Section 4.3.3. Infrastructure was ultimately never deployed, and the permit was voided.

3.4.3 Lessons Learned and Best Practices

The hydrogen fuel cell yard tractor demonstration was not a success for a variety of reasons, none of which was related to the infrastructure or fuel. However, there are some benefits, as the Port now has a hydrogen mobile fueler permitting and infrastructure process in place, as well as a relationship with the City permit inspection staff, streamlining future hydrogen projects. Following are some of the key takeaways:

- An internal hydrogen permitting process and timeline was created to allow other hydrogen projects going forward to be more efficient.
- A task for City permitting efforts should always be included in the contract with the hydrogen provider.
- Engineering and basic civil construction services may be required for hydrogen mobile fuelers, which should be built into the budget and schedule. This may include the deployment of concrete pads, grounding electrical cables, lighting, and other security systems.
- Operators continue to indicate interest in hydrogen fuel cell CHE, as the refueling process with labor is similar to the existing process for traditional diesel equipment.

4 Equipment Deployment and Demonstration

C-PORT advanced two types of pre-commercial ZE CHE, the first of their kind in the world. As a result of this demonstration, manufacturers were able to take steps toward subsequent models and widespread commercialization in the California marketplace and beyond. The project demonstrates the practicality and economic viability of widespread adoption of advanced off-road technologies as well as provides valuable lessons to apply moving forward at the Port, other seaports, and the industry as a whole.

> *C-PORT advanced two types of pre-commercial ZE CHE, the first of their kind in the world.*

Top handlers move cargo vertically around the terminals, often on and off ships and trains. Yard tractors move cargo around the terminals. These pieces of equipment are extremely common in port environments, so ZE models as replacements would reduce emissions significantly across the Port complex. The demonstration took place at two Port terminals, with two different operations and duty cycles. No two marine terminals are the same, and C-PORT allowed stakeholders to experience how the Taylor top handler functioned as viable products for their unique needs. Originally, C-PORT had included a battery-electric and fuel-cell yard tractor direct comparison at LBCT; however, due in no part to its fuel, the fuel cell yard tractor design was deemed unsuitable for operations at the Port and was not demonstrated in revenue service.

Important dates for C-PORT are summarized in Table 4. Upon delivery of the equipment, the units were inspected and commissioned to evaluate technical performance associated with the vehicle specification and the OEMs, and technology providers presented training to the operators. Once all units were placed in service to evaluate performance in revenue operations, data collection was initiated; a data collection and analysis report is described in Section 5.

The Port delivered a written *Notice of Demonstration Commencement* to CARB by February of 2020 that all equipment had begun the demonstration phase at its respective terminals. The technology providers and OEMs provided maintenance of the equipment and technical trouble-shooting support, as needed, during this period. The terminals also coordinated with the data collection and analysis consultants. This period concluded with submission of a written *Notice of Demonstration Completion* in July of 2021.

Table 4: Important demonstration dates

	Taylor Top Handlers at SSA Marine	Taylor Top Handler at LBCT	Kalmar Yard Tractor at LBCT
Delivery	August 27, 2019 September 5, 2019	August 19, 2019	May 1, 2019
Placed in Service, Demonstration Commenced	January 27, 2020	February 3, 2020	July 17, 2019
Data Collection Started	February 13, 2020	February 13, 2020	March 20, 2020
Data Collection Ended, Demonstration Concluded	December 31, 2020	July 25, 2021	June 19, 2021

4.1 Taylor Electric Top Handlers

Taylor, a well-known and respected OEM within the Port and goods movement industry, provided confidence that it could deliver a quality, viable product to the terminals, who have much experience with the diesel counterparts. To develop the electric top handlers (Figure 21), Taylor partnered with BYD for ZE technology components to be integrated into Taylor's traditional top handler equipment. Taylor and BYD studied the application requirements, duty cycles, and drive schedules for top handlers at both LBCT and SSA Marine. Taylor and BYD also conducted power/energy calculations to design the units to meet the functional requirements for each end use. To reach the final design specifications, the preliminary design and build specifications were combined with essential safety and functional requirements, as defined by industry-standard practices, as well as design and safety standards and a comprehensive safety review.

David Gully, Regional Sales Manager for Taylor Machine Works, said that these battery-electric top handlers are important to Taylor's clients because, "Having the first zero-emissions container handling equipment is an important step in moving forward to be zero-emissions by 2030 or 2035."

Figure 21: Top handler for LBCT (left) and for SSA Marine (center and right)

Taylor Engineering R&D is separated into discrete tasks with respective personnel responsible for planning, evaluation, testing, and determination of project goal completion. To support the Taylor Engineering R&D staff, and because of the amount of new technology on the battery-electric top handler — including motors, power inverters, powertrain control, battery containment, and vehicle controls — Taylor coordinated heavily with its suppliers during the prototype planning, build, validation, and testing processes. Individual components were delivered for assembly and validated, tested, and certified where possible.

> *“The top handler was the largest piece of battery-operated equipment in that setting at the time.”*
>
> *-Rob Fulton, Taylor Machine Works*

4.1.1 Top Handler Equipment Specifications

The ZLC Taylor Top Handlers were designed to meet or exceed all requirements outlined in OSHA 29 CFR 1910.178 for use, ANSI/ITSDF B56.1 for use and design, and UL 583 for electrical safety and fire prevention.

A selection of standard features includes:

- 42" ULTRA-VIEW Telescopic Mast for stacking 5-High (9' 6" loaded).
- 20-40 ISO Container Handling Attachment, Chain Suspended, with reach, slew, side shift, guide arms, and mechanical pile slope.
- Accumulator in Lift Circuit.
- 615V All-electric battery power drivetrain. Two full-shift run time (under normal work cycles).
- Taylor/Dana TE-30 multi-speed transmission designed specifically for battery-powered drivetrains.
- Kessler D-102W HD planetary drive axle with wet disc brakes.
- Taylor 600 welded steel steer axle with stud protectors (single hydraulic cylinder design with heavy-duty links from the cylinder ram directly to tapered roller bearing mounted spindles).
- 18.00 x 25 – 40 PR bias pneumatic drive and steer tires.

Detailed truck dimension specifications, standard features, serviceability, hydraulics and brakes, Taylor's integrated control system, and engineering bill of materials are available as part of the *Taylor Top Handler Final Report* (Appendix B). Some modifications to three units were made, as preferred by the two end-user terminals, including the color of the units. Air conditioning (AC) does not come standard on these ZLC models. Operators at LBCT are accustomed to AC and to provide a comparable experience to the diesel equivalent units, LBCT absorbed the cost of this customization.

Table 5 through Table 8 provide technical specifications related to performance, battery capacity and power source for the Taylor ZLC-906.

Table 5: Performance specifications for the ZLC-906 electric top handler

Performance: ZLC-906			
Travel Speed	Max Fwd/Rev – No Load	14.5 mph	23.3 km/h
	Max Fwd/Rev – With Load	14.5 mph	23.3 km/h
Lift Speed	No Load	60 fpm	0.31 m/s
	With Load	48 fpm	0.24 m/s
Lowering Speed	No Load	61 fpm	0.31 m/s
	With Load	61 fpm	0.31 m/s
Grade Clearance	Center of Truck	27%	
	Rear Overhang	50%	
Gradeability (Max @ Zero Speed)	No Load	30%	
	With Load	18%	
Traction Effort	Maximum	50,000 lb	222 kN
Note: Performance specifications are based on trucks with standard equipment. Performance specifications are affected by the condition of the vehicle, its components, and the nature and condition of the operating area.			

Table 6: Battery capacity and charger details for the battery-electric top handler

ZLC-906 Battery Capacity		
Batteries	Manufacturer	BYD Lithium Iron Phosphate (Lithium Ion)
	Capacity (kWh)	922
	Charging Time	5-6 hours
	Lithium Iron Phosphate battery technology provides industry-leading power density, battery longevity, stability, and safety when compared with other Lithium-Ion battery chemistries. Lithium Iron Phosphate chemistry is also one of the most eco-friendly battery chemistries available in these applications.	
Charger	Manufacturer	BYD
	Power Rating	200 kW

Table 7: Details about the power source for the battery-electric top handler

ZLC-906 Power Source			
Traction Power Source	Make and Model	BYD PMSM (Permanent Magnet Synchronous Motor) Traction Motor	
	Tier Compliance	ZE	
	Fuel	All-Electric Battery Power	
	Maximum Traction Output	241 hp	180 kW
	Maximum Traction Torque	1106 ft-lb/RPM	1500 Nm/RPM
Battery Pack	Voltage	615 V	
	Capacity	922 kWh	
Low Voltage	Battery	Volt/Ah (2 batteries)	24/2300
		Amps	70

Table 8: Transmission specifications for the battery-electric top handler

ZLC-906 Transmission		
Batteries	Make and Model	Taylor/Dana TE-30 Base with Special Application
	Number of Speeds (Fwd/Rev)	5/3
	Gear Change	Electronic/TICS Max Gear Selection
	Direction Change	Column Mounted Directional Control
	The multi-speed powershift transmission has been developed specifically for ZE all-electric battery-powered top handler applications. Included are electronic controls designed to provide the maximum traction effort required for full duty cycle application while optimizing efficiency, maximizing power capacity, and resulting in high-quality shift controls.	

4.1.2 Top Handlers Procurement Timeline

Taylor, in coordination with BYD, oversaw the fabrication, ordering, and delivery of the necessary components to build the battery-electric top handlers. The three top handlers were built off the main production line in Taylor's R&D facility because of the prototype nature of the builds. Taylor is a vertically integrated manufacturer, not just an assembly plant; most of the components were built on-site. Over the course of this prototype build process, thousands of personnel hours and tens of thousands of individual parts and processes were invested into the success of these prototype units. Taylor completed the component sourcing phase and began installing delivered parts by the end of 2018 (Figure 22 and Figure 23).

Figure 22: Partially assembled chassis and fully assembled battery pack (left), the electric drive system (center), and battery pack analysis testing with a partially assembled battery pack (right)

Figure 23: Operational stage buildout ready to begin testing (left) and testing and safety audit with test loads (right)

By June of 2019, the first top handler unit was in the production line. The first unit was delivered to LBCT on August 19, 2019, and the next two were delivered to SSA Marine on August 27, 2019 and September 5, 2019.

4.1.3 Top Handler Equipment Commissioning and Training

To commission the battery-electric top handlers, Taylor developed New Product Development Milestones, which included specific tasks for testing functional safety, certification, and validation for vehicle components, systems, and subsystems.

The use of powered industrial lift trucks, including top handlers, is governed by OSHA 29 CFR 1910.178. Contained in the OSHA standard is a requirement to purchase and operate equipment according to the requirements of ANSI/ITSDF B56.1, which is the overarching safety standard for units operating in North America. Also included in these standards are requirements for approved electric trucks, which are designated "E" to meet the requirements of UL 583 for fire protection and safety. Taylor contracted Intertek — an NRTL — to oversee and audit, to the extent possible, the design to meet the UL 583 standard. This included a full operational safety audit. In the "pre-production" phase, a requirement of the grant application, many components do not carry full certification due to the prototype nature and likelihood of modifications learned during the demonstration.

Figure 24: The battery electric top handler demonstrated at SSA Marine

The top handlers (Figure 24) were fully audited for safety relative to the applicable standard referenced above, including the third-party safety audit provided by Intertek. The units were delivered, meeting all requirements for the pre-production units.

> *"[C-PORT] has helped us get on the path to commercialization in a very short time."*
>
> *-Spencer Pope, Taylor Machine Works*

As the last step before preparing the demonstration units for delivery, Taylor tested the onboard charging equipment with BYD EVSE with success. The electric top handlers then passed performance testing conducted prior to delivery, though later issues with the charging unit — which impacted the ability to use the vehicles — were identified once installed. See Section 3.3 for information about the infrastructure.

Taylor conducted a training session with SSA Marine in November of 2019, and at LBCT in February of 2020, to educate the terminals about proper operation and maintenance of the equipment.

4.1.4 Top Handler Equipment Operations

Taylor designed the top handlers to meet a 16-hour, two-shift duty cycle, with the expectation that the units could charge during breaks and other down time. However, it is normal practice that many container terminals staff top handlers so that when one operator takes a break, or at shift change, another operator immediately runs the machine — so there is no real downtime for a top handler unit. Opportunity charging is not guaranteed, as labor agreements require specific laborers to plug-in the machines, and they might not be available when needed. Additional labor may be required, which is a costly and unplanned component of deploying ZE technologies. SSA Marine is a busy container terminal where the top handlers have a heavy-duty cycle and are required to operate two entire shifts. As such, operators found that due to the nature of the work and limitations around opportunity charging, the units did not maintain enough battery life to be comfortably used for the full two shifts. The greatest measured battery discharge (usage) during the demonstration was 91% during operations for 7.61 hours. The longest day for the tested SSA Marine diesel top handler (Unit 80361) was 12.43 hours, with 29% of the days with data collected from the diesel unit showed operations longer than 7.61 hours, the maximum identified ZE unit range. A sample day of top handler use is shown in Figure 25.

Figure 25: Data showing the routes at SSA Marine taken over the course of an example set of operational data

At LBCT, top handlers are primarily used for swapping out chassis or repairs, which is a different use than a traditional container terminal and therefore are not used as heavily or often. As a result, the battery life for the top handler demonstrated at LBCT often lasted days, not requiring even daily charging. The Taylor top handler successfully met the specific requirements of LBCT. A sample day of top handler use is shown in Figure 26.

Figure 26: Data showing the routes at LBCT taken over the course of an example set of operational data

Taylor maintained a detailed log of equipment challenges. A detailed operational event summary is provided in the *Taylor Top Handler Final Report* (Appendix B). A summary of a selection of challenges is provided in Table 9.

Table 9: Top handler event summary

Unit	Operational Event
LBCT	High-voltage system error due to moisture in the cab heater circuit. Solved after one day of downtime.
	Transmission oil leak was identified. Repair occurred the next day; only one day of downtime.
	Vehicle was removed from service for all of January of 2021 while the dealer installed over-height lugs (installation is not associated with being an electric vehicle). While out of service, work was conducted on the wiring harness and battery management system. Unit was returned to service on February 5, 2021.

Unit	Operational Event
	Upon return to service (February 5, 2021), challenges with the AC, heater, and inching function remained. In addition, the lack of a defogger was challenging for the operators. Operator also identified a noise issue. Cal Lift (dealer) was on-site for the week to make repairs.
	No defogger in the cab was creating issues for the operators.
	Coupling failure on a pump resulting in nine days of downtime while the unit was repaired.
	Spindle shims on the steer axle were incorrect, resulting in the wheels rubbing on the steer axle, and issues with the charger panel display resulted in removal from service for repairs from May 20, 2021, to June 7, 2021.
SSA Marine #1	On-board charger issue that limited the charging rate to 1/2 the normal capacity. This issue took several months to completely fix in part due to COVID restrictions limiting travel and access to the equipment. Issue persisted between May 7, 2020, and May 12, 2020.
SSA Marine #2	Cracked differential drive motor that was identified by visual leak detection. Repair was delayed due to COVID impacts to the supply chain and restrictions to the site. Vehicle was out of operations from March 11, 2020, through April 13, 2020.
	Lift steer motor coupling broke; repaired the next day for one day of downtime.
	Nylon coupling failed. Repair was made within the week, resulting in five days of downtime.

4.1.5 Workforce Testimonials

Reports from the terminals and operators were generally positive. Initially, operators were hesitant to use the top handlers at LBCT because, unlike the diesel-powered top handlers at the terminal, the ZE unit did not have AC. Operators used it in their regular operations without issue, after LBCT paid for the install of AC.

The top handlers were designed to be identical to the diesel units, so operating one is the same for the labor force but without the noise, vibration, and diesel odor and emissions (Figure 27). Operators also appreciated that the controls were identical to the machines they normally operate and did not notice a difference between the diesel top handler they are used to and the ZE demonstration unit. It was also noted that the ZE top handlers were faster because there was no waiting for the engine to rev up. The Taylor top handlers were very well received by the labor force at both LBCT and SSA.

Figure 27: The cab of the Taylor top handler

4.1.6 Top Handler Lessons Learned

Over the demonstration period, several valuable lessons were gleaned about this new technology:

The Taylor top handlers were very well received by the labor force at both LBCT and SSA Marine.

- Keep the cab design and controls similar to traditional diesel units to aid in operator comfort and willingness to adopt a new technology.
- Before designing ZE CHE, it should be clear which features and specifications are necessary for the unit to be used and meet particularly heavy-duty cycles. Each terminal is unique, and manufacturers should fully investigate and analyze the requirements, including “opportunity charging” expectations.
- The cost of delivery was not included in the original agreements, which resulted in unforeseen costs as well as other items such as insurance responsibility. To avoid this challenge, contractual agreements between the end user and OEMs should be established.
- OEMs and terminal operators both agreed that some sort of mechanized charging is essential for full commercialization of the top handlers. This would allow for more “opportunity charging” within a given shift.
- Working with international technology vendors creates extra challenges if the technology is not made to meet U.S. quality standards. Additional upfront evaluation and diligence will reduce this challenge in the future.

4.2 Kalmar Battery-Electric Yard Tractor at LBCT

Kalmar is a well-known OEM of CHE at the Port, and well respected by the terminals and operators. It offers a range of cargo handling solutions and services to ports, terminals, and distribution centers. Kalmar is one of the industry leaders in terminal automation and in energy-efficient container handling, with one in four container movements around the globe being handled by a Kalmar solution. Kalmar designed one ZE battery-electric yard tractor for LBCT, in partnership with TransPower/Meritor (Figure 28).

Kalmar and TransPower/Meritor studied the application requirements, duty cycles, and drive schedules for yard tractors at LBCT. Kalmar and TransPower/Meritor also conducted power/energy calculations to design the units to meet the functional requirements for the vehicle. To reach the final design specifications, the preliminary design and build specifications were combined with essential safety and functional requirements, as defined by industry-standard practices, design, and safety standards as well as a comprehensive safety review.

Figure 28: Kalmar-TransPower/Meritor yard tractor at LBCT

Additional detailed information about the yard tractor demonstration is provided in the Kalmar *Yard Tractor Final Report* (Appendix C).

4.2.1 Equipment Specifications

Kalmar, with support from TransPower/Meritor, reviewed and planned functional requirements, duty cycle and drive schedules, and power/energy calculations and prepared a Technical Specification report. Upon confirmation that the yard tractor met the identified specifications, Kalmar sourced a drive system kit from TransPower/Meritor that consisted of three major subsystems: a motive drive subsystem, a power control and accessory subsystem, and an energy storage system (ESS).

The ESS

- The ESS houses batteries and a controller to store and supply energy
- Each ESS contains 44 kW of energy
- The battery pack for the Kalmar yard tractor comes in options of 3, 4, and 5 strings[6]

Each ESS contains the following components:

- Batteries

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[6] A battery string is a set of connected battery cells

- Battery control module
- Contactor
- High-voltage fusible link

The motor

- Single motor that is directly attached to an Eaton 6-speed transmission
- High voltage cables are attached to the motor supply 3-phase voltage from the ICU (Inverter Charger Unit) to turn the motors

A Specification Acknowledgement and Application Survey was provided to LBCT so that Kalmar and TransPower/Meritor could understand their requirements and produce a viable product.

4.2.2 Procurement Timeline

Kalmar production began in early February of 2019, though was slightly delayed due to shipping times for the powertrain. To build the unit, Kalmar ran it on its assembly line to test the manufacturing process for this product. The unit followed the normal production process and testing procedures for current production. Certain operations were modified to support the electrical product, and its testing procedure was modified to align with electrical requirements. By March of 2019, production was complete and subsequently sent to Cal-lift, a local California vendor, for the unit to receive final components and sign-off that it was ready for delivery.

4.2.3 Equipment Commissioning and Training

In April of 2019, Kalmar displayed the unit at the Advanced Clean Transportation Expo (Figure 29) and showcased it in the ride-and-drive event in Long Beach. Kalmar delivered the yard tractor to LBCT on May 1, 2019. Commissioning and training occurred on June 21, 2019, including instructions for shut-down procedures, display features, and charging, which was led by the TransPower/Meritor team.

Figure 29: The Kalmar battery-electric yard tractor at the Advanced Clean Transportation Expo

Prior to operation, LBCT installed its own telematics operating system, and it was at this point that the terminal determined that additional requirements were needed that were not requested in the initial specification — including a Falling Object Protective Structure (FOPS) and an intermediate cab step. Once this was rectified, in June of 2019, the operators tested the unit before putting it into official demonstration mode. The ZE yard tractor was placed into service on July 17, 2019, and formally initiated the demonstration phase of C-PORT.

4.2.4 Yard Tractor Operations

A plot of the routes taken on a standard single-shift 6.5-hour workday is presented in Figure 30. On this workday, the yard tractor drove 47 miles, averaged a speed of 9.2 mph, and used 65% of its total charge.

In October of 2019, due to the placement of the five battery packs, one of the packs was damaged when the vehicle performed a jackknife maneuver, and the bombcart struck the corner of the battery box. The jackknife maneuver is used when backing up the chassis into a parking spot or other small spaces, and includes the folding of the vehicle such that the cab creates an acute angle with the chassis. This is not a common maneuver among all terminals, but it is necessary for LBCT due to size constraints and small spaces and was not accounted for when the tractor was designed. Kalmar engineers identified a solution to keep the demonstration running; instead of the five battery packs, one was removed. This does, of course, impact the range of the unit but allows the tractor to perform its essential duties.

Figure 30: Plot of the routes followed by the LBCT yard tractor for a 6.5-hour workday

Recurring maintenance issues were logged and are summarized in Table 10.

Table 10: Maintenance summary for the battery-electric yard tractor

Month	Report
Jun 2019	The yard tractor drivers found that when performing a jackknife maneuver while backing into a trailer, the power steering would quit operating but the vehicle would still drive. After reproducing the fault, TransPower/Meritor discovered a loose fuse, which was fixed. LBCT put the vehicle into a validation period to test the solution, but two weeks later the fault appeared again. TransPower/Meritor, along with its inverter supplier, determined the root cause on July 15 and, on July 17, TransPower/Meritor fixed the unit. As for operator feedback, an operator noted “hard steering” and that the unit would stall under a trailer. A loose pin was found in the connector of the harness, which addressed the stall, and the issue was addressed. The pressure was adjusted to fix the power steering issue and ultimately in July, a loose fuse was repaired — which fully fixed the issue.
Sep 2019	A connectivity issue with the telematics system was discovered, and the data logger was replaced in February of 2020.

Oct 2019	Vehicle sustained damage from a terminal chassis striking the corner of the battery box. Ultimately the fifth battery was removed to avoid the potential for this damage to occur again. The unit was placed back in service in January of 2020, creating a four-month delay in the demonstration period.
Jun 2020	Service was needed for the transmission, which required that the unit be removed from the site for repair at the dealer. Ultimately, the transmission was replaced. An ESS string was damaged during operation with all bolts stripped from the cover. This damage required the unit to be removed from service for the string to be replaced. The unit was out of service for approximately six weeks, returning to service on August 10, 2020.
Sep 2020	Unit was in operation but not transmitting data due to blown fuse for the data logger, which was replaced.
Nov 2020	Unit experienced communication issues with the telematics system and the telematics systems was replaced.
Dec 2020	Transmission issues were again identified, and the vehicle was removed from service for repairs at the dealer. The transmission was replaced again and returned to service; however, electrical issues were identified soon thereafter, and the unit was immediately returned for repairs to the electrical system and the X-Y shifter. Prior to return to service on February 10, 2021, additional repairs to change the bonding and grounding scheme, installation of a variable reluctance sensor, and updates to the wiring harness were completed.
Mar 2021	Telematics logger was replaced.
Jun 2021	On June 3, 2021, the unit was taken out of service due to noise from the transmission and transported to the dealer where the transmission was replaced for a third time. However, the unit still lost pressure due to the air dryer continuing to purge. The OEM believes the issue has now been fully rectified, and the terminal will continue to monitor for any further transmission issues.

4.2.5 Workforce Testimonials

Overall, the operators provided positive feedback on the Kalmar yard tractor, with great satisfaction in operator comfort, noise level, and rideability.

The operator of the yard tractor reported that she really enjoyed operating the vehicle. The driver reported that after a shift on the ZE yard tractor, she felt healthier than after operating the diesel yard tractors; her body didn't feel as tired or worn out, and her clothes didn't smell like diesel fumes.

Alan Wilson, Kalmar Director of Operations said, “Overall operator feedback has been extremely positive.”

4.2.6 Yard Tractor Lessons Learned

Over the course of this demonstration, project partners identified valuable lessons and best practices to apply to future projects:

- Manufacturers should study how each terminal uniquely conducts business and the way they operate the units. Because LBCT requires a jackknife maneuver, the efficiency and capability were reduced with the removal of one battery and the unit was not able to run the full duty cycle. This was not identified during the simulation modeling and therefore was not initially incorporated into the design.
- Ongoing transmission issues were a concern to the terminal, which should be quickly rectified to increase confidence in the ZE product and marketplace. It should be noted that this is *not* based on the ZE technology itself, but rather on other vehicle components.
- Identifying clear roles and communication processes about when the yard tractor was being worked on and taken out of service, as well as the deployed solutions, would alleviate delays and confusion during a demonstration.

4.3 CNHTC Fuel Cell Electric Yard Tractor

CNHTC, in partnership with UQM and in collaboration with Loop Energy, planned to demonstrate the first and only fuel cell yard tractor in development at the time. Technology manufacturer Loop Energy and OEM CNHTC were tasked with designing, building, and delivering a hydrogen fuel cell tractor. CNHTC studied the application requirements, duty cycles, and drive schedules for yard tractors at LBCT. Based on these data, energy calculations were completed to design the units to meet the functional vehicle requirements (Figure 31).

4.3.1 Equipment Specifications

Loop Energy's pre-commercial eFlow hydrogen fuel cell system used a proprietary design that removes 30-40% of the capital cost of traditional fuel cells through uniform oxygen dispersion across the entire active area of the fuel cell, increasing power production per unit of the area by up to 40% while cutting capital costs.

The hydrogen fuel cell yard tractor was designed to the following specifications:

- Wheelbase 3050 mm
- 10-mm steel plate; rectangular cross-section, and L-shape reinforcement at outside
- Front and rear tow devices
- Beavertail-tapered extension located at the rear of the frame
- Maximum speed 40 km/h

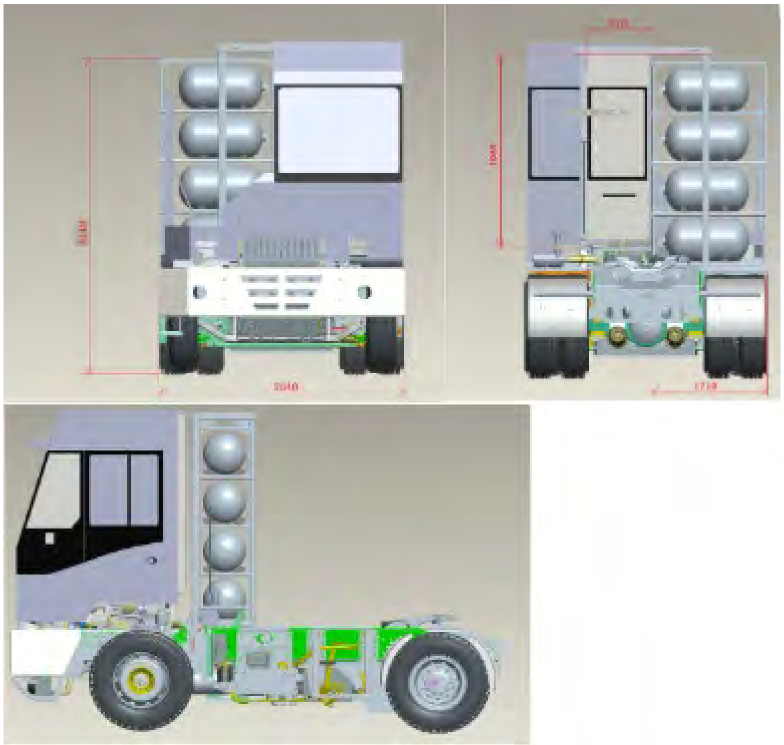

Figure 31: Sinotruck hydrogen fuel cell tractor drawing

4.3.2 Procurement Timeline

An initial prototype vehicle was completed by CNHTC for initial performance testing in December of 2018; performance testing was also completed. During this period, Loop Energy’s components were not meeting all the expected required parameters for operation. One problem was the integration of Loop Energy's 30-kw fuel cell, as the power testing was not reaching its capacity for optimal performance. It was determined that a change in vendor to ReFire, a supplier for the fuel cell compressor system, was needed. The OEM, CNHTC did not provide technical details about why the fuel cell was not able to meet the performance specification.

4.3.3 Equipment Commissioning

In Spring of 2019, the project team encountered the unexpected issue of obtaining visas for engineers from CNHTC who were tasked with commissioning the vehicle (Figure 32). The company was initially not prepared to send and house personnel, though staff eventually did travel to Long Beach.

At this time, several substantial issues began to compound throughout the remainder of the project task's life, ultimately leading its removal from the C-PORT demonstration.

The vehicle arrived in the United States at the Port on June 2, 2019. In August of 2019, while conducting a test drive, it was discovered that the 5th wheel boom collides with the hydrogen fuel tank when making a required jack knife maneuver to back up to the bombcart (Figure 33).

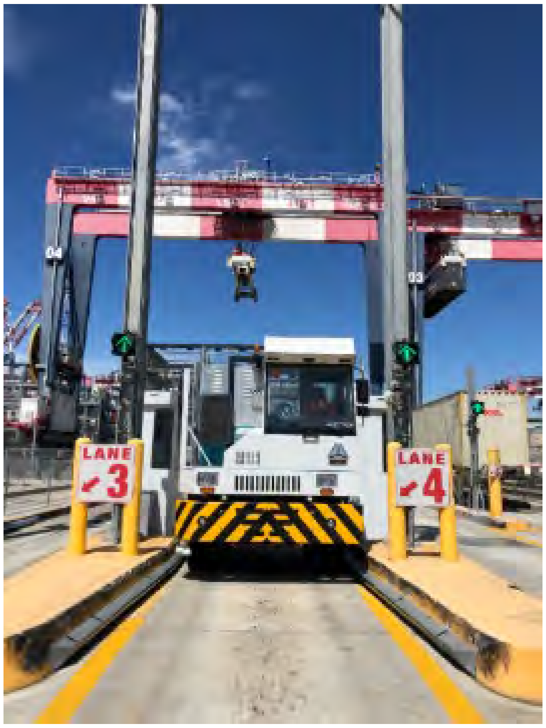

Figure 32: Sinotruk hydrogen fuel cell tractor at LBCT

This was a significant safety concern that needed addressing. The design of the Sinotruk hydrogen tractor did not meet standard tractor dimensions nor did it move the various sizes of bombcarts, rendering it unfeasible to drive on the terminal. Sinotruk agreed to re-manufacture the boom and shift the 5th wheel. It was found that the engineers failed to measure the different sizes of bombcarts used by LBCT when visiting the terminal in 2018 to prepare for the yard tractor build. No progress was made on this issue in the months following, with repeated inquiries from Port and terminal staff.

Further, the vehicle was nine inches wider at the wheel than the units at LBCT, creating a situation in which the drivers had difficulty safely backing the vehicle into the lanes repeatedly throughout the duration of the shifts. The additional width also created a tire safety hazard by rubbing against concrete K-Rails and steel safety guides. In addition, the yard tractor had blind spots for the driver due to the location of the hydrogen fuel cells behind the driver’s cab. For this reason, the side mirrors were extended 2.5 feet, which caused impact with terminal infrastructure.

Figure 33: The fuel tank with clear impact markings from the 5th wheel

Furthermore, it was found that Sinotruk did not print the model or VIN/serial number on the vehicle before shipping it to the United States for demonstration — a standard in vehicles deployed in this country.

In addition to design flaws, required engineering certifications, analysis, and documentation requested by the Port and terminal did not meet expected standards or American engineering requirements. The company was not able to provide a Stamped Engineering Report from an American-registered engineering firm on the hydrogen tank after repeated requests from LBCT. A Collision and Impact Analysis for the hydrogen cylinders was provided but was highly deficient. It did not address how the fuel cell component would respond to impact during a vehicle collision or direct impact to the tank structure itself. An elementary schematic of the power supply was provided in Chinese only and did not constitute a proper electrical diagram with review and approval by a professional engineer.

In October of 2019, LBCT and the Port, in consultation with CARB, made the decision not to proceed with demonstrating the Sinotruk hydrogen fuel cell yard tractor. This was ultimately due to many factors, of which *none* is related to the hydrogen fuel cell technology itself — including safety, lack of engineering certification or documentation, and the tractor not being able to meet the performance requirements at a port terminal. The Port cancelled its contract with UQM, as well as the Harbor Development Permit, and the CHNTC yard tractor was shipped back to China.

4.3.4 Workforce Training

The training on the unit was completed in July of 2019 by visiting CNHTC personnel, however, fueling the unit was not included, as it was not yet permitted (Figure 34).

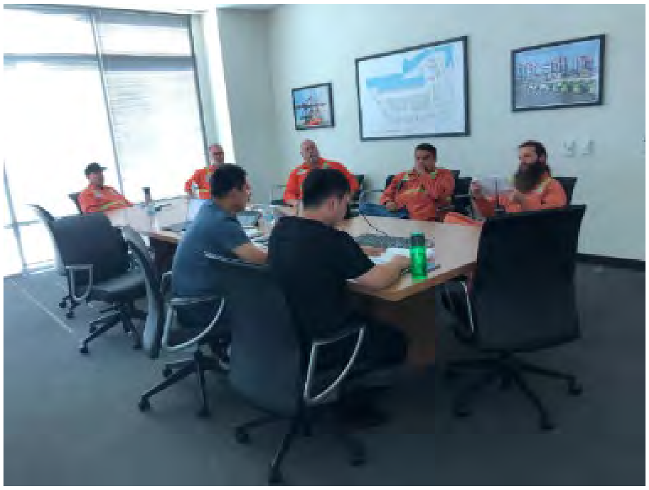

Figure 34: Sinotruk hydrogen fuel cell yard tractor workforce training

4.3.5 Workforce Testimonials

As a result of the project being removed from the demonstration, there were no opportunities for workforce to operate the unit.

4.3.6 Lessons Learned

Even though this piece of equipment was ultimately removed from C-PORT, there were still valuable lessons to be learned from this exercise:

- The CNHTC design was flawed, but fuel cell technology was *not* in itself the barrier to successful implementation. The Port continues to seek viable options to demonstrate hydrogen CHE.
- Out-of-country project partners should expect to meet American requirements and standards, and equipment that does not meet them will not be allowed to operate.
- Fuel cell vehicles are shipped with nitrogen as a default. Additional charges to remove the nitrogen and replace it with hydrogen should be determined prior to contracting, due to increased costs, along with any relevant shipping logistics due to the transport of hydrogen-fueled products.
- When working with an international partner, stakeholders will need to ensure there are translation and translator services provided for communication and documentation.
- The design phase is incredibly vital to a successful deployment of any new technology; insufficient, or inaccurate designs, could render the unit inoperable.

5 Data Collection and Baseline Emissions Testing

Demonstrations are important for technology vendors and OEMs to advance technology and refine and further develop ZE CHE products as well as to provide concrete insights to end users of the equipment with real-world data to understand the costs and reliability of the system, compared to traditional diesel operations. Data collection efforts were led by Tetra Tech, in collaboration with the renowned UCR CE-CERT laboratory and research team. Both organizations have extensive history and expertise conducting in-field data collection and testing on diesel and ZE CHE. The data collected and analyzed are vital to understanding how the units truly performed in real-world port operations and to realize the full GHG and criteria pollutant benefits.

5.1 Baseline Emissions Testing

To establish an emissions baseline, Tetra Tech and UCR CE-CERT conducted PEMS testing on traditional diesel units at the two terminals participating in the project. A *Baseline Emissions Testing Plan* was submitted to CARB in January of 2019 to CARB. Due to a change in project scope through the demonstration and deployment process, Tetra Tech slightly updated the *Baseline Emissions Testing Plan* (Appendix D) in April of 2020 to accurately reflect the changes in the project, per CARB's direction. The baseline data collected are included in the *Baseline Emissions Testing Report* (Appendix E), submitted in January of 2021.

5.1.1 Baseline Emission Testing Plan

For the Baseline Emissions Testing Plan (Appendix D), PEMS testing was conducted on the two units of baseline diesel equipment (one top handler at SSA Marine and one yard tractor at LBCT) (Figure 35). The PEMS testing provided important information on the baseline diesel emissions and fuel consumption for the diesel equipment, which in turn will provide a basis for comparison to the ZE CHE units. The baseline PEMS measurements included emissions for oxides of nitrogen (NOx), particulate matter (PM), carbon monoxide (CO), carbon dioxide (CO_2), and total hydrocarbon (THC). Fuel consumption was determined from the emissions measurements based on the carbon balance method.

Figure 35: Picture of PEMS rack mount

The PEMS collected measurements for a typical day of operation for each piece of equipment during its typical operation. The PEMS were installed the day prior to each testing day, so that a full day or shift of actual operation could be captured, and the PEMS were removed at the end of the day or shift of operation. A PEMS system used for the test at SSA Marine was a SEMTECH AVL 494 PM gas-phase analyzer that UCR obtained from the U.S. EPA via a CRADA. The AVL 494 PM system combines AVL's 483 micro-soot sensor with a gravimetric filter module option. This system recently received type approval by U.S. EPA as a total PM measurement solution for in-use testing. A second mini-PEMS system was used at the LBCT test unit, because of spatial constraints on the diesel yard tractor that prohibited the installation of the larger SEMTECH and AVL 494 PM system. More specifics on the PEMS systems are available in the *Baseline Emissions Testing Plan* (Appendix D).

In conjunction with the PEMS system, a full range of information from the engine control module (ECM) was also collected. The data loggers used for this study were HEM Data Corporation data loggers (Figure 36). These HEM data loggers were provided for and maintained through the EPA CRADA. A subset of the data collected is provided in Table 11.

Figure 36: Picture of HEM data logger

Table 11: A subset of data collected from each heavy-duty vehicle

Vehicle and Engine Information	ECU Data	GPS Data
Vocational Use	Vehicle Speed	Speed
Vehicle Type	Engine Horsepower	Latitude
Axle Configuration	Engine RPM	Longitude
Vehicle Model Year	Fuel Rate	Altitude
VIN Number	Exhaust and SCR Temperatures	Date and Time
Engine Make	Engine Percent Load	No. of Satellites Fixed
Engine Size	Engine Percent Torque	Fix Quality
Engine Model	Reference Engine Torque	Position Dilution of Precision
Engine Model Year	Engine Intake Manifold Temperature	Engine On/Off
	Engine Turbo Boost Pressure	
	Engine Coolant Temperature	

For the testing set up, the equipment was housed in a rack designed to hold all the PEMS equipment as well as the associated auxiliary equipment required to power the PEMS. The PEMS rack was mounted to the equipment at a convenient location that provides access to the equipment's tailpipe for the exhaust connection, while at the same time not impeding the visibility of the driver. To gather accurate measurements, pre- and post-test calibration, internal leak checks, and purging occurred during the testing. The system completes a functional check for each of the analyzers and to validate that the analyzers and sampling lines reached the appropriate temperatures.

5.1.2 Baseline Emissions Test Final Report

Tetra Tech — in collaboration with UCR — installed and made PEMS measurements on the three pieces of baseline diesel equipment. PEMS measurements were for a typical day of operation for each piece of equipment over a single shift. The PEMS were installed the day prior to the testing day so that a full day or shift of actual operation could be captured, and the PEMS were removed at the end of the day or shift of operation. A summary of the results is presented in Table 12. Full details can be gleaned in the *Baseline Emissions Testing Report* (Appendix E).

Table 12: A summary of the PEMS data results.

Diesel Equipment			
Emissions		*Top Handler*	*Yard Tractor*
NOx	grams per mile (g/mi)	22.90	7.56
	grams per brake horsepower-hour (g/bhp-hr)	2.87	1.91
	grams per gallon (g/gal)	57.6	30.25
	grams per hour (g/hour)	354.6	61.16
	grams per day (g/day)	1,803.3	169.4
PM	g/mi	0.728	0.000015
	g/bhp-hr	0.091	0.0000039
	g/gal	1.830	0.000061
	g/hour	11.270	0.000124
	g/day	57.306	0.000344
THC	g/mi	0.034	
	g/bhp-hr	0.004	
	g/gal	0.086	
	g/hour	0.529	
	g/day	2.692	
CO	g/mi	4.2	3.429
	g/bhp-hr	0.5	0.868
	g/gal	10.7	13.719

Diesel Equipment			
Emissions		*Top Handler*	*Yard Tractor*
	g/hour	65.8	27.736
	g/day	334.4	76.829
CO2	g/mi	4,025.3	2,062.7
	g/bhp-hr	505.0	522.4
	g/gal	10,123.9	8,252.9
	g/hour	62,330.1	16,684.5
	g/day	316,948.3	46,216.1
Fuel Consumption	gal/bhp-hr	0.05	0.06
	gal/hr	6.2	2.8
	gal/day	31.3	5.6

5.2 Data Collection and Analysis

Portable Activity Measurement System (PAMS) measurements testing of the four ZE CHE units was conducted as part of the Data Collection and Analysis efforts. The *Data Collection and Analysis Test Plan* (Appendix F) was submitted in January of 2019, and the *Final Data Collection and Analysis Report* (Appendix G) was completed July of 2021.

5.2.1 Data Collection and Analysis Test Plan

The purpose of the Data Collection and Analysis Plan was to better understand the activity and performance benefits of the individual ZE equipment units. For this testing, UCR installed data loggers (Figure 37) and made PAMS measurements on each of the four pieces of ZE equipment and three baseline diesel units (note: while only one diesel top handler was planned to be utilized at SSA Marine, diesel top handler 80290 experienced HEM logger malfunctions caused by excess engine heat, which initiated the switch to top handler 80361 to be instrumented instead in October of 2020.) One diesel one yard tractor at LBCT was utilized. The PAMS data loggers used for the study were HEM Data Corporation data loggers, capable of collecting a full range of information from the ECM (see Table 11), including GPS data on a second-by-second basis. These HEM data loggers are provided for and maintained through the U.S. EPA CRADA, such that they meet the highest standards for data measurement quality.

Figure 37: Outlet and HEM data logger used for the activity monitoring program

Tetra Tech and UCR CE-CERT collaborated with the OEMs to obtain proprietary signals as part of previous projects, including chassis dynamometer testing and other programs. The team coordinated with the terminal operators to collect additional information related to the normal operational use and activities.

The Tetra Tech team analyzed the performance of the equipment, and data collected were read into Matlab where they were reviewed, underwent QA/QC, and corrected as needed. The procedures for the data scrubbing and QA/QC were developed under the U.S. EPA CRADA so that the final data sets were of the quality level expected for application in emissions models and other uses for agencies such as CARB and U.S. EPA. Based on the information collected by the data loggers from the ECM, UCR CE-CERT processed and analyzed the collected data to determine activity patterns, including hours of operation, days of operation per year, average miles traveled per day, average value and distribution of speed and acceleration, and idling time. Some data, as outlined in Appendix F in the CARB solicitation (not provided as an appendix in this report), are impossible to collect via normal data collectors, such as:

- Amount of fuel/electricity, date, and fuel price per unit when charged
- Refueling time/charging time
- Refueling/charging source (e.g., on-site energy storage, grid, and delivery)
- Off-peak and/or renewable energy load shifting potential

To address these issues, the Port installed two energy meters at an existing switchboard at LBCT in August of 2020 and were ready for use in September. Relevant data for the SSA Marine top handlers were collected manually.

Data collection and testing activities and completion dates are provided in Table 13.

Table 13: Data collection and testing activities and completion dates

Task	Completion Dates
Notice Commencement of Demonstration	March 2020
Baseline Emissions Testing Plan	January 2019
Perform Baseline Emissions Testing	July and December 2020
Baseline Emissions Test Final Report	January 2021
Data Collection and Analysis Plan	January 2019
Install Data Collection Equipment	February 2020
Perform Data Collection	July 2021

5.2.2 Data Collection and Analysis Final Report

Detailed tables and analysis are provided in the *Final Data Collection and Analysis Report* (Appendix G).

5.2.2.1 Top Handler Data Collection and Analysis

A summary of the data collected is provided in Table 14 and Table 15. Full details are available in Appendix G.

Table 14: Breakdown of each electric top handler's performance (daily averages)

Daily Averages	Electric SSA Marine Top Handler #1	Electric SSA Marine Top Handler #2	LBCT Top Handler
Energy Use (kWh)	382	301	63
SOC Use (%)	38	43	7
Hourly Electricity Use Rate (kWh/hr)	67	57	28
Time Operational (Hours)	5.2	4.7	2.6
Speed (mph)	3	2.5	0.5
Distance (miles/day)	18	13	1

Table 15: Breakdown of the traditional diesel top handler's performance (daily averages)

Daily Averages	SSA Marine Diesel Top Handler (a)	SSA Marine Diesel Top Handler (b)
Engine Load (%)	41	22
Engine Torque (%)	27	41.3
Time Operational (hours)	5	4.8
Speed (mph)	1.6	1.4
Distance (miles/day)	7.4	8.5
Fuel Consumption (gal/day)	29	21.7

The electric and diesel top handlers at SSA Marine shared similar statistics over the course of the data logging period. Both types of top handlers were used on average about 5 hours per day. The electric top handlers at SSA Marine traveled almost twice as far as their diesel counterparts; however, this may be skewed by several low-mileage days during the limited data collection period on the diesel tractors. Both types averaged about the same speed of 1.5-2.5 mph. The ZE top handler at LBCT displays a different pattern of activity than the ZE top handlers at SSA Marine. The LBCT top handler was not used as extensively and averaged under 3 hours of operation per day, less than 1 mile, and less than 1 mph. It was estimated using the fuel rate of the diesel top handlers and the hours of use that they used on average 29 and 21.7 gallons of fuel per day for diesel top handlers (a) and (b), respectively. Converting this to kWh gives 1,093 and 818 kWh on average per day for diesel top handlers (a) and (b), respectively. The electric top handlers averaged 382, 301, and 63 kWhr of energy for the SSA Marine top handlers (1) and (2) and the LBCT top handler, respectively. Dividing these energy values by the average daily number of miles traveled gives 180 and 158 kWhr/mi for the diesel top handlers (a) and (b), respectively. The electric top handlers on average did 27, 25, and 110 kWhr/mi for the SSA Marine top handlers (1) and (2) and the LBCT top handler, respectively.

5.2.2.2 Yard Tractor Data Collection and Analysis

The LBCT yard tractor averaged 95 kWh, 56% of SOC use, 15 kWh/hr, 6 hours, 8 mph, and 42 miles per day. The LBCT diesel yard tractor averaged 28% engine load, 57% engine torque, 7 hours, 5.5 mph, and 44 miles and used 6.6 liters per hour of fuel per day (Table 16).

Table 16: Breakdown of performance metrics for both the electric and diesel yard tractors (daily averages)

	Electric Yard Tractor	Diesel Yard Tractor
Daily Averages	95 kWh	28% engine load
	56% of SOC use	57% engine torque
	15 kWh/hr	6.6 liters per hour of fuel per day
	6 hours	7 hours
	8 mph	5.5 mph
	42 miles per day	44 miles per day

The ZE yard tractor performed similarly to its diesel counterpart at LBCT. Both yard tractors traveled on average over 40 miles per day. The ZE yard tractor averaged a slightly higher speed. The diesel yard tractor averaged a higher operating time than the electric yard tractor, but both were able to perform over 12 hours of use during a single day.

It was estimated using the fuel rate of the diesel yard tractor and the hours of use that it used on average 13.6 gallons of fuel per day. Converting this to kWh gives 510.8 kWh on average per day. The electric yard tractor averaged 95.1 kWh of energy. Dividing these energy values by the average daily number of miles traveled gives 13.5 and 2.35 kWh/mi for the diesel and electric yard tractors, respectively.

5.3 Emission Reduction Estimates

Using well-to-wheel GHG emissions calculation methodology, as provided in Appendix D of the CARB grant solicitation, emission reductions are estimated. Where actual data are available from the data collection, these data are used instead of the CARB default values. The CARB default values are included as reference. All formulas referenced in this section are associated with the formals provided in Appendix D of the CARB grant solicitation.

5.3.1 Assumptions

The following assumptions were utilized in the Port's application and emission reductions estimate for CARB's Off-Road Advanced Technology Demonstration Project grant solicitation.

- Carbon Intensity of California Grid Electricity in 2020: 82.92 gCO2e/MJ[7]
- Carbon Intensity of Diesel: 100.45[8]
- Energy Density of Diesel: 134.47 MJ/gal[9]
- Energy Density of Electricity: 3.6 MJ/kWh[10]

5.3.2 Greenhouse Gas Emission Reductions

5.3.2.1 ZE Equipment GHG Emissions

The four ZE units' cumulative operational data, miles driven, and energy use during their respective demonstration periods are presented in Table 17.

Table 17: ZE equipment operational days, hours, distance driven, and energy used during the demonstration period

	Days Operated	Hours Operated	Distance Driven	Energy Used
Units	Days	hr	mi	kWh
SSA Marine Top Handler 80367	186	974	2,696	71,099
SSA Marine Top Handler 80368	179	840	2,361	53,942
LBCT Top Handler	98	273	49	6,649
LBCT Yard Tractor Kalmar	110	594	4,092	9,342

Based on the electricity consumed, the ZE equipment GHG emissions are calculated using the equation below and presented in Table 18.

$$GHG\ EF\left(\frac{metric\ tons\ CO2e}{year}\right) = \left(\frac{gram\ CO2e}{MJ}\right) * \frac{MJ}{kWh} * \frac{kWh}{year} * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right)$$

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[7] CARB's LCFS Pathway ELC000L00072020

[8] CARB's LCFS Pathway ULS000L0072019

[9] Table 4 in the LCFS Regulation approved on May 27, 2020. Unofficial Electronic Version accessible: https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf

[10] Table 4 in the LCFS Regulation approved on May 27, 2020. Unofficial Electronic Version accessible: https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf

Table 18: GHG emissions associated with ZE equipment charging during the demonstration period

	Emission Factor for Electricity	Energy Density	Energy Used	GHG Emissions
Units	gCO2e/MJ	MJ/kWh	kWh	MTCO2e
SSA Marine Top Handler 80367	75.93	3.6	71,099	19.4
SSA Marine Top Handler 80368			53,942	14.7
LBCT Top Handler			6,649	1.8
LBCT Yard Tractor Kalmar			9,342	2.6
Total			**141,032**	**38.6**

5.3.2.2 Avoided Diesel and Associated Avoided Emissions

Based on the results from the *Baseline Emissions Test Final Report* (Appendix E) and the Final *Data Collection and Analysis Report* (Appendix G), the two SSA Marine diesel top handlers averaged 5.8 gal/hr (Unit 80290), and 4.5 gal/hr fuel (Unit 80361) usage rates based on average operations of 5.0 hr/day and 4.8 hr/day, respectively. Using the average of these two measured results, the avoided diesel associated with the ZE top handlers is calculated as the average of the two fuel consumption rates: 5.2 gal/hr.

In the Data Collection and Analysis Report by UCR, the average energy consumption of the diesel top handlers (1,093 and 818 kWh on average per day) was compared directly to the average energy consumption of the ZE top handlers (382 and 301 kWh of energy per day). This energy consumption is equivalent to 2.8 and 2.7 EER, consistent with the published EER for eCHE of 2.7. The diesel yard tractor at LBCT averaged 1.7 gal/hr. The average energy consumption of the diesel yard tractor was 510.8 kWh on average per day, compared to 95.1 kWh on average per day for the ZE yard tractor. This energy consumption is equivalent to a 5.1 EER, consistent with published EER for an electric truck of 5.0.

Using these measured values, avoided diesel usage associated with the demonstration project is estimated in Table 19 using the formula below.

$$\begin{aligned} &Estimated\ Avoided\ Diesel\ (gal) \\ &\qquad = ZE\ Equipment\ Operations\ (hr) \\ &\qquad * Average\ Diesel\ Consumption\ of\ Equivalent\ Diesel\ Unit\ \left(\frac{gal}{hr}\right) \end{aligned}$$

Table 19: Estimated diesel consumption based on measured data

	ZE Equipment Operation	Average Diesel Consumption of Equivalent Unit	Estimated Avoided Diesel
Units	hr	gal/hr	gal
SSA Marine Top Handler 80367	974	5.2	5,065
SSA Marine Top Handler 80368	840		4,368
LBCT Top Handler	273		1,420
LBCT Yard Tractor Kalmar	594	1.7	1,010
		Total	**11,862**

Avoided GHG emissions from the estimated avoided diesel are calculated based on the formula below with the results presented in Table 20.

$$GHG\ EF\left(\frac{metric\ tons\ CO2e}{year}\right) = \left(\frac{gram\ CO2e}{MJ}\right) * \frac{MJ}{gal} * \left(\frac{gal}{year}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right)$$

Table 20: Estimated avoided GHG emissions from avoided diesel

	Emission Factor for Diesel	Energy Density	Estimated Avoided Diesel	GHG Emissions
Units	gCO2e/MJ	MJ/gal	gal	MTCO2e
SSA Marine Top Handler 80367	100.45	134.47	5,065	68.4
SSA Marine Top Handler 80368			4,368	59.0
LBCT Top Handler			1,420	19.2
LBCT Yard Tractor Kalmar			1,010	13.6
		Total	**11,862**	**160.2**

5.3.2.3 GHG Reductions and Comparison to the Grant Application

The GHG emissions reductions are calculated as the difference of the estimated avoided diesel GHG emissions as in the Port's grant application and the Estimated GHG Emissions from Electricity Consumption from the demonstration, presented in Table 21 using the formula below.

$$\begin{aligned} &Net\ GHG\ Reductions\ (MTCO2e) \\ &\qquad = Estimated\ Avoided\ Diesel\ GHG\ Emissions\ (MTCO2e) \\ &\qquad - Estimated\ GHG\ Emissions\ from\ Electricity\ Consumption\ (MTCO2e) \end{aligned}$$

Table 21. Estimated GHG emission reductions during the demonstration period

	Estimated Avoided Diesel GHG Emissions	Estimated GHG Emission from Electricity Consumption	Net GHG Reductions
Units	MTCO2e	MTCO2e	MTCO2e
SSA Marine Top Handler 80367	68.4	19.4	49.0
SSA Marine Top Handler 80368	59.0	14.7	44.3
LBCT Top Handler	19.2	1.8	17.4
LBCT Yard Tractor Kalmar	13.6	2.6	11.1
Total	**160.2**	**38.6**	**121.7**

The Port's grant application, submitted in September of 2017, estimated emissions reductions based on average operations at the two terminals in 2017. This estimation included more operational hours than were measured during the data collection period in 2020, as well as in 2021 during the COVID-19 pandemic, which saw untraditional operational usage such as downtime for enhanced sanitization practices and complete shutdown during reduced cargo throughput. A comparison of the estimated emission reductions based on the actual demonstration periods versus the original application, normalized to the hours of operation, is presented in Table 22.

Table 22: Comparison of the estimated GHG emissions reductions to the original grant application

	Hours Operated during the Demonstration Period	Net GHG Reductions based on the Demonstration Period	Average GHG Reductions per Operating Hour based on Demonstration Data
Units	hr	MTCO2e	MTCO2e/hr
SSA Marine Top Handler 80367	974	49.0	0.050
SSA Marine Top Handler 80368	840	44.3	0.053
LBCT Top Handler	273	17.4	0.064
LBCT Yard Tractor Kalmar	594	11.1	0.019
Total/Average	**2,681**	**121.7**	**-**

(Table continues on next page)

	Annual Hours Estimated in the Application Calculations	Net GHG Reductions from the Application	Average Reductions per Operating Hour based on the Application Calculations
Units	hr	MTCO2e	MTCO2e/hr
SSA Marine Top Handler 80367	3,276	80.0	0.024
SSA Marine Top Handler 80368	3,276	80.0	0.024
LBCT Top Handler	1,095	36.4	0.033
LBCT Yard Tractor Kalmar	3,484	64.2	0.018
Total	**11,131**	**260.5**	**-**

As expected from any emissions estimation versus actuals, there are some differences between the assumptions that were estimated in the application and those realized during the demonstration period. Several easily identifiable differences include:

- Carbon Intensity of Electricity dropped from 105.16 gCO2e/MJ to 82.92 gCO2e/MJ.
- Carbon Intensity of Diesel dropped from 102.01 gCO2e/MJ to 100.45 gCO2e/MJ.
- EERs for off-road equipment were added (2.7 for eCHE and 5.0 for electric trucks). The application used 3.8 associated with electric forklifts as it was the only off-road equipment available in the LCFS program at the time.

In addition, conservative diesel consumption estimates were utilized in the application, 2.44 gal/hr for the SSA Marine top handlers, 3.32 gal/hr for the LBCT top handler, and 1.8 gal/hr for the LBCT yard tractor. The fuel consumption measured for the diesel top handlers during data collection (5.2 gal/hr) was substantially higher than the application estimates, and was likely based on the use of average data across the entire fleet at that particular time period, not representative of use as one of the primary equipment units used for operations or testing. For the LBCT diesel yard tractor, where the fuel consumption estimate (1.8 gal/hr) was consistent with the data (1.7 gal/hr), the average reduction per operating hour was similar (0.019 MTCO2e/hr for the demonstration period vs. 0.018 MTCO2e/hr in the application).

5.3.3 Criteria Pollutant Emission Reductions

As in the tank-to-wheel analysis conducted in the application, no criteria pollutant emissions are attributed to the use of a battery-electric vehicle. Criteria emission reductions are estimated based on the formula below.

$$\begin{aligned}&Annual\ Emission\ Reduction\ for\ Criteria\ Emission\ X\\&\quad = Emission\ Factor\left(\frac{g}{gal}\right) * Fuel\ Consumption(gal) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right)\end{aligned}$$

The emission factors presented in the *Baseline Emissions Test Final Report* (Appendix E) are summarized in Table 23, and compared to those utilized in the application. The emission factors utilized in the application include reactive organic gases (ROG) and PM10. The emission factors measured during the baseline PEMS testing were total hydrocarbons (THC) and PM, as approved by CARB in the Baseline Emissions Testing Plan. The grant application calculated savings based on a Tier 4 Final engine specification while the baseline emission data was collected on a Tier 3 engine — a representative average of the SSA Marine top handler fleet.

Table 23: Criteria pollutant emission factors as measured compared to the Application

	Application Emission Factor (Tier 4f)	Measured Emission Factor for the Top Handler (Tier 3)	Measured Emission Factor for the Yard Tractor (Tier 3)
Pollutants	g/bhp-hr	g/bhp-hr (g/gal)	g/bhp-hr (g/gal)
NOx	0.26	2.87 (57.60)	1.91 (30.25)
ROG (application) THC (measured)	0.06	0.004 (0.086)	Not measured
PM10 (application) PM (measured)	0.008	0.091 (1.83)	0.0000039 (0.0000614)

Using the estimated avoided diesel calculated in Table 19, the estimated avoided emissions is presented using the measured emission factors from the Tier 3 engine (Table 24) using the following equations.

$$\begin{aligned} &\mathit{Estimated\ Avoided\ Pollutant\ Emissions}\ (ton) \\ &\quad = \mathit{Emission\ Factor}\left(\frac{g\ Pollutant}{gal}\right) * \mathit{Estimated\ Diesel\ Consumption}(gal) \\ &\quad * \left(\frac{1\ ton}{907{,}200\ g}\right) \end{aligned}$$

Table 24: Estimated criteria emission reductions

	Estimated Avoided Diesel	NOx Emission Factor	Estimated Avoided NOx Emissions
Units	gal	g/gal	ton
SSA Top Handler 80367	5,065	57.6	0.32
SSA Top Handler 80368	4,368		0.28
LBCT Top Handler BYD	1,420		0.09
LBCT Yard Tractor Kalmar	1,010	30.25	0.03
Total	**11,862**		**0.72**

(Table continues on next page)

	Estimated Avoided Diesel	THC Emission Factor	Estimated Avoided THC Emissions
Units	Gal	g/gal	ton
SSA Top Handler 80367	5,065	0.086	0.00048
SSA Top Handler 80368	4,368		0.00041
LBCT Top Handler BYD	1,420		0.00013
LBCT Yard Tractor Kalmar	1,010	-	0.00000
Total	**11,862**		**0.00103**

	Estimated Avoided Diesel	PM Emission Factor	Estimated Avoided PM Emissions
Units	Gal	g/gal	ton
SSA Top Handler 80367	5,065	1.83	0.010
SSA Top Handler 80368	4,368		0.009
LBCT Top Handler BYD	1,420		0.003
LBCT Yard Tractor Kalmar	1,010	0.0000614	0.00000007
Total	**11,862**		**0.022**

The weighted surplus emission reductions are calculated using the following equation.

$$Weighted\ Surplus\ Emission\ Reduction\ \left(\frac{tons}{year}\right) = NOx\ Reductions\ \left(\frac{tons}{yr}\right) + ROG\ reductions\ \left(\frac{tons}{year}\right) + 20 * PM\ Reductions\ \left(\frac{tons}{year}\right)$$

Using the emissions calculated above, the weighted surplus emission reductions estimated by substituting THC for ROG:

$$Weighted\ Surplus\ Emission\ Reduction\ \left(\frac{tons}{year}\right) = 0.72\ \left(\frac{tons}{yr}\right) + 0.00103\left(\frac{tons}{year}\right) + 20 * 0.022\left(\frac{tons}{year}\right) = 1.16\frac{tons}{year}$$

5.4 Lessons Learned

Based on this demonstration, the Port identified the following lessons learned that it has already begun to implement in other demonstration efforts:

- Work closely with the funding agency upfront to understand which data points of interest can be collected from traditional data loggers versus more resourceful, costly collection methods, to create a common understanding of what can and cannot be collected.
- If the demonstration relies on OEM/technology vendor data provided by proprietary telematics systems, create a process to frequently validate that those data are being properly recorded.
- Data collection periods should be clarified to include downtime and not exclusively be considered the days being operated. Even when a technology is not in use, the downtime — including length of time to return to service after maintenance, for example — is relevant information to evaluate technology performance.

6 Outreach, Communications, and Education

A significant and major component of C-PORT was to communicate information about the project to interested stakeholders, including outreach that targets local DAC. Through websites, special events, tours, publications, and presentations, the Port reaches a wide group of stakeholders in the immediate region and in the international community. Green Education was tasked with leading much of the communications and outreach efforts of C-PORT; the Port was also engaged through its award-winning AGL program and Communications Department.

> *C-PORT is a key steppingstone in the ZE transformation at the Port. As such, it is imperative that the communities who will realize the benefits are engaged.*

Marine port operations produce air toxic and climate pollutant emissions; C-PORT is a key steppingstone in the ZE transformation at the Port. As such, it is imperative that the communities who will realize the benefits are engaged, aware, and brought into the conversation early and often.

6.1 Ribbon-Cutting Event

The Port hosted a successful ribbon-cutting event in celebration of California's Clean Air Day on October 2, 2019. The public and interested stakeholders were invited to view the ZE battery-electric Kalmar yard tractor on display at the new Long Beach Civic Center Plaza, as well as hear from government representatives and other leaders. Speakers included CARB Board Member Hector De La Torre, Long Beach Harbor Commission President Bonnie Lowenthal, Port Executive Director Mario Cordero, and Deputy Executive Director at the Port Rick Cameron (Figure 38 and Figure 39).

Figure 38: Port representatives and local leaders cutting a big blue ribbon in front of the fuel-cell yard tractor

Figure 39: Rick Cameron, Deputy Executive Director at the Port, speaking at the Ribbon-Cutting Ceremony

6.2 Public and Industry Outreach and Acknowledgments

For C-PORT, the Port developed a *General Outreach Plan* with CARB. The goal of the plan was to educate and inform stakeholders about C-PORT and targeted the public, community residents and students, port tenants, local and state elected officials, and other interested stakeholders. The Port's outreach efforts resulted in more than a dozen press mentions across a range of publications. The Port also discussed its many ZE efforts — including this project — at its popular forums, such as its Annual State of the Port and Let's Talk Port events. A compendium of press releases, media mentions, photographs, and other outreach and education materials is provided in the *General Outreach Report* (Appendix H).

In addition, this project attracted regulatory agency attention when the Port received a Clean Air award from the SCAQMD for C-PORT, discussed in detail in Section 6.4. C-PORT was also nominated for a prestigious international award under the 2020 IAPH World Ports Sustainability Awards in the Climate and Energy category and was the only North American Port represented; the nomination is testament to the importance and relevance of this project globally.

6.3 Outreach by Green Education

The Port partnered with Green Education, a community-based group that organizes one of Long Beach's largest environmental events — The Green Prize Festival — to aid with outreach, particularly to the local DAC communities.

The popular Annual Green Prize Festival (Figure 40) took place on October 27, 2018, at Admiral Kidd Park, in Long Beach, CA. At the festival, Green Education held a groundbreaking ceremony, operated a Port booth, and conducted a presentation about the project and its benefits during the event. It coordinated the festival with Port personnel; ZE OEMs including Taylor, TransPower/Meritor, and UQM; as well as local community organizations representing renewable energy, energy efficiency, urban farming, water conservation, and environmental justice. ZE technology developers UQM and TransPower/Meritor participated in presenting at the Main Stage, displaying ZE mockups of off-road port technology and staffing a Green Education table to educate residents about C-PORT.

Green Education secured an in-kind donation from SoCal Gas to distribute free air purifiers to all festival attendees (Figure 41). Approximately 300 complementary purifiers were distributed during the

Figure 40: Photos from the Green Prize Festival

festival. Approximately 30 community-based organizations, City departments, green vendors and Green Prize Festival awardees participated in the day-long festival. Activities included educational demonstrations, green career opportunities, environmental health organizations, food trucks, live entertainment, and an awards celebration to recognize local environmental leaders across the city. Approximately 750 residents attended and considered it a very successful community event.

Figure 41: Air purifier sign from the event and an air purifier

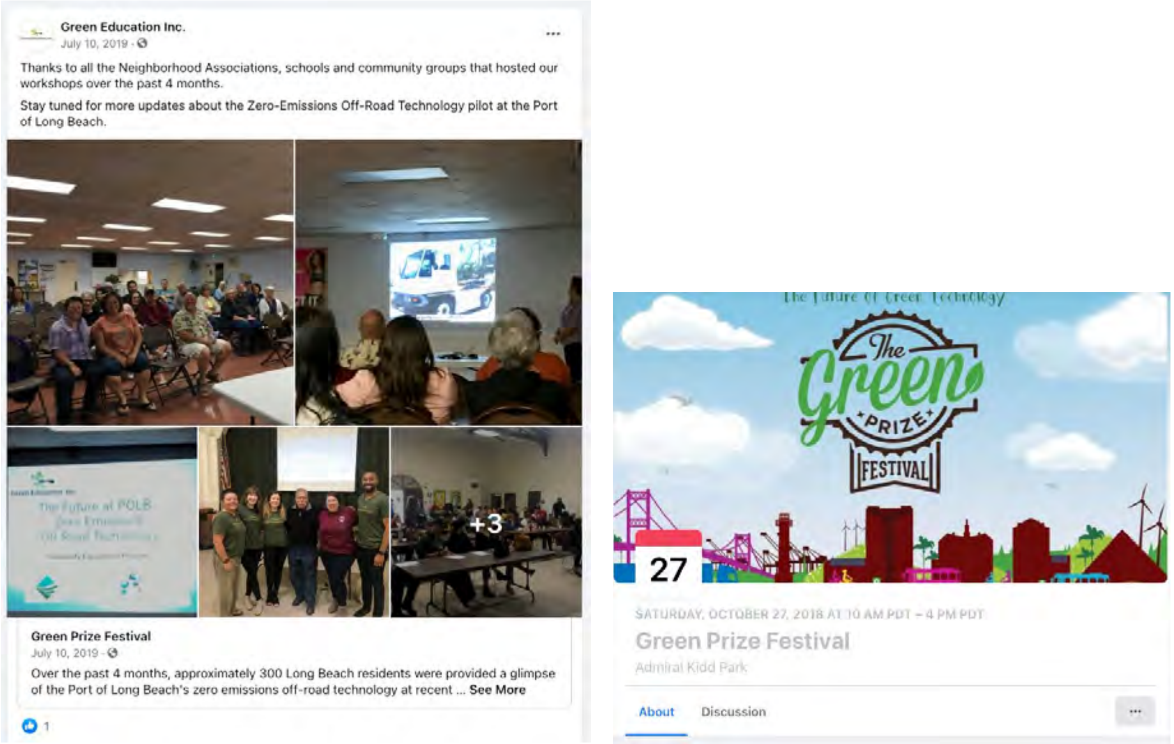
With support and subject matter expertise provided by the Port and ZE technology companies, Green Education designed educational outreach materials that provided residents and community organizations with an overview of C-PORT, as well as the ZE Off-Road Technologies being piloted at the Port. Green Education representatives presented the information during 10 citywide community workshops, with approximately 340 residents total in attendance. Workshops were conducted in disadvantaged communities located in Districts 1, 2, 6, 7, and 9 (Figure 42). Organizations/city officials that hosted the workshops included:

- District 1 Councilmember Lena Gonzalez
- District 2 Councilmember Jeannine Pearce
- Wilmore Neighborhood Association
- AOC7 Neighborhood Association
- Grant Neighborhood Association
- District 7 Councilmember Roberto Uranga
- Garfield Elementary School
- Hudson Elementary School
- West Long Beach Neighborhood Association

Figure 42: Workshop attendance

Green Education created and maintained a social media-based outreach campaign promoting ZE technologies. Social media posts were created before and after each workshop presentation to announce a series of workshops and to highlight participation at each event. The posts included customized fliers for each host to promote in its online newsletters, Facebook pages, and other social media posts (Figure 43 and Figure 44). Two e-mails went out to almost 5,000 POLB contacts, garnering 18% and 20% open rates.

Figure 43: The Green Prize Flier (left) and the Community Workshop Flier (right)



Green Education Inc.
July 10, 2019 ·

Thanks to all the Neighborhood Associations, schools and community groups that hosted our workshops over the past 4 months.

Stay tuned for more updates about the Zero-Emissions Off-Road Technology pilot at the Port of Long Beach.

Green Prize Festival
July 10, 2019 ·
Over the past 4 months, approximately 300 Long Beach residents were provided a glimpse of the Port of Long Beach's zero emissions off-road technology at recent ... **See More**

SATURDAY, OCTOBER 27, 2018 AT 10 AM PDT – 4 PM PDT
Green Prize Festival
Admiral Kidd Park

Figure 44: Sample posts for social media-based outreach

6.4 The Academy of Global Logistics

Since 2016, LBUSD and CITT at CSLB have operated an award-winning Port-sponsored academy at Cabrillo High School in West Long Beach, which is identified as a DAC. The Port is incredibly proud of its AGL program, and both the program and the C-PORT component concept could serve as a model for other industries and school courses. Statistics have shown that AGL has fostered increased enrollment, retention, GPA, and attendance. The AGL at Cabrillo High School is part of the Port's comprehensive education outreach programs that nurture future industry leaders and experts. Approximately 670 students so far have participated in the four-year Academy program, which combines academic curriculum with industry-relevant training to support educational and career development.

Through AGL, the Port created a senior student ZE Transformation Capstone Project for C-PORT. The project challenged AGL students to help solve a real-world problem: "How can one of the nation's largest ports transitions to ZE over the next decade while remaining a vital economic engine?"

The project was kicked off at Cabrillo High School on September 26, 2018. The 2018 AGL class had a total of 72 students, split across two classes. Six topics were presented every other week by an industry expert, including CARB staff. Issues identified and industry presentations included the following:

1) Air Quality and Climate Science: What health- and climate-related impacts are driving the need for transformation to a ZE port?

2) Technology Development: What does it take to develop the equipment necessary to handle port operations without emissions? What have been some of the major challenges and breakthroughs?
3) Commercialization: What are the barriers to commercializing ZE terminal equipment?
4) Infrastructure: What type of infrastructure is needed to support this new equipment?
5) Finance and Funding: What is the cost of this new equipment? How will the operators pay for it? How can the Port support these investments?
6) Workforce: What changes will be required in the workforce as we transition to ZE?
7) Communications and Outreach: How can the Port communicate the challenges and our successes to the community?

Figure 45: A picture of the winning student group as well as the awardee committee and AGL educators

The students participated in a field trip in March of 2019 to learn about real-world Port operations. The students then created a presentation about creative emerging technologies and ZE strategies for a committee, including LBUSD teachers, AGL administrators, and Port and CARB staff. The chosen lead student group (Figure 45) presented their findings in May of 2019, and each received a stipend of $2,500 for use in pursuing higher education.

The Port’s outreach and training efforts were recognized by the SCAQMD with a Clean Air Award in October of 2019. The Port received SCAQMD’s Clean Air Education Outreach Award for the learning program category. The Award is for ‘outstanding individual or group effort designed to educate the public on air quality issues, promote efforts to improve air quality, or both.’ The award was presented at the SCAQMD’s 31st annual Clean Air Awards luncheon in Los Angeles (Figure 46).

Figure 46: The LBUSD students that participated in the Capstone Project and Port staff at the Clean Air Awards luncheon.

7 Best Practices and Future Commercialization

7.1 Recommendations and Best Practices

The Port and the C-PORT partners successfully completed one of the most ambitious demonstration projects in California and marine Ports — by demonstrating first-of-their-kind ZE CHE. The Port gained valuable insight and the project resulted in several exciting best-practices and recommendations that, for some, have already been implemented in other demonstration projects. These best practices and recommendations include:

- Grant Execution: The Port has created processes and procedures around grant execution that specifically address unique timeline constraints and scope uncertainty inherent in multi-year projects that are developed over a six-to-ten-week application period. These best practices include:
    - Establish a clear chain of command so that communications, questions, and issues are addressed as soon as possible.
    - Execute legally binding agreements with project stakeholders who hold obligations, including partners who may not receive grant dollars but are instrumental to project success.
    - Anticipate extended design and commissioning processes than for conventional infrastructure projects.
    - Build additional contingency into the schedule for activities never before experienced, such as permitting.
    - Promote activities that highlight project successes and foster relationship building amongst project partners, including the granting agency and community.

- Project Design
    - Question and confirm all assumptions, as stakeholders are addressing new design considerations for the first time.
    - Engage regulatory and permitting agencies early.
    - Design demonstration projects to reduce upfront capital costs may negatively impact the demonstration phase (e.g., locating chargers near electrical capacity [reducing installation cost] may result in non-optimal charging locations [negatively impacting the demonstration]).
    - Establish unique specifications for each terminal, as duty cycles vary significantly between operations.
    - Memorialize all site requirements. This is particularly significant when collaborating with international vendors that may not have developed products that meet U.S. standards.

- Demonstration and Data Collection
    - Demonstration equipment that are similar to traditional units (e.g., navigational controls in the same location) so that the assessments are about the core performance of the technology itself.
    - Establish the root cause of performance challenges, particularly if the performance issues are created by failure of componentry or design aspects unrelated to the technology innovation.
    - Utilize data collection equipment and processes that allow for frequent checks and validation to limit the risk of data loss.
    - Establish constraints on data collection time periods that are inclusive of operational downtime — an important data point during a demonstration project.

- Budget
    - Memorialize cost responsibilities in contractual agreements, including for insurance and warranty packages.
    - Include budget for preparing hydrogen fueling infrastructure for operation, including permitting and costs to remove the nitrogen used during shipment and completing the initial fill of hydrogen.
    - Include contingency for infrastructure components.

7.2 Future Application & Commercialization

C-PORT provided an important first step in full commercialization of these, and other, ZE units for Taylor and Kalmar, as well as the technology providers. ZE off-road vehicles, mobile equipment, and CHE are rapidly developing markets, and knowledge gleaned from C-PORT will be applied to future products by Taylor and Kalmar. Information from C-PORT, including onboard energy or charging power level is required for certain applications, to design requirements and end-user preferences, are vital to produce quality, practical CHE that the industry will desire to purchase and operate for years to come. ZE products are currently offered, or expected to come, at a premium price; until technologies and products are truly commercialized, demonstrations such as C-PORT remain imperative to aid the marketplace in its path to ZE commercialization. Further, the capital cost of the equipment will need to come down in order to spur widespread adoption. ZE products available today are 2-3x more expensive than their diesel counterparts and the additional cost of supporting, electrical infrastructure remains a substantial barrier. Additional data collection on future, more advanced pilots is warranted to better understand the true cost of ownership. Demonstration projects, which by nature include quite a bit of down time for troubleshooting

> *Both terminals were pleased with the ZE equipment that at the conclusion of the project, will take ownership of the pre-commercial ZE yard tractor and top handlers.*

and repairs, are not necessarily the appropriate case studies for running total cost of ownership calculations.

The OEMs haven taken their experiences on C-PORT and applied them to product development. Taylor has reported that the next generation of ZE ZLC-996 series top handlers will be a commercialized unit which will feature technology directly evolved from the pre-commercial unit that were a part of C-PORT. Taylor is also manufacturing ZE forklifts that will parallel the systems introduced in the ZLC models. Both LBCT and SSA Marine are taking ownership of their Taylor demonstration units and supporting infrastructure at the completion of C-PORT.

Kalmar has reported that the information gleaned from C-PORT will be used to improve the next generation of ZE yard tractor products that are planned to go into production late 2022. LBCT is taking ownership of their Kalmar demonstration yard tractor and supporting infrastructure at the completion of C-PORT.

8 Conclusion

C-PORT represents a significant advancement of the Port community's experience in deploying ZE CHE. Being at the forefront of environmental stewardship and piloting the way for the industry, the Port appreciates that the road to the ZE transformation is not a simple one. C-PORT — the Port's first ZE CHE and infrastructure deployment — was no exception. After more than three years of dedicated and focused efforts (that included unprecedented delays and impacts due to the COVID-19 pandemic), the Port accomplished the goals and objectives of the project. Most importantly, all the participating project partners have meaningfully improved their understanding of the opportunities and challenges of the Port's ZE commitments as part of the CAAP:

- **OEMs and Technology Vendors** made significant advancements in the design, development, and commercialization of ZE CHE technologies. Although C-PORT demonstrated first-generation units, each OEM has built on the lessons learned in these demonstrations to advance its technology offerings by multiple generations.
- **Terminal Operators and Port Staff** gleaned important lessons, learning important design considerations for future ZE deployments including equipment and facility layout, technology expectations and standards, and infrastructure development timelines and costs. Each terminal operator has developed a better understanding of the specifications and performance characteristics needed for subsequent ZE procurement. SSA Marine has continued to work closely with technology vendors to invest in additional ZE equipment, building in lessons learned from this project. LBCT is keen to operate and explore these and subsequent CHE models. Across the Port, terminal operators have been continuing to demonstrate new ZE equipment, and the lessons learned about infrastructure deployment have helped streamline these processes and avoid or reduce the delays experienced during C-PORT.
- **The Surrounding Community** is encouraged to see the Port delivering on CAAP commitments, demonstrating ZE equipment that will make a true impact on air emissions. The Port remains committed to engaging with its community partners to communicate the monumental efforts and challenges that lie ahead, and the approach the Port is taking to continue working towards its 2030 and 2035 CAAP goals.

The Port is grateful for CARB's dedication and commitment to this project. CARB's investment in this project advanced the timeline for ZE CHE, and it is critical to terminal operators and the Port to make the transformation economically feasible. The Port also appreciates CARB's willingness to work together to address new and unexpected barriers and collaborate on creative solutions that made C-PORT a success.

C-PORT Final Report

Appendix A: Commissioning Report

Port of Long Beach
C-PORT: The Commercialization of POLB Off-Road Technology Demonstration Project

Grant Agreement Number: G16-DEMO-03

Infrastructure Commissioning Report

February 28, 2020

The Port of Long Beach is pleased to provide this Commissioning Report for the C-PORT: The Commercialization of POLB Off-Road Technology Demonstration Project. This report shall suffice for tasks 4.1.1 and 3.4. per our grant agreement.

Three BYD EVSE units, one TransPower EVSE unit, associated infrastructure and equipment are now operational and ready for revenue service.

This hereby concludes engineering projects 1478-3028 pier J ZE Phase 1 – Charging stations for top handlers and 1480-3032 pier E ZE Phase 1 – Charging stations for top handler and yard truck.

Sincerely,

Jacqueline M Moore

Jacqueline M. Moore
Environmental Planning-Air Quality

Fred Patricio

Fred Patricio
Program Management-Civil Engineering

Task 4.1.1 – Commissioning of Equipment and Fueling Infrastructure

For the Pier E Zero Emissions Phase1 Project, 1 BYD EVSE and 1 TransPower EVSE were officially commissioned by the City as of January 10, 2020.
The one Taylor top handler was placed into operation on February 3, 2020.
The one Kalmar yard truck was placed into operation on July 17, 2019.

For the Pier J Zero Emissions Phase1 Project, 2 BYD EVSE were officially commissioned by the City as of December 13, 2019.
The two Taylor top handlers were placed into operation on January 27, 2020.

POLB Engineering Tasks:

Task 1 – The City will perform site evaluations for each project locations.
Task 2 – The City will perform an engineering evaluation to determine what upgrades are required, as necessary.
Task 3 – The City will prepare scaled site design plans, specifications, estimate (PS&E) and a charging profile for each project location.
Task 4 – The City will implement quality control procedures and perform necessary quality control reviews and risk assessments at appropriate design review submissions.
Task 5 – The City and its contractor will obtain all necessary permits for the charging stations.
Task 6 – Technology providers will deliver four EVSE units.
Task 7 - A contractor appropriately licensed in the State of California shall construct appropriate supporting infrastructure and other work including trenching, running conduits, and other related miscellaneous work, as required.

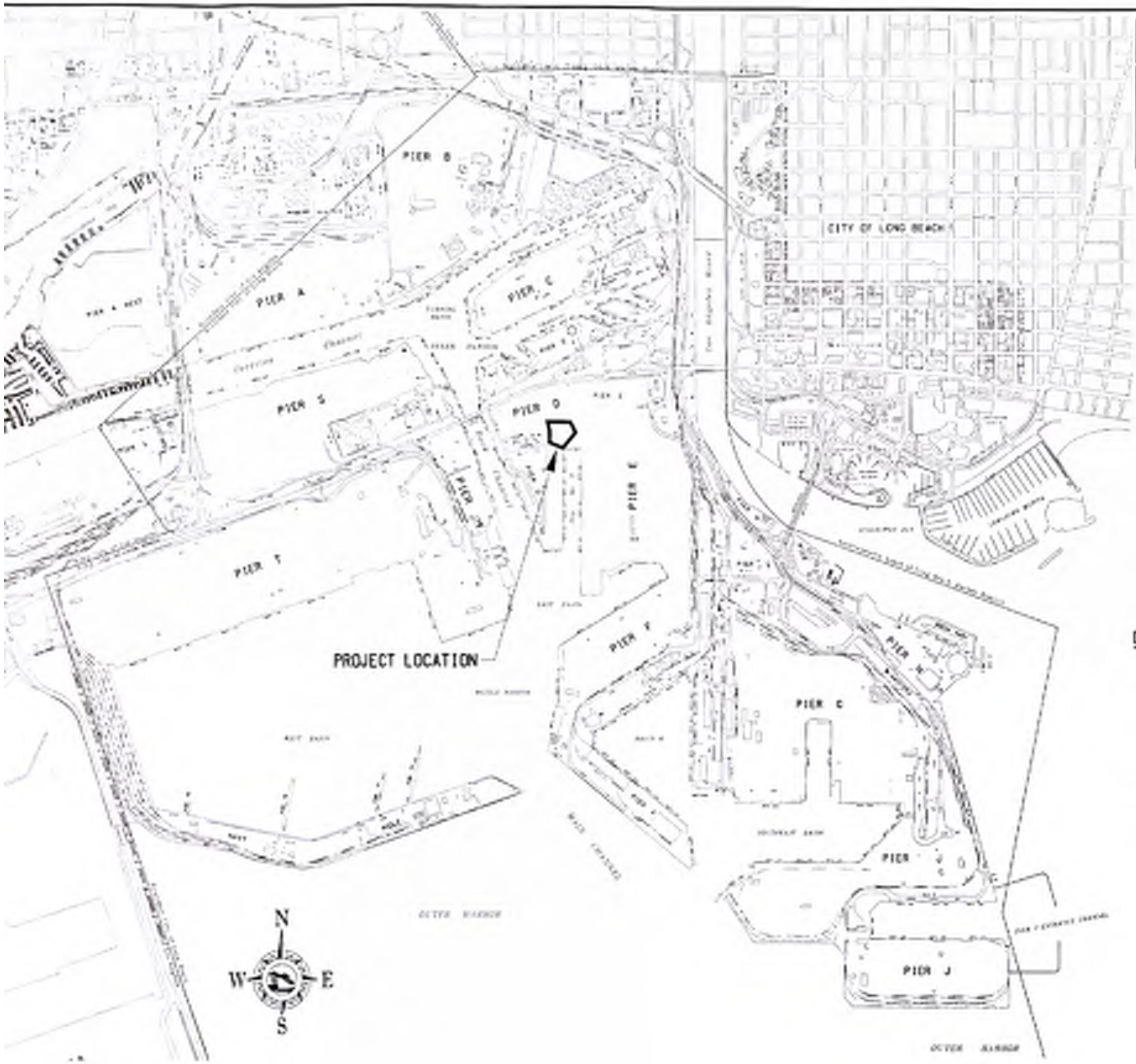
Task 9 –The City's contractor will install one BYD EVSE unit and one TransPower EVSE unit at LBCT and two BYD EVSE units at SSA.
Task 10 – The 4 EVSE units shall be UL certified, or comparable.
Task 11 – The technology provider, OEM, City, contractors and/or staff will commission the EVSE and close out the engineering project.

Task 3.4 POLB engineering and electric charger vendor will provide all necessary documentation

Attachments as listed below fulfill this requirement of commissioned EVSE.

1)	Pier E permits Electrical: BELE220717	pg. 6
2)	Pier J permits Electrical: BELE220716	pg. 17
3)	Pier J HDP	pg. 22
4)	Pier E HPD	pg. 25
5)	Pier J Final Layout	pg. 28
6)	Pier E Final Layout	pg. 30
7)	Pier J City Inspector Form	pg.32
8)	Pier E City Inspector Form	pg. 33
9)	Pier J EVSE City Commissioning Letter	pg. 35
10)	Pier E EVSE City Commissioning Letter	pg. 36
11)	Pier J TUV Report	pg. 37
12)	Pier J TUV Sticker	pg. 88
13)	Pier E TUV Report	pg. 89
14)	Pier E TUV Sticker	pg. 135
15)	Pier E UL Report	pg. 136
16)	Pier E UL Sticker	pg. 149
17)	Pier E TransPower Validation Testing	pg. 150
18)	Pier E/J BYD validation Testing	pg. 152
19)	Pier E BYD EVSE photo	pg. 154
20)	Pier E TransPower EVSE photos	pg. 155

20) Pier J Final BYD EVSE Photos pg. 159
21) Pier J/ Pier E BYD User Manual pg. 161
22) Pier E TransPower User Manual pg. 207
23) Pier E TransPower Spec Sheet pg. 259
24) Pier E Kalmar Letter of Commencement pg. 260
25) Pier E Taylor Letter of Commencement pg. 261
26) Pier J Taylor Letter of Commencement pg. 262



CONTRACTOR TO CONTACT UNDERGROUND SERVICE ALERT AT 811 TWO WORKING DAYS PRIOR TO EXCAVATION.

SCOPE OF WORK

PROJECT INCLUDES INSTALLATION OF CHARGING STATIONS FOR ELECTRIC YARD HOSTLERS AND TOP PICKS. THIS INCLUDES ALL EQUIPMENT REQUIRED TO SUPPLY POWER TO THE CHARGING STATIONS AND THE CONCRETE PADS FOR THE CHARGING STATIONS.

CODES AND STANDARDS

CALIFORNIA BUILDING CODE (CBC) - 2016
CALIFORNIA MECHANICAL CODE (CMC) - 2016
CALIFORNIA ELECTRICAL CODE (CEC) - 2016
CALIFORNIA PLUMBING CODE (CPC) - 2016
CALIFORNIA FIRE CODE (CFC) - 2016
CALIFORNIA ENERGY CODE - 2016

NFPA 72 - 2016

SHEET INDEX

DRAWING NUMBER	SHEET. NO.	SHEET TITLE
10-02314-EL001	001	PROJECT LOCATION, SHEET INDEX, AND NOTES
10-02314-EL002	002	GENERAL NOTES
10-02314-EL003	003	LEGEND AND ABBREVIATIONS
10-02314-EL004	004	SINGLE LINE DIAGRAM
10-02314-EL005	005	EQUIPMENT ELEVATIONS
10-02314-EL006	006	AREA PLAN
10-02314-EL007	007	ENLARGED AREA PLAN
10-02314-EL008	008	DETAILS
10-02314-EL009	009	FIRE ACCESS PLAN

REFERENCE DRAWING LIST

DWG. SET NO.	TITLE	YEAR
HD 10-1891	PIERS D, E, & F BERTHS D28-D31, E11-E27, F1-F6	2010
HD 10-02049	PIER E TERMINAL CONTAINER YARD/INTERMODAL RAILROAD PHASE 1.	2012
HD 10-02068	PIER E MIDDLE HARBOR TERMINAL MARINE OPS BLDG & POWER SHOP	2013-

PROJECT DATUM

HORIZONTAL DATUM:

NORTH AMERICAN DATUM 1983 (NAD83) COORDINATES, CALIFORNIA COORDINATE SYSTEM ZONE 5 EPOCH 2007

VERTICAL DATUM:

CBM GPS 5320, ELEVATION=20.52 MLLW MAY 1990, FOUND 1" BRASS DISK STAMPED "5320" SOUTHEAST CORNER OF PIER E STREET AND PICO AVE ON NORTHEAST CORNER OF CATCH BASIN.

City of Long Beach

APPROVED

BY: DATE: 7/15/18

PERMIT NO: BELE 220717

P2S Inc.

Port of LONG BEACH

SPEC. NO.: HD-53032
CADD STD. VER: 1.5
DWG. SCALE: NONE
EPOCH: 2007
PROJECT MGR.: KS
CONSTRUCTION REV:
CHECKED BY: MC
DRAWN BY: JV
DESIGNED BY: BI
DESIGN MGR.: KS
DATE:
DATE: 07/31/2018
DATE: 07/31/2018
POLB DM: BS
POLB PM: TP
HORIZONTAL CONTROL: NAD83 ZONE 5 / VERTICAL CONTROL: NGVD 29 MLLW

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
PROJECT LOCATION, SHEET INDEX, AND NOTES

10-02314-EL001
SHEET 001 OF 009

BELE 220717

BELE 220717

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VERSION 5

4-EL003	003	LEGEND AND ABBREVIATIONS
4-EL004	004	SINGLE LINE DIAGRAM
4-EL005	005	EQUIPMENT ELEVATIONS
4-EL006	006	AREA PLAN
4-EL007	007	ENLARGED AREA PLAN
4-EL008	008	DETAILS
4-EL009	009	FIRE ACCESS PLAN

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REFERENCE DRAWING LIST

TITLE	YEAR
PIERS D, E, & F BERTHS D28-D31, E11-E27, F1-F6	2010
PIER E TERMINAL CONTAINER YARD/INTERMODAL RAILROAD PHASE 1.	2012
PIER E MIDDLE HARBOR TERMINAL MARINE OPS BLDG & POWER SHOP	2013

PROJECT DATUM

DATUM:

CAN DATUM 1983 (NAD83)
, CALIFORNIA COORDINATE
E 5 EPOCH 2007

VERTICAL DATUM:

CBM GPS 5320, ELEVATION=10.52 MLLW
MAY 1990, FOUND 1" BRASS DISK STAMPED
"5320" SOUTHEAST CORNER OF PIER E
STREET AND PICO AVE ON NORTHEAST
CORNER OF CATCH BASIN.

City of Long Beach
Building and Safety Bureau
Electrical Plan Check

APPROVED

This set of plans MUST be at the job site during construction. It is unlawful to alter, change, or deviate from these plans, without approval from the Building and Safety Bureau. The stamping of this plan SHALL NOT be held to permit or to be an approval of the violation of any provisions of Ordinance or Law.

BY: H.A.
DATE: 7/25/18
PERMIT NO.: BELE 220717

JOHN T. CHUN, P.E., NO. C-59867
DIRECTOR OF ENGINEERING DESIGN
DATE

Port of
LONG BEACH
The Green Port

SPEC. NO: HD-S3032
CADD STD. VER: 1.5
DWG. SCALE: NONE
EPOCH: 2007
PROJECT MGR.: KS
CONSTRUCTION REV:
CHECKED BY: MC
DRAWN BY: JV
DESIGNED BY: DI
DESIGN MGR.: KS
DATE:
DATE: 07/03/2018
DATE: 07/03/2018
POLB BM: RG
POLB PM: FP
HORIZONTAL CONTROL: NAD83 ZONE 5 VERTICAL CONTROL: NGVD 29 MLLW

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
PROJECT LOCATION, SHEET INDEX, AND NOTES

BELE 220717

10-02314-EL001
SHEET 001 OF 009

BELE 220717

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VERSION 1

7

GENERAL NOTES

1. FURNISH AND INSTALL ALL CONDUITS, WIRES, BOXES, SWITCHES, RECEPTACLES, DEVICES, PANELBOARDS, AND OTHER EQUIPMENT SHOWN ON THE DRAWINGS AND/OR AS REQUIRED FOR A COMPLETE AND OPERATIONAL ELECTRICAL SYSTEM.

2. THE CONTRACTOR'S BID AND ALL WORK SHALL COMPLY WITH THE 2016 EDITION OF THE CALIFORNIA ELECTRICAL CODE AND ALL OTHER APPLICABLE FEDERAL, STATE, AND LOCAL CODES. WHERE THE PLANS SHOW MORE RESTRICTIVE REQUIREMENTS, THE PLANS SHALL GOVERN. HOWEVER, NOTHING ON THESE PLANS SHALL BE INTERPRETED AS AUTHORITY TO VIOLATE ANY CODE OR REGULATION. WHEN REFERENCES ARE MADE TO SPECIFIC CODE SECTIONS, STANDARDS, GUIDES, AND OTHER SIMILAR REFERENCES, THEY ARE INTENDED TO ADD EMPHASIS TO THE REQUIREMENTS OF THAT PARTICULAR REFERENCE AND ARE NOT INTENDED IN ANY WAY TO RELIEVE THE CONTRACTOR OF THE REMAINING REFERENCES.

3. THE CONTRACTOR SHALL OBTAIN AND PAY FOR ALL REQUIRED PERMITS AND ALL FEES, UNLESS OTHERWISE NOTED.

4. THE ELECTRICAL DRAWINGS DO NOT SHOW ALL OFFSETS, BENDS, FITTINGS, JUNCTION BOXES, PULL BOXES, AND EXPANSION FITTINGS REQUIRED TO MEET FIELD CONDITIONS. DETERMINE ACTUAL MATERIAL AND HARDWARE REQUIREMENTS AND VERIFY ALL DIMENSIONS, EXISTING EQUIPMENT, AND STRUCTURAL MEMBER LOCATIONS BY FIELD INSPECTION.

5. SUBMIT SHOP DRAWINGS, CALCULATIONS, AND CATALOG CUTS FOR ALL SWITCHBOARDS, PANELBOARDS, MANHOLES, PULLBOXES, TRANSFORMERS, IN ACCORDANCE WITH THE SPECIFICATIONS.

6. PROVIDE A SET OF AS-BUILT DRAWINGS SHOWING THE LOCATIONS OF ALL UNDERGROUND CONDUITS AND INDICATING ALL CHANGES MADE DURING CONSTRUCTION AND ANY DEVIATIONS FROM THE ELECTRICAL DRAWINGS, IN ACCORDANCE WITH THE SPECIFICATIONS. ALL UNDERGROUND DUCTBANKS SHALL BE SURVEYED PRIOR TO BACKFILLING.

7. UNLESS OTHERWISE NOTED, ALL DEVICES AND EQUIPMENT INSTALLED EXPOSED TO WEATHER OR IN DAMP LOCATIONS SHALL BE WEATHERPROOF WITH MARINE GRADE, CORROSION RESISTANT FINISH.

8. EXPOSED CONDUIT SHALL BE RIGID GALVANIZED STEEL IN DAMP LOCATIONS OR WHERE SUBJECT TO PHYSICAL ABUSE. UNDERGROUND CONDUIT SHALL BE CONCRETE ENCASED PVC SCHEDULE 40 WITH PVC COATED RIGID GALVANIZED STEEL CONDUIT ELBOWS AND RISERS TO GRADE IN EXPOSED AREAS. UNDERGROUND DUCT BANKS SHALL BE INSTALLED IN ACCORDANCE WITH DRAWINGS AND SPECIFICATIONS.

9. CONNECTIONS TO DEVICES SUBJECT TO VIBRATION, SUCH AS MOTORS, TRANSFORMERS, AND SENSORS, SHALL BE SHORT LENGTHS (6" MAX) OF LIQUIDTIGHT FLEXIBLE STEEL CONDUIT, TERMINATED WITH APPROVED LIQUIDTIGHT METAL FITTINGS AND PROVIDED WITH A SEPARATE GROUND CONDUCTOR INSTALLED WITH THE PHASE CONDUCTORS.

10. PROVIDE LAMINATED TYPEWRITTEN DIRECTORY CARD IN EACH PANEL. IDENTIFY LOAD SERVED BY EACH CIRCUIT BREAKER. PROVIDE LAMINATED PLASTIC NAMEPLATES TO IDENTIFY ALL LOADS SERVED BY SWITCHGEAR AND DISTRIBUTION PANELS. IN ADDITION TO CODE REQUIRED NAMEPLATES, CONTRACTOR SHALL PROVIDE PORT OF LONG BEACH IDENTIFYING NAMEPLATE INFORMATION, WHICH IS PRINTED ON AN APPROPRIATE SURFACE, AND SHALL INSTALL INSIDE THE SWITCHBOARD/PANELBOARD WITH THE FOLLOWING INFORMATION:

    PORT OF LONG BEACH
    PANEL xxxxx (NAME OF PANELBOARD)
    HD-S3032
    HD 10-02314
    CONTACT MANUFACTURER: (NAME OF PERSON MOST FAMILIAR BY MANUFACTURER, AND TELEPHONE NUMBER)
    DATE: XX/XX/XX (CONTRACTOR'S NOTICE TO PROCEED DATE)

11. MAKE POWER CONNECTIONS TO EQUIPMENT FURNISHED BY OTHERS. PROVIDE SUPPORT FOR ALL ELECTRICAL EQUIPMENT TO COMPLY WITH THE SEISMIC REQUIREMENTS OF THE CALIFORNIA BUILDING CODE 2016 SEC. 1708A.5 AND ALL LOCAL ORDINANCES.

12. INSTALL ALL CONDUITS AND WIRES WITH A MINIMUM NUMBER OF BENDS AND IN SUCH A MANNER AS TO CONFORM TO THE STRUCTURE, AVOID OBSTRUCTIONS, PRESERVE HEAD ROOM, AND KEEP OPENINGS AND PASSAGEWAYS CLEAR, AND MEET ALL STRUCTURAL CODE REQUIREMENTS.

13. DO NOT BORE, NOTCH, OR IN ANY WAY CUT INTO ANY STRUCTURAL MEMBER WITHOUT WRITTEN APPROVAL FROM THE ENGINEER.

14. IF EQUIPMENT SUBSTITUTIONS ARE MADE BY THE CONTRACTOR, THE CONTRACTOR SHALL BE RESPONSIBLE FOR HAVING A CONCRETE PAD DESIGNED FOR THAT EQUIPMENT BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF CALIFORNIA.

15. CONTRACTOR SHALL CONTACT DIG ALERT TWO FULL WORKING DAYS IN ADVANCE PRIOR TO ANY EXCAVATION. DIG ALERT: 811.

16. TRANSPORTATION WORKERS IDENTIFICATION CREDENTIAL (TWIC) CARDS WILL BE REQUIRED FOR ALL PERSONNEL ENTERING THE FACILITY.

17. FINAL CONDUIT STUB-UP LOCATIONS SHALL BE VERIFIED PRIOR TO ROUGH-IN AGAINST EQUIPMENT MANUFACTURER'S DIMENSIONS AND RECOMMENDED LOCATIONS.

18. ALL ELECTRICAL EQUIPMENT SHALL BE LISTED BY TESTING AGENCY RECOGNIZED BY THE CITY OF LONG BEACH. CONTRACTOR IS RESPONSIBLE FOR ANY THIRD PARTY FIELD LISTINGS NECESSARY TO OBTAIN CITY APPROVAL.

CITY OF LONG BEACH GENERAL NOTES

1. ALL WORK TO COMPLY WITH THE 2016 CALIFORNIA ELECTRICAL CODE AND 2016 CALIFORNIA ENERGY CODE.

2. MARKING - UNGROUNDED SYSTEMS SHALL BE LEGIBLY MARKED "UNGROUNDED SYSTEM" AT THE SOURCE OR FIRST DISCONNECTING MEANS OF THE SYSTEM. THE MARKING SHALL BE OF SUFFICIENT DURABILITY TO WITHSTAND THE ENVIRONMENT INVOLVED.

3. PROVIDE SWITCH AND RECEPTACLE HEIGHTS PER STATE OF CALIFORNIA ACCESSIBLE REQUIREMENTS.

4. THE ISSUANCE OF A PERMIT SHALL NOT PREVENT THE BUILDING OFFICAL FROM REQUIRING THE CORRECTION OF ERRORS ON THESE PLANS OR FROM PREVENTING ANY VIOLATION OF THE CODES ADOPTED BY THE CITY, RELEVANT LAWS, ORDINANCES, RULES AND/OR REGULATIONS.

5. FOR FIRE RATED WALL/CEILING PENETRATION AND/OR MEMBRANE PENETRATION, COMPLETE NRTL CLASSIFICATION SHEETS SHALL BE PROVIDED TO THE INSPECTOR AT THE TIME OF INSPECTION.

6. GIVE SOUTHERN CALIFORNIA EDISON (SCE) WRITTEN NOTICE OF THE EXTENT AND NATURE OF ANY MATERIAL CHANGE IN THE SIZE, CHARACTER, OR EXTENT OF THE UTILIZING EQUIPMENT OR OPERATIONS FOR WHICH SCE IS SUPPLYING ELECTRIC SERVICE BEFORE MAKING ANY SUCH CHANGE.

7. EACH MULTIWIRE BRANCH CIRCUIT SHALL BE PROVIDE WITH A MEANS THAT WILL SIMULTANEOUSLY DISCONNECT ALL UNGROUNDED CONDUCTORS AT THE POINT WHERE THE BRANCH CIRCUIT ORIGINATES.

8. MULTIWIRE BRANCH CIRCUITS SUPPLYING POWER TO THE PARTITION SHALL BE PROVIDED WITH A MEANS TO DISCONNECT SIMULTANEOUSLY ALL UNGROUNDED CONDUCTORS AT THE PANELBOARD WHERE THE BRANCH CIRCUIT ORIGINATES.

9. PROVIDE SEPERATE SUBMITTAL, OBTAIN ALL REQUIRED PERMITS, INSPECTIONS AND APPROVALS FOR ALL FIRE ALARM SYSTEM INSTALLATIONS AND/OR MODIFICATIONS FROM THE LBFD AND LBDS DEPARTMENTS.

10. ALL INSTALLED MATERIALS AND EQUIPMENT SHALL BE LISTED U.L., NTRL OR LISTED AND APPROVED BY A CITY OF LONG BEACH APPROVED TESTING LABORATORY.

11. ALL NEW OVERCURRENT DEVICES INSTALLED IN EXISTING PANELS/SWITCHBOARDS SHALL MATCH THE MAKE, MODEL AND INTERRUPTING CAPACITY OF THE EXISTING OVERCURRENT DEVICES.

12. RACEWAY SEALS, CONDUITS OR RACEWAYS THROUGH WHICH MOISTURE MAY CONTACT LIVE PARTS SHALL BE SEALED OR PLUGGED AT BOTH ENDS.

13. ALL 15-20 AMP 120 VOLT, SINGLE PHASE RECEPTACLES WITHIN KITCHEN AND FOOD PREPARATION) AREAS TO BE GFCI PER CEC 210.8.

14. ALL LIGHT FIXTURES WITHIN KITCHEN AND FOOD PREPARATION AREAS TO BE SHATTER PROOF.

15. REFRIGERANT DETECTION - DECTION AND ALARM SYSTEMS SHALL BE POWERED AND SUPERVISED AS REQUIRED FOR FIRE ALARM SYSTEMS IN THE FIRE CODE.

16. PROVIDE LOCAL DISCONNECTS FOR ALL HARDWIRED EQUIPMENT THAT IS NOT "WITHIN SIGHT" OF THE SOURCE PANEL.

17. MULTIPLE RACEWAYS CONTAINING MORE THAN 3 CURRENT CARRYING CONDUCTORS SHALL COMPLY WITH [2016 CEC, 310.15(B)(2)(A)].

18. THE IDENTIFICATION OF EVERY CIRCUIT OF A PANEL BOARD AND SWITCHBOARD SHALL BE LEGIBLY IDENTIFIED AS TO ITS CLEAR, EVIDENT, AND SPECIFIC PURPOSE OR USE AND SHALL INCLUDE SUFFICIENT DETAIL TO ALLOW EACH CIRCUIT TO BE DISTINGUISHED FROM ALL OTHERS. 2013 CEC 408.4) PROVIDE MORE DETAIL ON PANEL SCHEDULE CIRCUIT DESCRIPTIONS.

19. A SINGLE RECEPTACLE INSTALLED ON AN INDIVIDUAL BRANCH CIRCUIT SHALL HAVE AN AMPERE RATING OF NOT LESS THAN THAT OF THE BRANCH CIRCUIT. INDICATE THE RECEPTACLE RATING.

20. PROVIDE RECEPTACLE OUTLETS WHEREVER CORD CONNECTED EQUIPMENT WILL BE USED.

21. WHERE DISCONNECTS ARE NOT PROVIDED WITHIN SIGHT FROM THE EQUIPMENT IT SUPPLIES, THE SWITCH OR CIRCUIT BREAKER MUST INCLUDE PROVISIONS FOR ADDING A LOCK, AND THESE PROVISIONS MUST REMAIN WITH THE EQUIPMENT. THESE LOCKING PROVISIONS HAVE TO BE PART OF THE EQUIPMENT, EITHER INHERENT TO THE EQUIPMENT DESIGN OR AN ACCESSORY FEATURE THAT CAN BE INSTALLED ON THE EQUIPMENT. [410.141(B), 422.31(B), 424.19, 440.14 EXCEPTION NO. 1, 600.6(A)(2)(3), 620.51(A) EXCEPTION NO. 1, 620.53, 620.55]

22. STANDARD NONLOCKING STRAIGHT-BLADE RECEPTACLES IN 120 AND 250 VOLT CONFIGURATIONS AT WET/DAMP LOCATIONS ARE REQUIRED TO BE LISTED WEATHER-RESISTANT TYPE.

23. FUSE HOLDERS SHALL BE DESIGNED SO THAT IT WILL BE DIFFICULT TO PUT A FUSE OF ANY GIVEN CLASS INTO A FUSE HOLDER THAT IS DESIGNED FOR A CURRENT LOWER, OR VOLTAGE HIGHER, THAN THAT OF THE CLASS TO WHICH THE FUSE BELONGS. FUSE HOLDERS FOR CURRENT LIMITING FUSES SHALL NOT PERMIT INSERTION OF FUSES THAT ARE NOT CURRENT LIMITING.

TYPICAL ARC FLASH LABEL

Arc Flash Information

Use this information in accordance with applicable OSHA standards, NFPA 70E-2015 and other required safe electrical work practices.

1.71 cal/cm²	Incident Energy at a Working Distance of 1 ft 6 in.
1 ft 10 in.	Arc Flash Boundary
208V	Shock hazard when cover is open
3 ft 6 in.	Limited Approach
1 ft 0 in.	Restricted Approach
Eqpt Name:	Date

APPROVED

BY: Hh DATE: 7/25

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
GENERAL NOTES

10-02314-EL002
SHEET 002 OF 009

ELECTRICAL ABBREVIATIONS

A	AMPERE, AMMETER
AF	AMPERE FRAME
AFC	AVAILABLE FAULT CURRENT
AFS	ABOVE FINISHED SURFACE
AGV	AUTOMATED GUIDED VEHICLE
ASC	AUTOMATED STACKING CRANE
AT	AMPERE TRIP
ATC	AIR TERMINAL CHAMBER
ATS	AUTOMATIC TRANSFER SWITCH
AUX	AUXILIARY
CB	CIRCUIT BREAKER
CEC	CALIFORNIA ELECTRICAL CODE
CKT	CIRCUIT
CM	CIRCUIT MONITOR
CO	CONDUIT ONLY
CPT	CONTROL POWER TRANSFORMER
CR	CONTROL RELAY
CU	COPPER
DB	DUCTBANK
DIA	DIAMETER
DN	DOWN
DPSW	DIFFERENTIAL PRESSURE SWITCH
DWG	DRAWING
(E)	EXISTING
EGW	ETHERNET GATEWAY
ELEC	ELECTRICAL
ELEV	ELEVATION
EMT	ELECTRICAL METALLIC TUBING
ERT	ETHERNET RADIO TRANSMITTER
FDR	FEEDER
F.O.	FIBER OPTIC
G,GND,GRD	GROUND
GA	GAUGE
GFCI	GROUND FAULT CIRCUIT INTERRUPTER
GFP	GROUND FAULT PROTECTION
HMI	HUMAN MACHINE INTERFACE
IC	INTERRUPTING CAPACITY
J,JB	JUNCTION BOX
KVA	KILOVOLT-AMPERE(S)
KWH	KILOWATT-HOUR
KW	KILOWATT(S)
L.C.	LOCK CLOSED
LFMC	LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT
LLI	LIVE LINE INDICATOR
L.O.	LOCK OPEN
LP	LIGHTING POLE
LV	LOW VOLTAGE
MCB	MAIN CIRCUIT BREAKER
MDB	MAIN DISTRIBUTION BOARD
MFR	MULTI-FUNCTION RELAY
MIN	MINIMUM
MOS	METHOD OF SERVICE
MPZ	MINI-POWER ZONE
MRCT	MULTI-RATIO CURRENT TRANSFORMER
MV	MEDIUM VOLTAGE
MVA	MEGAVOLT-AMPERE(S)
(N)	NEW
NC	NORMALLY CLOSED
NEUT	NEUTRAL
NGR	NEUTRAL GROUNDING RESISTOR
NIC	NOT IN CONTRACT
NO	NORMALLY OPEN
NRTL	NATIONALLY RECOGNIZED TESTING LABORATORY
O.C.	ON CENTER
OD	OUTSIDE DIAMETER
OH	OPPOSITE HAND
OIT	OPERATOR INTERFACE TERMINAL
P,PNL	PANEL
PB	PULLBOX
PC	PHOTOCELL
PH,Ø	PHASE
PLC	PROGRAMMABLE LOGIC CONTROLLER
PM	POWER MONITOR
POC	POINT OF CONNECTION
POLB	PORT OF LONG BEACH
PVC	POLYVINYL CHLORIDE
PT	POTENTIAL TRANSFORMER
PTW	POWER, TELEPHONE, AND WATER
RECEPT	RECEPTACLE
RGS	RIGID GALVANIZED STEEL
R.O.	REEFER OUTLET
RS	RECEPTACLE STATION
SA	SURGE ARRESTER
SCE	SOUTHERN CALIFORNIA EDISON
S.K.	SUPERVISORY KEY
SPO	SHORE POWER OUTLET
SUB	SUBSTATION
SW	SWITCH

ELECTRICAL ABBREVIATIONS (CONT.)

SWBD	SWITCHBOARD
SWGR	SWITCHGEAR
SYM	SYMMETRICAL
T	TRIP
TB	TERMINAL BLOCK
TC	TIME CLOCK
[illegible]	[illegible] OPERATION COMPANY
TVSS	TRANSIENT VOLTAGE SURGE SUPPRESSOR
TYP	TYPICAL
UG	UNDERGROUND
UGPS	UNDERGROUND PULL SECTION
UGS	UNDERGROUND STRUCTURE
U.O.N.	UNLESS OTHERWISE NOTED
V	VOLTMETER, VOLT
VD	VOLTAGE DROP
VT	VOLTAGE TRANSFORMER
WP	WEATHERPROOF
W/	WITH
W/O	WITHOUT
XFMR	TRANSFORMER
XMTR	TRANSMITTER

CONDUIT AND RACEWAY

ABOVE GROUND RACEWAY - POWER (BELOW 600V)

EXISTING DUCTBANK - ELECTRICAL (BELOW 600V)

TREADPLATE HOSE RAMP

REFERENCE SYMBOLS

NUMBER OF DETAIL REFERENCED CONSECUTIVELY ON EACH SHEET.

EX - DRAWING NUMBER WHERE DETAIL ORIGINATED.

EY - DRAWING NUMBER WHERE DETAIL IS DRAWN.

LETTER OF SECTION REFERENCED CONSECUTIVELY ON EACH SHEET.

EX - DRAWING NUMBER WHERE SECTION ORIGINATED.

EY - DRAWING NUMBER WHERE SECTION IS DRAWN.

ONE-LINE DIAGRAM

GROUNDING ELECTRODE

TRANSFORMER, CONFIGURATIONS PRIMARY 3Ø Δ, SECONDARY 4W

40A — CIRCUIT BREAKER, TRIP SHOWN, 3 POLE UNLESS OTHERWISE NOTED, CURRENT RATING INDICATED

40A — SWITCH, CURRENT RATING INDICATED, 3 POLE UNLESS OTHERWISE NOTED.

P1 — PANELBOARD - P1 INDICATES DESIGNATION

APPROVED

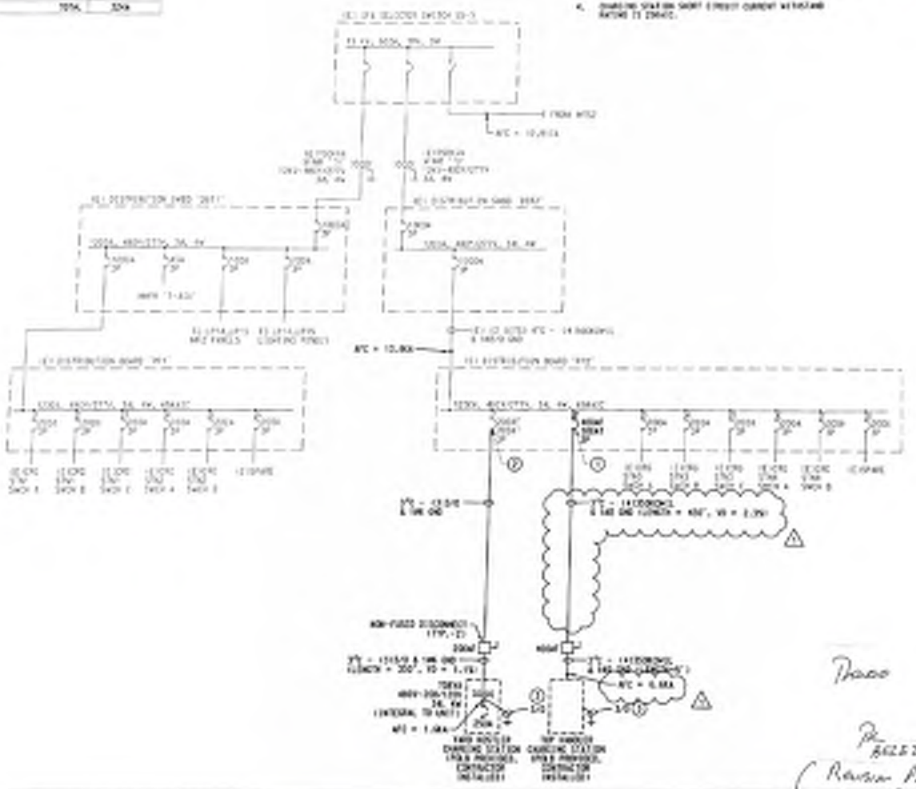
Port of LONG BEACH

PIER C TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
LEGEND AND ABBREVIATIONS

10-02314-EL003
SHEET 003 OF 009

DISTRIBUTION BOARD 'PP2' LOAD SCHEDULE

CIRCUIT	DESCRIPTION	LOAD
1	YARD HOSTLER CHARGING STATION	[illegible]
2	TOP HANDLER CHARGING STATION	[illegible]
3	EXISTING LOAD	[illegible]
	TOTAL	[illegible]



GENERAL NOTES:

1. NEW WORK IS SHOWN BOLD, ALL OTHER EQUIPMENT IS EXISTING TO REMAIN AND SHALL BE PROTECTED IN PLACE, U.O.N.
2. CONDUCTOR LENGTHS ARE SHOWN FOR VOLTAGE DROP PURPOSES ONLY.
3. [illegible] CONDUCTORS SHALL BE 90 DEG C RATED AND STRANDED COPPER. INSULATION FOR CONDUCTORS 250KCMIL AND LARGER SHALL BE XHHW, OTHERWISE INSULATION SHALL BE THHN.
4. CHARGING STATION SHORT CIRCUIT CURRENT WITHSTAND RATING IS 25KAIC.

CONSTRUCTION NOTES:

① INSTALL (N) CIRCUIT BREAKER IN (E) SQUARE D I-LINE SWITCHBOARD. BREAKER SHALL BE SQUARE D [illegible] AND HAVE PROVISIONS FOR BEING LOCKED OPEN. MATCH EXISTING BREAKER AIC RATING.

② TERMINATE (N) CONDUCTORS ON (E) CIRCUIT BREAKER.

③ CONNECT TO EQUIPMENT PAD UFER GROUND

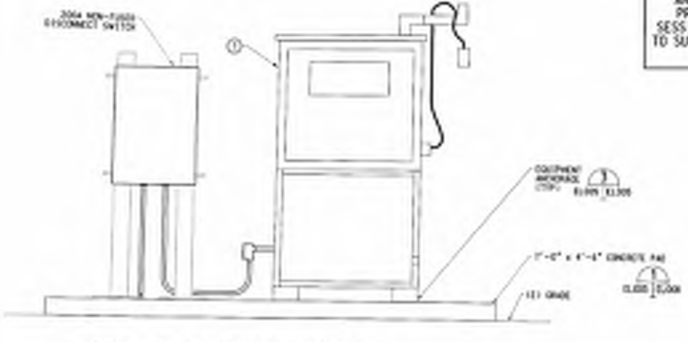
Revision Plan

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
SINGLE LINE DIAGRAM

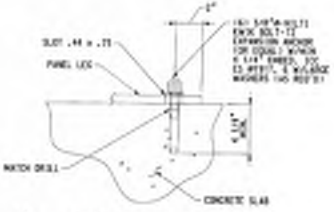
10-02314-EL004
SHEET 004 OF 009

VERSION 1

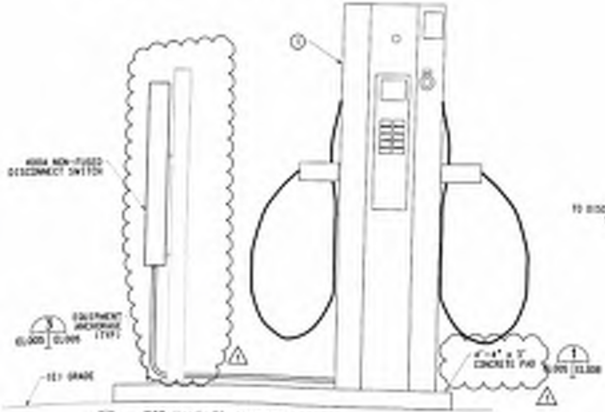
THE CONTRACTOR IS REQUIRED TO PARTICIPATE IN THE COMMISSIONING PROCESS TO CONFIRM THE ELECTRIC YARD HOSTLER AND TOP HANDLER TERMINAL EQUIPMENT CAN BE SUCCESSFULLY CHARGED ONCE ALL ELECTRICAL INFRASTRUCTURE IMPROVEMENTS HAVE BEEN COMPLETED AND ACCEPTED BY THE ENGINEER. THE COMMISSIONING PROCESS WILL BE CONDUCTED IN TWO (2) FOUR-HOUR SESSIONS WITH THE CONTRACTOR PRESENT AND RESPONSIBLE TO SUPPORT ALL ELECTRICAL INFRASTRUCTURE IMPROVEMENTS CONSTRUCTED AS PART OF THIS CONTRACT.



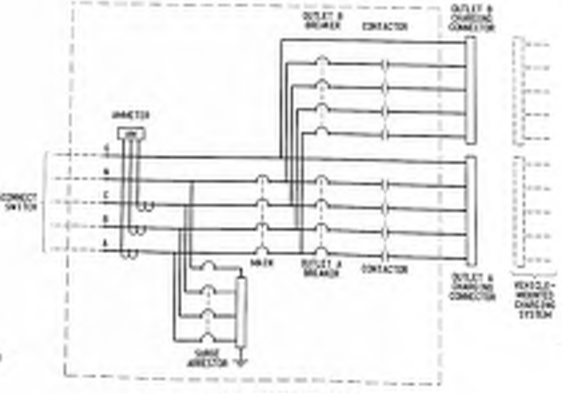
1 EL007 EL006 YARD HOSTLER CHARGING STATION
SCALE: NONE



3 EL006 EL005 EQUIPMENT ANCHORAGE DETAIL
SCALE: NTS



2 EL007 EL006 TOP HANDLER CHARGING STATION
SCALE: NONE



(FOR REFERENCE ONLY)

4 EL006 EL005 CHARGING STATION WIRING DIAGRAM
SCALE: NONE

CONSTRUCTION NOTES:

① INSTALL CHARGING STATION (OWNER PROVIDED, CONTRACTOR INSTALLED) ON CONCRETE PAD AND TERMINATE CABLES.

CHARGING STATION COMMISSIONING PROCEDURE:

1. THE POLB WILL PARK AND POWER OFF THE ELECTRIC VEHICLE AT THE CHARGING STATION.
2. CHARGING STATION AND ELECTRIC VEHICLE MANUFACTURER'S REPRESENTATIVES WILL BE PRESENT DURING COMMISSIONING PROCESS TO ASSIST WITH INSTALLATION AND COMMISSIONING ISSUES.
3. VISUALLY INSPECT CHARGING STATION, INCLUDING THE CHARGING CORDS.
4. OPEN THE VEHICLE-MOUNTED CHARGING INLET DOOR AND ENSURE IT IS FREE OF DUST, WATER, AND FOREIGN OBJECTS.
5. TAKE OUT THE CHARGING CONNECTOR(S) FROM THE THE FRONT SIDE OF THE CHARGING STATION.
6. INSERT THE CHARGING CONNECTOR(S) INTO THE VEHICLE-MOUNTED OUTLET(S) PER THE MANUFACTURER'S INSTRUCTIONS. INSPECT FOR A PROPER CONNECTION, AND VERIFY THAT THE VEHICLE IS NOW CHARGING. IF THE VEHICLE IS NOT CHARGING, DISCONNECT THE CHARGING CONNECTOR(S) AND COORDINATE WITH THE POLB AND MANUFACTURER'S REPRESENTATIVE(S) FOR CORRECTIVE ACTIONS.
7. ONCE CHARGING IS VERIFIED TO BE COMPLETE, REMOVE THE CHARGING CONNECTOR(S) FROM THE VEHICLE-MOUNTED OUTLET(S) PER THE MANUFACTURER'S INSTRUCTIONS.
8. RETURN TO THE CHARGING CONNECTOR(S) TO THE CHARGING STATION AND CLOSE THE CHARGING INLET DOOR.

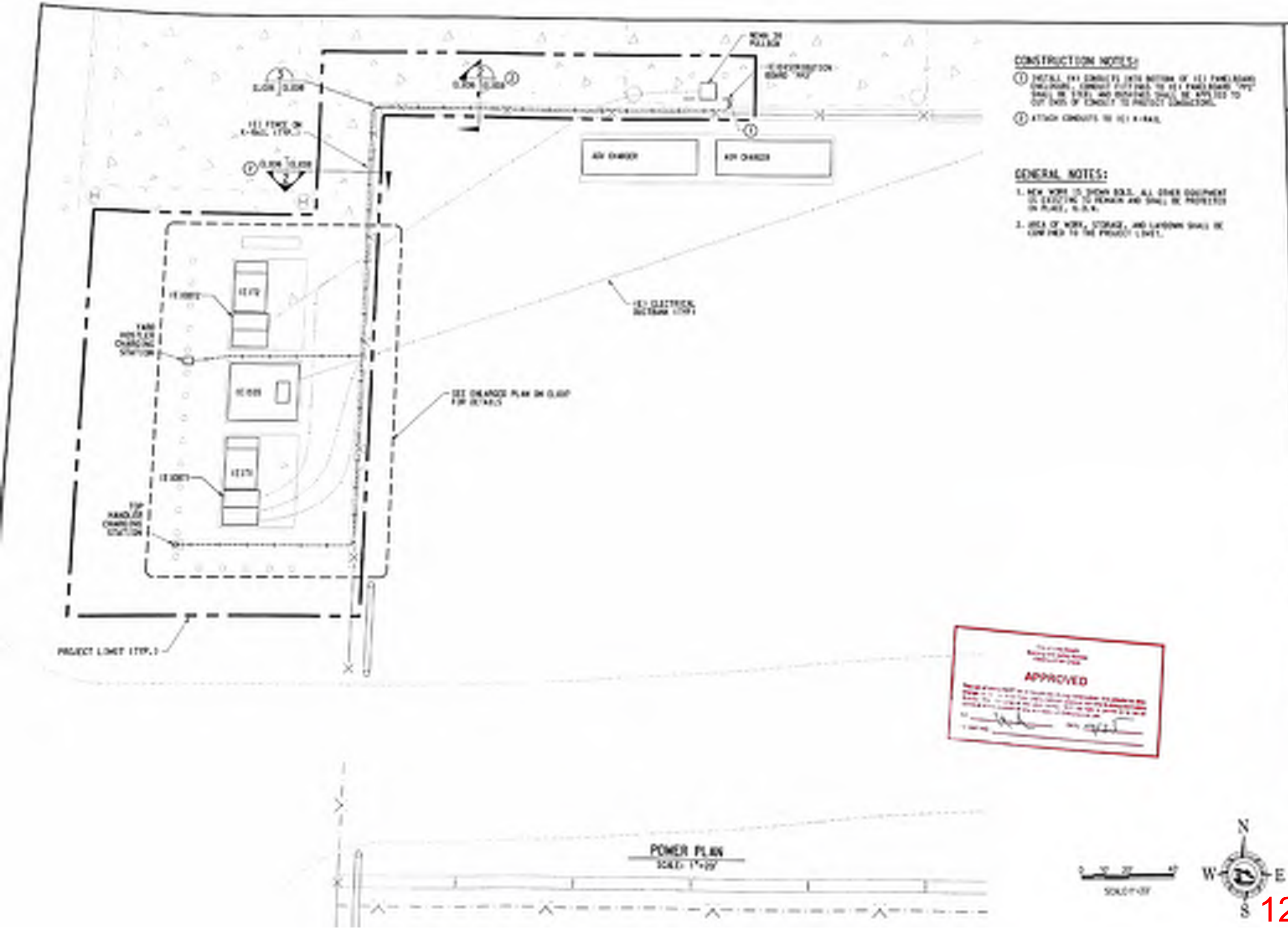
12/5/16

P2S

Port of LONG BEACH

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
EQUIPMENT ELEVATIONS

10-02314-EL006
SHEET 006 OF 009



APPROVED

CONSTRUCTION NOTES:

① INSTALL (N) CONDUITS INTO BOTTOM OF (E) PANELBOARD ENCLOSURE. CONDUIT FITTINGS TO (E) PANELBOARD "PP1" SHALL BE STEEL AND BUSHINGS SHALL BE APPLIED TO CUT ENDS OF CONDUIT TO PROTECT CONDUCTORS.

② ATTACH CONDUITS TO (E) K-RAIL.

GENERAL NOTES:

1. NEW WORK IS SHOWN BOLD. ALL OTHER EQUIPMENT IS EXISTING TO REMAIN AND SHALL BE PROTECTED IN PLACE, U.O.N.
2. AREA OF WORK, STORAGE, AND LAYDOWN SHALL BE CONFINED TO THE PROJECT LIMIT.

P2S

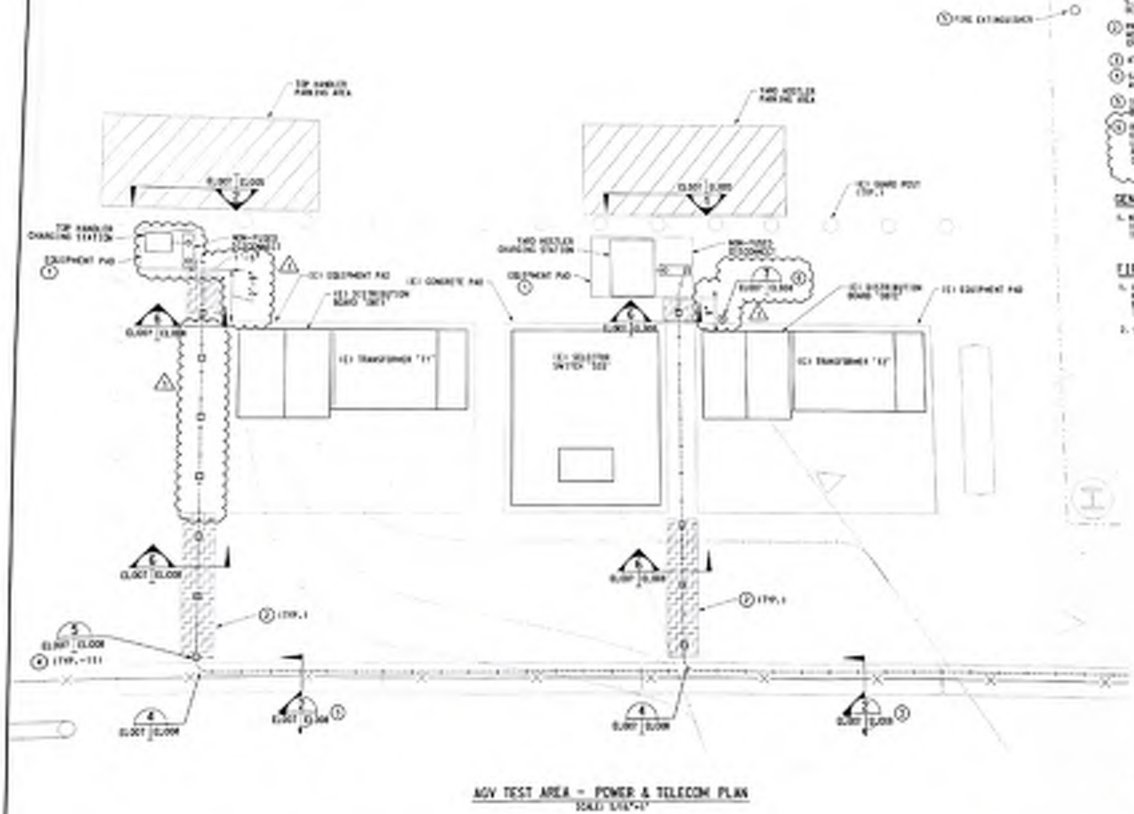
Port of LONG BEACH

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
AREA PLAN

10-02314-EL006

SHEET 006 OF

13



AGV TEST AREA - POWER & TELECOM PLAN

SCALE: 1/16"=1'

CONSTRUCTION NOTES:

① SAWCUT AND REMOVE (E) AC PAVING AND BASE FOR INSTALLATION OF CHARGING STATION CONCRETE PAD. CONSTRUCT (N) AC PAVING AND BASE TO MATCH THE (E) PAVING. SEE DETAIL 5, EL007 FOR EXISTING PAVING SECTION DETAILS.

② PROVIDE AND INSTALL 3/4" TREADPLATE HOSE RAMP, [illegible] OR APPROVED EQUAL.

③ ATTACH CONDUITS TO (E) K-RAIL.

④ SAWCUT AND REMOVE (E) PAVING TO 12" DEEP AND FILL WITH CONCRETE.

⑤ INSTALL FIRE EXTINGUISHER IN WEATHERPROOF BOX [illegible]

⑥ REMOVE (E) GROUND ROD IN CONFLICT WITH EQUIPMENT PAD AND RELOCATE TO NEW LOCATION. EXTEND GROUND GRID TO NEW ROD LOCATION WITH 4/0 BARE COPPER CONDUCTOR.

GENERAL NOTES:

1. NEW WORK IS SHOWN BOLD. ALL OTHER EQUIPMENT IS EXISTING TO REMAIN AND SHALL BE PROTECTED IN PLACE, U.O.N.

FIRE ACCESS NOTES:

1. (E) ELECTRICAL EQUIPMENT IS IN LOCKED [illegible] ENCLOSURES AND NOT ACCESSIBLE BY UNQUALIFIED WORKERS, SO NO (E) FENCE IS INSTALLED.
2. SEE EL009 FOR FIRE ACCESS PLAN.

12/6/18

SCALE: 1/16"

P2S

Port of LONG BEACH

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER AND TOP HANDLER CHARGING STATIONS
ENLARGED AREA PLAN

10-02314-EL007
SHEET 001 OF 009

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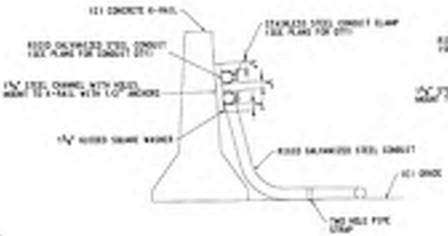
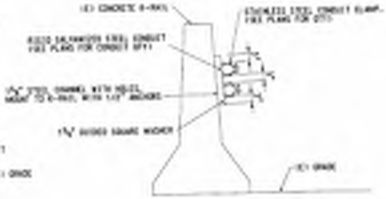
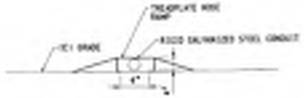


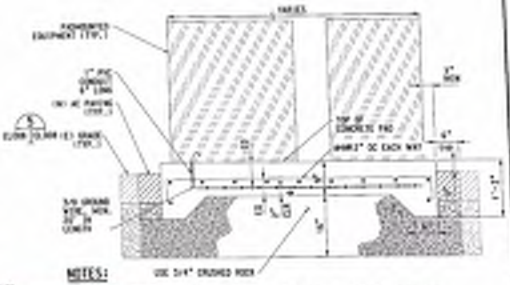


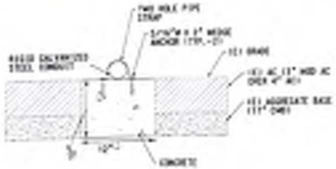


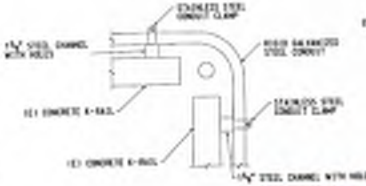
6 CONDUIT RAMP SECTION
SCALE: NONE

4 TRANSITION FROM K-RAIL TO GRADE
SCALE: NONE

2 CONDUIT K-RAIL ATTACHMENT
SCALE: NONE







NOTES:

1. INSTALL GROUND WIRE 3" ABOVE BOTTOM OF PAD. BOND TO ELECTRICAL EQUIPMENT.
2. CONCRETE SHALL BE CLASS 560-C-3250 WITH A MAXIMUM SLUMP OF 5", ... ON THE CONTRACT PLANS.
3. REINFORCING STEEL SHALL BE DEFORMED REBARS ASTM A615 OR ASTM A706, GRADE 60. PLACING OF REINFORCEMENT AND SPLICING LENGTH SHALL CONFORM TO ACI CODE, LATEST EDITION.

APPROVED

5 CONDUIT ATTACHMENT TO GRADE
SCALE: NONE

3 CORNER CONDUIT SWEEP
SCALE: NONE

1 TYPICAL CONCRETE PAD SECTION
SCALE: NONE

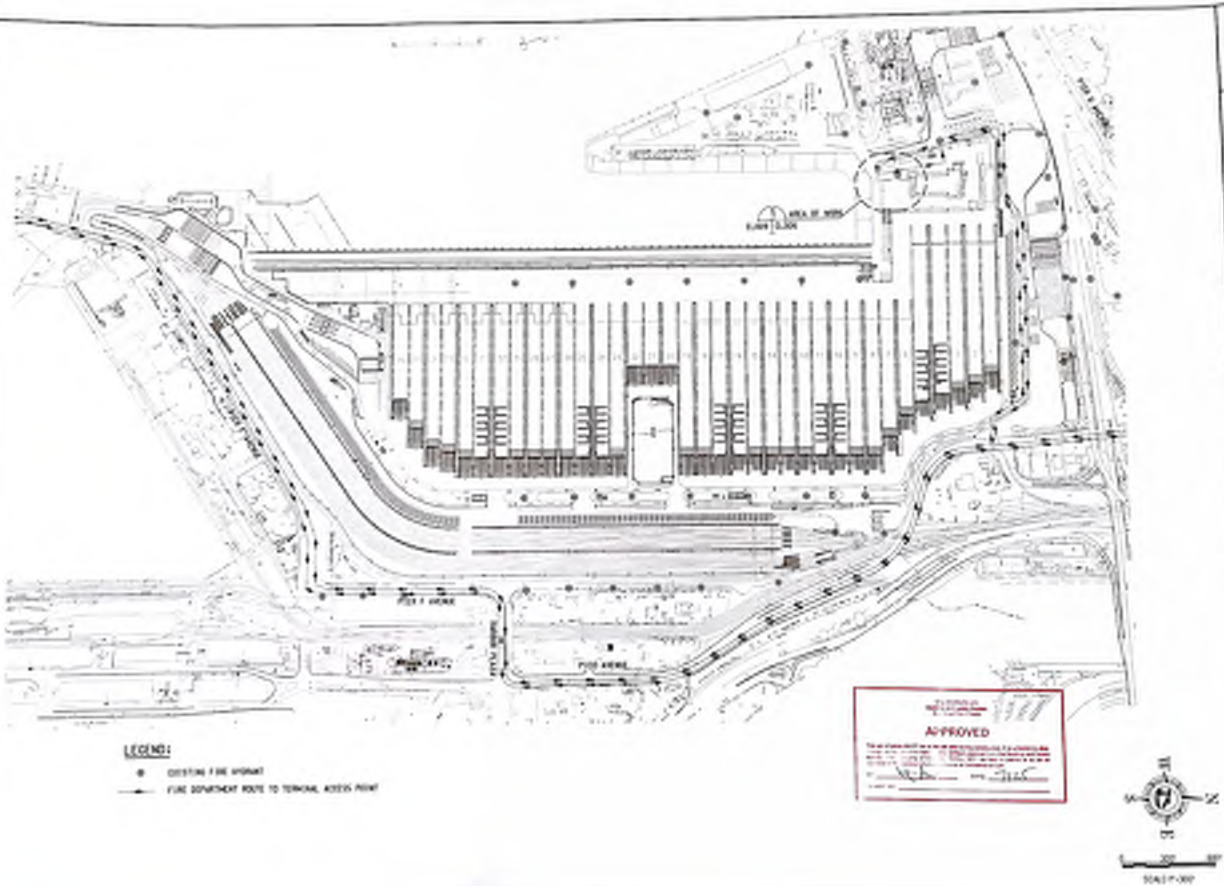
P25

Port of LONG BEACH

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
DETAILS

10-02314-EL008
SHEET 008 OF 008

SUBMITTAL



LEGEND:

● EXISTING FIRE HYDRANT

—◆— FIRE DEPARTMENT ROUTE TO TERMINAL ACCESS POINT

APPROVED

Port of LONG BEACH

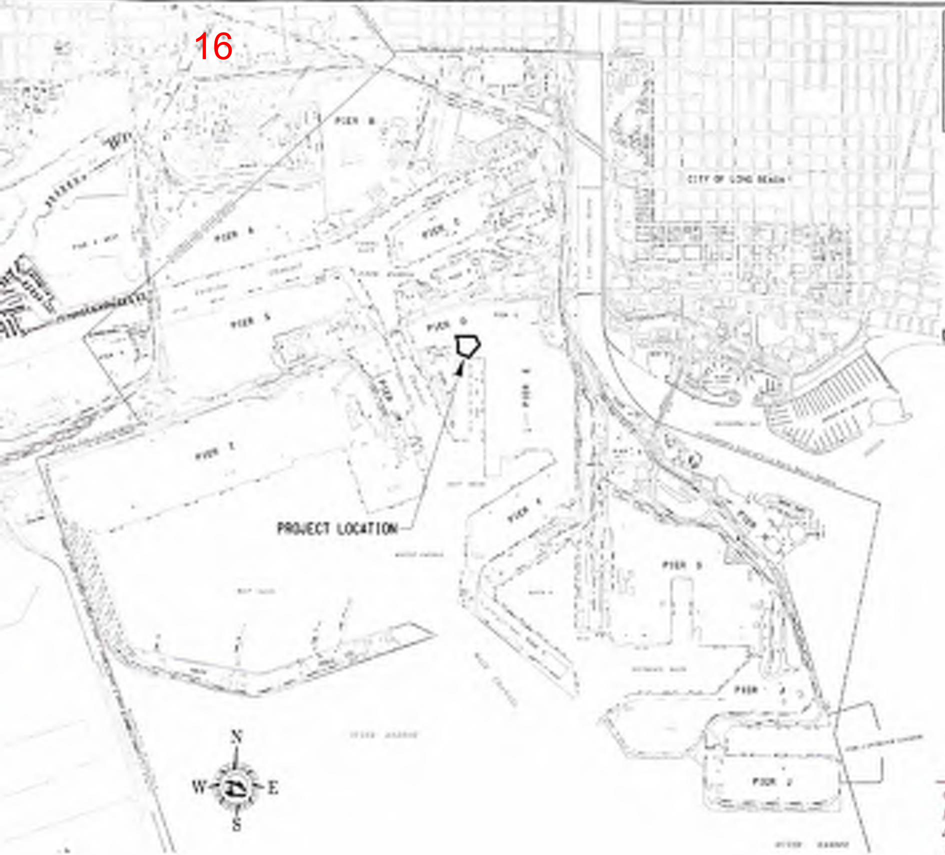
PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
FIRE ACCESS PLAN

COVER SHEET

10-02314-EL009
SHEET 009 OF 009

SUBMITTAL

Ave



CONTRACTOR TO CONTACT UNDERGROUND SERVICE ALERT AT 811 TWO WORKING DAYS PRIOR TO EXCAVATION.

SCOPE OF WORK

PROJECT INCLUDES INSTALLATION OF CHARGING STATIONS FOR ELECTRIC YARD HOSTLERS AND TOP PICKS. THIS INCLUDES ALL EQUIPMENT REQUIRED TO SUPPLY POWER TO THE CHARGING STATIONS AND THE CONCRETE PADS FOR THE CHARGING STATIONS.

PROJECT DATUM:

HORIZONTAL DATUM:

NORTH AMERICAN DATUM 1983 (NAD83) COORDINATES, CALIFORNIA COORDINATE SYSTEM ZONE 5 EPOCH 2007

VERTICAL DATUM:

CBM GPS 5320, ELEVATION=20.52 MLLW NAT 1990, FOUND 1" BRASS DISK STAMPED "5320" SOUTHEAST CORNER OF PIER E STREET AND PICO AVE ON NORTHEAST CORNER OF CATCH BASIN.

CODES AND STANDARDS

CALIFORNIA BUILDING CODE (CBC) - 2016
CALIFORNIA MECHANICAL CODE (CMC) - 2016
CALIFORNIA ELECTRICAL CODE (CEC) - 2016
CALIFORNIA PLUMBING CODE (CPC) - 2016
CALIFORNIA FIRE CODE (CFC) - 2016
CALIFORNIA ENERGY CODE - 2016

NFPA 72 - 2016

REFERENCE DRAWING LIST

DWG. SET NO.	TITLE	YEAR
HD 10-1891	PIERS D, E, & F BERTHS D28-D31, E11-E27, F3-F6	2000
HD 10-02049	PIER E TERMINAL CONTAINER YARD/INTERMODAL RAILROAD PHASE 1	2012
HD 10-02068	PIER E MIDDLE HARBOR TERMINAL MARINE OPS BLDG & POWER SHOP	2013

SHEET INDEX

DRAWING NUMBER	SHEET. NO.	SHEET TITLE
02314-EL001	001	COVER SHEET
02314-EL002	002	GENERAL NOTES
02314-EL003	003	LEGEND AND ABBREVIATIONS
02314-EL004	004	SINGLE LINE DIAGRAM
02314-EL005	005	EQUIPMENT ELEVATIONS
02314-EL006	006	AREA PLAN
02314-EL007	007	ENLARGED AREA PLAN
02314-EL008	008	DETAILS

APPROVED

10PP 17.021

1st. Review 6/8/18

electrical plan check review sent. Return with 2 revised sets and answer sheets to all comments and mark → PS.

Stamp & Sign

P25

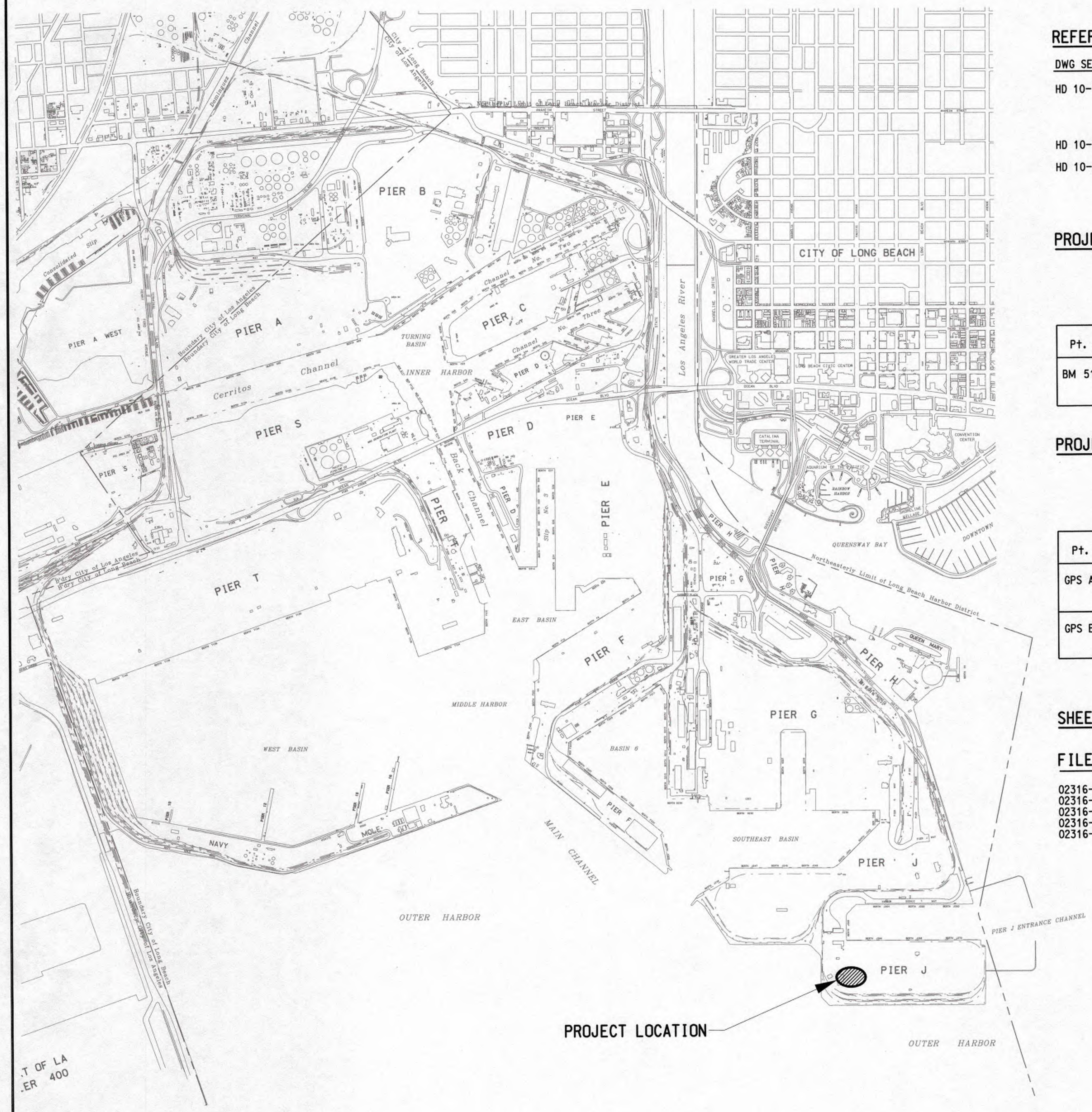
Port of LONG BEACH

PIER E TERMINAL
ZERO EMISSION PHASE I - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
COVER SHEET

10-02314-EL001
SHEET 001 OF XXX

SUBMITTAL

RELE 220747



REFERENCE DRAWINGS

DWG SET NO.	TITLE	YEAR
HD 10-1741	PIERG, BERTHS 232-236 TERMINAL REDEVELOPEMENT BERTH 236 WHARF, LANDFILL AND BACK AREA	2005
HD 10-86	PIER J, BERTH 234 WHARF	1974
HD 10-1045	PIER J, BERTH 232-234 100 FOOT GAGE CRANE RAIL	1987

PROJECT VERTICAL DATUM

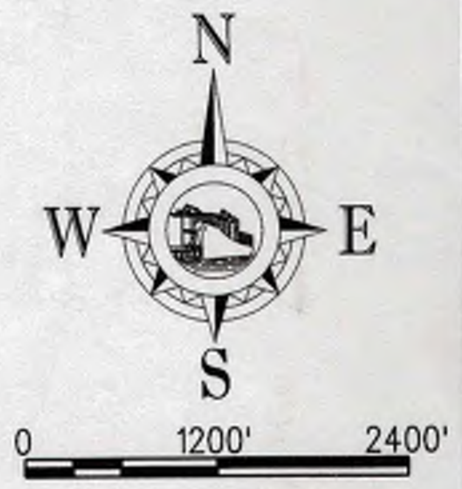
Pt. #	NORTHING	EASTING	ELEVATION	DESCRIPTION
BM 5150	1733309.01	6499658.16	36.06'	2-INCH BRASS DISK ON THE EAST SIDEWALK OF PIER G STREET NEAR THE NORTH ABUTMENT OF THE BRIDGE, APPROX. 200 FEET SOUTH OF HARBOR PLAZA

PROJECT HORIZONTAL DATUM

Pt. #	NORTHING	EASTING	DESCRIPTION
GPS A	1733309.01	6499658.16	POINT A - LOCATED ON EAST SIDEWALK OF PIER G STREET NEAR THE NORTH ABUTMENT OF THE BRIDGE, APPROX. 200 FEET SOUTH OF HARBOR PLAZA
GPS B	1731882.28	6496648.65	POINT B - LOCATED ON THE FACE OF A ROCK ON PIER J, AT THE MOST SOUTHEAST CORNER OF BERTH J260

SHEET INDEX

FILE NAME	DRAWING NUMBER	SHEET NUMBER	SHEET TITLE
02316-0-GN-TT-S001	GN001	1	PROJECT LOCATION AND SHEET INDEX
02316-0-EL-NO-S002	EL002	2	GENERAL NOTES, SYMBOLS AND ABBREVIATIONS
02316-0-EL-PL-S003	EL003	3	ELECTRICAL LAYOUT PLAN
02316-0-EL-DI-S004	EL004	4	SUBSTATION DS2 ONE-LINE DIAGRAM
02316-0-ST-DT-S005	ST005	5	DETAILS



SCALE:1"=1200'

MARK	DATE	BY	REVISION DESCRIPTION

TYLER W. SPARKS
E16039
EXP. 09-30-19

JOHN Y. CHUN, P.E. NO. C-58867
DIRECTOR OF ENGINEERING DESIGN
DATE

Port of LONG BEACH
The Green Port

SPEC. NO: S3028	CONSTRUCTION REV: DATE:
CADD STD. VER: 1.5	CHECKED BY: RN DATE:
DWG. SCALE: 1"=1200'	DRAWN BY:SC DATE: 04/24/2018
EPOCH: 2007.0	DESIGNED BY:TS POLB DM:
PROJECT MGR.:	DESIGN MGR.: POLB PM:
HORIZONTAL CONTROL: NAD83-VF	VERTICAL CONTROL: NGVD 29 MLLW

PIER J ZERO EMISSION PHASE 1
TOP HANDLER CHARGING STATIONS
PROJECT LOCATION AND SHEET INDEX

10-02316-GN001
SHEET 1 OF 5

12-JUL-2018 10:19

RESUBMITTAL

BELE 220716

pw://PLBPWIntSvr1.polb.local:projectwisedb01/Documents/2 Projects/HA1478/5.0 Drawings/5.2 Design/Project Consultants/02316-0-GN-TT-S001.dgn
VERSION 1

GENERAL NOTES

1. ALL WORK SHALL COMPLY WITH THE LATEST EDITION OF THE 2017 CALIFORNIA ELECTRICAL CODE: 2017 CALIFORNIA ENERGY CODE AND ALL OTHER APPLICABLE FEDERAL, STATE AND LOCAL CODES. WHERE THE PLANS SHOW MORE RESTRICTIVE REQUIREMENTS, THE PLANS SHALL GOVERN. BUT NOTHING ON THESE PLANS SHALL BE INTERPRETED AS AUTHORITY TO VIOLATE ANY CODE OR REGULATION. WHEN REFERENCES ARE MADE TO SPECIFIC CODE SECTIONS, STANDARDS, GUIDE AND OTHER SIMILAR REFERENCES, THEY ARE INTENDED TO ADD EMPHASIS TO THE REQUIREMENTS OF THAT PARTICULAR REFERENCE, AND ARE NOT INTENDED IN ANY WAY TO RELIEVE THE CONTRACTOR OF THE REMAINING REFERENCES.

2. IN THE EVENT OF A CONFLICT OR INCONSISTENCY BETWEEN ITEMS INDICATED ON THE PLANS AND/OR SPECIFICATIONS OR WITH CODE REQUIREMENTS, THE NOTE, SPECIFICATION OR CODE WHICH PRESCRIBES AND ESTABLISHES THE MORE COMPLETE JOB OR THE HIGHER STANDARD SHALL PREVAIL.

3. THE CONTRACTOR SHALL OBTAIN AND PAY FOR ALL REQUIRED PERMITS AND ALL FEES.

4. THE ELECTRICAL DRAWINGS ARE DIAGRAMMATIC AND DO NOT SHOW ALL OFFSETS, BENDS, FITTINGS, JUNCTION BOXES, PULL BOXES AND EXPANSION FITTINGS REQUIRED TO MEET FIELD CONDITIONS. DETERMINE ACTUAL MATERIAL AND HARDWARE REQUIREMENTS AND VERIFY ALL DIMENSIONS EXISTING EQUIPMENT AND STRUCTURAL MEMBER LOCATIONS BY FIELD INSPECTION.

5. SUBMIT SHOP DRAWINGS AND CATALOG CUTS FOR ALL ELECTRICAL EQUIPMENT IN ACCORDANCE WITH THE SPECIFICATIONS.

6. PROVIDE A SET OF AS-BUILT DRAWINGS SHOWING THE LOCATIONS OF ALL UNDERGROUND CONDUITS AND INDICATING ALL CHANGES MADE DURING CONSTRUCTION AND ANY DEVIATIONS FROM THE ELECTRICAL DRAWINGS IN ACCORDANCE WITH THE SPECIFICATIONS.

7. ALL CIRCUIT BREAKERS, FUSES AND ELECTRICAL EQUIPMENT SHALL HAVE AN INTERRUPTING RATING NOT LESS THAN THE MAXIMUM SHORT CIRCUIT CURRENT TO WHICH THEY MAY BE SUBJECTED.

8. ALL DEVICES AND EQUIPMENT INSTALLED OUTSIDE OR IN DAMP LOCATIONS SHALL BE WEATHERPROOF WITH MARINE GRADE, CORROSION RESISTANT FINISH. THE FINISH FOR OUTDOOR, WEATHERPROOF, NEMA 3R ENCLOSURES, SHALL HAVE ALL COVERS AND DOORS THOROUGHLY CLEANED USING A PHOSPHATE WASH. APPLY A ZINC RICH CORROSION RESISTANT PRIMER AND THEN A POLYESTER POWDER COAT SUITABLE FOR MARINE ENVIRONMENT. EXTERIOR SURFACES SHALL BE GIVEN A FINAL FINISH COAT ON ANSI 61 LIGHT GREY AIR-DRIED ACRYLIC ENAMEL, COVERED WITH A CLEAR POLYURETHANE TOP COAT.

9. EXPOSED CONDUIT SHALL BE RIGID GALVANIZED STEEL UNLESS NOTED OTHERWISE. UNDERGROUND CONDUIT SHALL BE CONCRETE ENCASED POLYVINYL CHLORIDE TYPE SCHEDULE 40 CONDUIT, WITH PVC COATED RIGID GALVANIZED STEEL CONDUIT ELBOWS AND RISERS TO GRADE. UNDERGROUND DUCTBANKS SHALL BE INSTALLED IN ACCORDANCE WITH THE SPECIFICATIONS. CONNECTIONS TO DEVICES SUBJECT TO VIBRATION, SUCH AS MOTORS, TRANSFORMERS AND SENSORS, SHALL BE SHORT LENGTHS OF LIQUIDTIGHT FLEXIBLE STEEL CONDUIT TERMINATED WITH APPROVED LIQUIDTIGHT METAL FITTINGS AND PROVIDED WITH A SEPARATE GROUND CONDUCTOR INSTALLED WITH THE PHASE CONDUCTORS.

10. ALL WIRE SHALL BE COPPER, UL LISTED, RATED FOR 600 VOLTS, TYPE THWN-2, NO. 10 AWG MINIMUM SIZE UNLESS NOTED. CONDUCTORS LARGER THAN #10 AWG AND CONTROL, INSTRUMENTATION AND COMMUNICATION CONDUCTORS SHALL BE STRANDED, UNLESS NOTED OTHERWISE.

11. MAKE POWER CONNECTIONS TO ALL EQUIPMENT FURNISHED BY OTHERS. PROVIDE SUPPORT FOR ALL EQUIPMENT TO COMPLY WITH THE SEISMIC REQUIREMENTS OF THE UNIFORM BUILDING CODE AND ALL LOCAL ORDINANCES.

12. INSTALL ALL CONDUITS AND WIRES WITH A MINIMUM NUMBER OF BENDS AND IN SUCH A MANNER AS TO CONFORM TO THE STRUCTURE, AVOID OBSTRUCTIONS, KEEP OPENINGS AND PASSAGEWAYS CLEAR, AND MEET ALL STRUCTURAL CODE REQUIREMENTS.

13. THE ENTIRE ELECTRICAL INSTALLATION SHALL BE GROUNDED AS REQUIRED BY ALL APPLICABLE CODES.

14. THE ENTIRE ELECTRICAL SYSTEM SHALL BE TESTED FOR SHORT CIRCUITS, GROUNDS AND INSULATION RESISTANCE BETWEEN CONDUCTORS AND TO GROUND.

15. FUNCTIONALLY TEST THE ELECTRICAL INSTALLATION FOR PROPER OPERATION.

16. WHEN REFERENCES ARE MADE TO SPECIFIC CODE SECTIONS, STANDARDS, GUIDELINES, AND OTHER SIMILAR REFERENCES, THEY ARE INTENDED TO ADD EMPHASIS TO THE REQUIREMENTS OF THAT PARTICULAR REFERENCE, AND ARE NOT INTENDED IN ANY WAY TO RELIEVE THE CONTRACTOR OF THE REMAINING APPLICABLE REFERENCES.

17. CONTRACTOR SHALL BE RESPONSIBLE TO PERFORM TESTING OF THE GROUND-FAULT PROTECTION SYSTEM AFTER INSTALLED ON SITE, IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE SECTION 230.95(C). A WRITTEN RECORD OF THIS TEST SHALL BE SUBMITTED TO THE ENGINEER.

18. CONDUIT THAT IS TO BE ABANDONED AND NOT REQUIRED TO REMAIN AS SPARE, SHALL HAVE WIRES REMOVED. THE CONDUIT ENDS SHALL BE REMOVED TO A DEPTH OF AT LEAST 12" BELOW THE FINSHED SURFACE. BOTH ENDS OF ABANDONED CONDUITS SHALL BE CRIMPED IF CONDUIT IS METALLIC. OTHERWISE, CAP ENDS WITH CONCRETE.

19. EACH MULTIWIRE BRANCH CIRCUIT SHALL BE PROVIDED WITH A MEANS THAT WILL SIMULTANEOUSLY DISCONNECT ALL UNGROUNDED CONDUCTORS AT THE POINT WHERE THE BRANCH CIRCUIT ORIGINATES. (210.4).

20. ALL INSTALLED MATERIALS AND EQUIPMENT SHALL BE LISTED U.L., NTRL OR LISTED AND APPROVED BY A CITY OF LONG BEACH APPROVED TESTING LABORATIORY.

21. PROVIDE ARC FLASH LABELIING AS REQUIRED PER (110.16).

22. ALL NEW OVERCURRENT DEVICES INSTALLED IN EXISTING SWITCHBOARDS SHALL MATCH THE MAKE, MODEL AND INTERRUPTING CAPACITY OF THE EXISTING OVERCURRENT DEVICES.

23. UNDERGROUND WIRING METHODS (0 TO 600V) SHALL COMPLY WITH 2010 CEC TABLE 300.5.

24. WHERE THE DISCONNECTS ARE NOT PROVIDED WITHIN SIGHT FROM THE EQUIPMENT IT SUPPLIES, THE SWITCH OR CIRCUIT BREAKER MUST INCLUDE PROVISIONS FOR ADDING A LOCK, AND THESE PROVISIONS MUST REMAIN WITH THE EQUIPMENT. THESE LOCKING PROVISIONS HAVE TO BE PART OF THE EQUIPMENT, EITHER INHERENT TO THE EQUIPMENT DESIGN OR AS AN ACCESSORY FEATURE THAT CAN BE INSTALLED ON THE EQUIPMENT. [410.141(B), 422.31(B), 424.19, 440.14 EXCEPTION NO. 1, 600.6(A)(2)(3), 620.51(A) EXCEPTION NO. 1, 620.53, 620.55].

City of Long Beach
Building and Safety Bureau
Electrical Plan Check

APPROVED

This set of plans MUST be at the job site during construction. It is unlawful to alter, change or deviate from these plans without approval from the Building and Safety Bureau. The stamping of this plan shall NOT be held to permit or to be an approval of the violation of any provisions of Ordinance or Law.

BY:
DATE: 7-12-18
PERMIT NO.:

ELECTRICAL ABBREVIATIONS

A	AMMETER
AF	AMPERE FRAME
AFC	AVAILABLE FAULT CURRENT
AT	AMPERE TRIP
ATC	AIR TERMINAL CHAMBER
ATS	AUTOMATIC TRANSFER SWITCH
AUX	AUXILIARY
AWG	AMERICAN WIRE GAUGE
BKR	BREAKER
CB	CIRCUIT BREAKER
CKT	CIRCUIT
CM	CIRCUIT MONITOR
CO	CONDUIT ONLY
CONT	CONTINUATION
CPL	CONTROL PANEL
CPT	CONTROL POWER TRANSFORMER
CR	CONTROL RELAY
CU	COPPER
D	DEPTH
DB	DUCT BANK
DEG	DEGREE
DIA	DIAMETER
DN	DOWN
DWG	DRAWING
(E), EX	EXISTING
EGX	ETHERNET GATEWAY
ELEC	ELECTRICAL
ELEV	ELEVATION
EMT	ELECTRICAL METALLIC TUBING
ERT	ETHERNET RADIO TRANSMITTER
FDR	FEEDER
FO	FIBER OPTIC
G, GND, GRD	GROUND
GA	GAUGE
GFCI	GROUND FAULT CIRCUIT INTERRUPTER
HMI	HUMAN MACHINE INTERFACE
IC	INTERRUPTING CAPACITY
I/O	INPUT/OUTPUT
J, JB	JUNCTION BOX
KVA	KILOVOLT-AMPERE(S)
KVAR	KILOVAR(S)
KW	KILOWATT(S)
L	LENGTH
L.C.	LOCK CLOSED
LFMC	LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT
LLI	LIVE LINE INDICATOR
L.O.	LOCK OPEN
LP	LIGHTING POLE
LTG	LIGHTING
LV	LOW VOLTAGE
MDB	MAIN DISTRIBUTION BOARD
MFR	MULTI-FUNCTION RELAY
MLLW	MEAN LOWER LOW WATER
MOS	METHOD OF SERVICE
MPZ	MINI-POWER ZONE
MRCT	MULTI-RADIO CURRENT TRANSFORMER
MV	MEDIUM VOLTAGE
MVA	MEGAVOLT-AMPERE(S)
(N)	NEW
NC	NORMALLY CLOSED
NEUT	NEUTRAL
NGR	NEUTRAL GROUNDING RESISTOR
NIC	NOT IN CONTRACT
NO	NORMALLY OPEN
NRTL	NATIONALLY RECOGNIZED TESTING LABORATORY

O.C.	ON CENTER
OD	OUTSIDE DIAMETER
OH	OPPOSITE HAND
OIT	OPERATOR INTERFACE TERMINAL
P, PNL	PANEL
PB, P/B	PULLBOX
PH, Ø	PHASE
PLC	PROGRAMMABLE LOGIC CONTROLLER
PM	POWER MONITOR
POC	POINT OF CONNECTION
POLB	PORT OF LONG BEACH
PRI/PRIM	PRIMARY
PTW	POWER, TELEPHONE, AND WATER
PVC	POLYVINYL CHLORIDE
PWR	POWER
RECEPT	RECEPTACLE
RGS	RIGID GALVANIZED STEEL
SA	SURGE ARRESTER
SCE	SOUTHERN CALIFORNIA EDISON
SECT	SECTION
SHLD	SHIELDED
S.K.	SUPERVISORY KEY
SPO	SHORE POWER OUTLET
SUB	SUBSTATION
SW	SWITCH
SWBD	SWITCHBOARD
SWGR	SWITCHGEAR
SYM	SYMMETRICAL
T	TRIP
TB	TERMINAL BLOCK
TERM	TERMINAL, TERMINATE
TOPKO	TIDELANDS OPERATION COMPANY
TX/RX	TRANSMIT/RECEIVE
TYP	TYPICAL
UG	UNDERGROUND
UGPS	UNDERGROUND PULL SECTION
UGS	UNDERGROUND STRUCTURE
U.O.N.	UNLESS OTHERWISE NOTED
UPS	UNINTERRUPTABLE POWER SUPPLY
V	VOLT, VOLTMETER
VA	VOLT-AMPERE(S)
VCB	VACUUM CIRCUIT BREAKER
VD	VOLTAGE DROP
VFI	VACUUM FAULT INTERRUPTER
VT	VOLTAGE TRANSFORMER
W	WIDTH
W/	WITH
W/O	WITH OUT
WP	WEATHERPROOF
XFMR	TRANSFORMER
XMTR	TRANSMITTER

PULLBOX IDENTIFICATION

P4 ☐	600V AND BELOW MANHOLE/PULLBOX
C4 ☐	COMMUNICATION MANHOLE/PULLBOX

CONDUIT AND RACEWAY

—P——P—	UNDERGROUND DUCT BANK - POWER (ABOVE 600V)
—E——E—	UNDERGROUND DUCT BANK - 600V AND BELOW
—COM——COM—	UNDERGROUND DUCT BANK - COMMUNICATIONS
——	EXISTING DUCT BANK
—GR——GR—	GROUND CONDUCTOR, SIZE AS NOTED ON PLANS
——○	RACEWAY TURNED UP OR TOWARDS VIEWER
——●	RACEWAY TURNED DOWN OR AWAY FROM VIEWER
——]	RACEWAY CAPPED, PROVIDE AND INSTALL MARKER AT GRADE
——}	RACEWAY CONTINUATION

ONE-LINE DIAGRAM

—■—	MEDIUM VOLTAGE SEPARABLE CONNECTOR
—◄—	MEDIUM VOLTAGE TERMINATION
⏚	GROUND
225 KVA	TRANSFORMER, KVA RATING
3 500:5	CURRENT TRANSFORMER, NUMBER INDICATED, RATIO AS INDICATED
—)(—	POTENTIAL TRANSFORMER, NUMBER IN PARENTHESIS (2) INDICATES QUANTITY
(GF) 400A	CIRCUIT BREAKER, TRIP SHOWN, GROUND FAULT PROTECTION, 3 POLE UNLESS OTHERWISE NOTED
400	SWITCH, 3 POLE UNLESS OTHERWISE NOTED
—≪	CONNECTOR OR DRAWOUT ASSEMBLY
(XX)	ANSI DEVICE (SEE ANSI DEVICE NUMBER LISTING)
⊙	COPPER CLAD GROUND ROD
▲ ▲	TOP HANDLER CHARGING STATION
P1	PANELBOARD - P1 INDICATES DESIGNATION
—▭—	FUSE
(GF)	GROUND FAULT PROTECTION

MARK	DATE	BY	REVISION DESCRIPTION

TYLER W. SPARKS E16039 EXP. 09-30-19

JOHN Y. CHUN, P.E. NO. C-58867
DIRECTOR OF ENGINEERING DESIGN
DATE

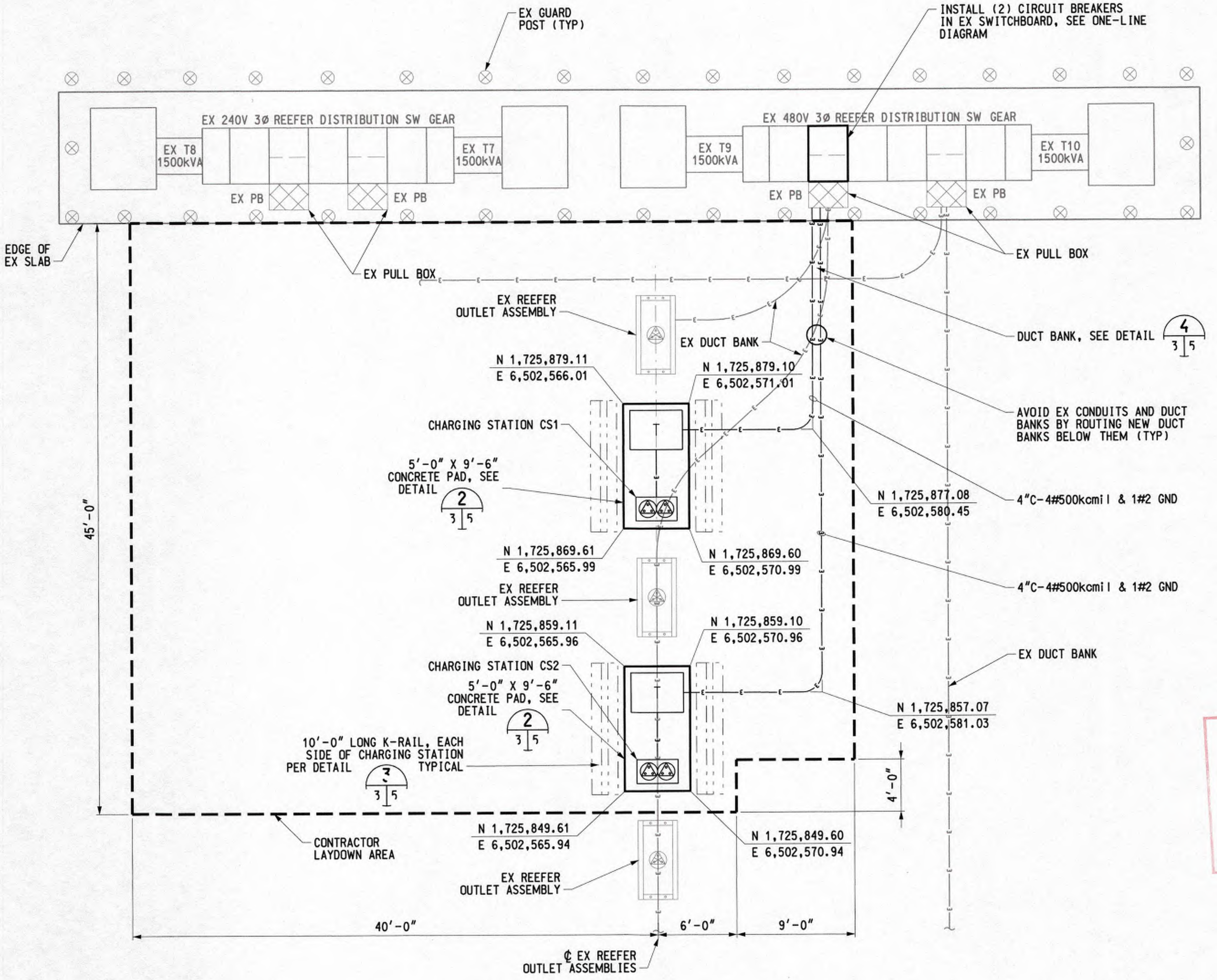
Port of
LONG BEACH
The Green Port

SPEC. NO: S3028
CADD STD. VER: 1.5
DWG. SCALE: NTS
EPOCH: 2007.0
PROJECT MGR.:
HORIZONTAL CONTROL: NAD83-VF
CONSTRUCTION REV:
CHECKED BY: RN
DRAWN BY: SC
DESIGNED BY: TS
DESIGN MGR.:
VERTICAL CONTROL: NGVD 29 MLLW
DATE:
DATE:
DATE: 04/24/2018
POLB DM:
POLB PM:

PIER J ZERO EMISSION PHASE 1
TOP HANDLER CHARGING STATIONS
GENERAL NOTES
SYMBOLS AND ABBREVIATIONS

10-02316-EL002
SHEET 2 OF 5

12-JUL-2018 10:20



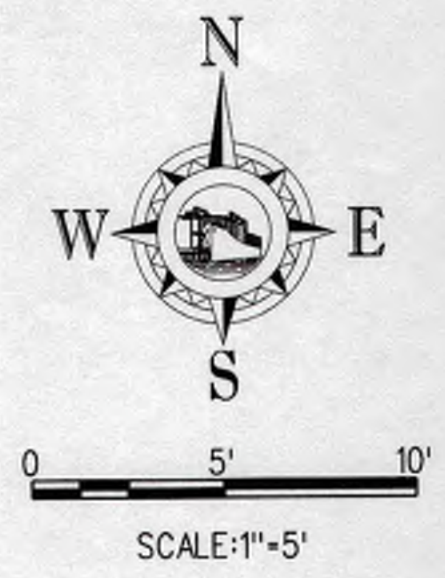
City of Long Beach
Building and Safety Bureau
Electrical Plan Check

APPROVED

This set of plans MUST be at the job site during construction. It is unlawful to alter, change or deviate from these plans, without approval from the Building and Safety Bureau. The stamping of this plan SHALL NOT be held to permit or to be an approval of the violation of any provisions of Ordinance or Law.

BY: Wayle DATE: 7-12-18

PERMIT NO. ______



SCALE:1"=5'

MARK	DATE	BY	REVISION DESCRIPTION

TYLER W. SPARKS E16039 EXP. 09-30-19

JOHN Y. CHUN, P.E. NO. C-58867
DIRECTOR OF ENGINEERING DESIGN

DATE

Port of
LONG BEACH
The Green Port

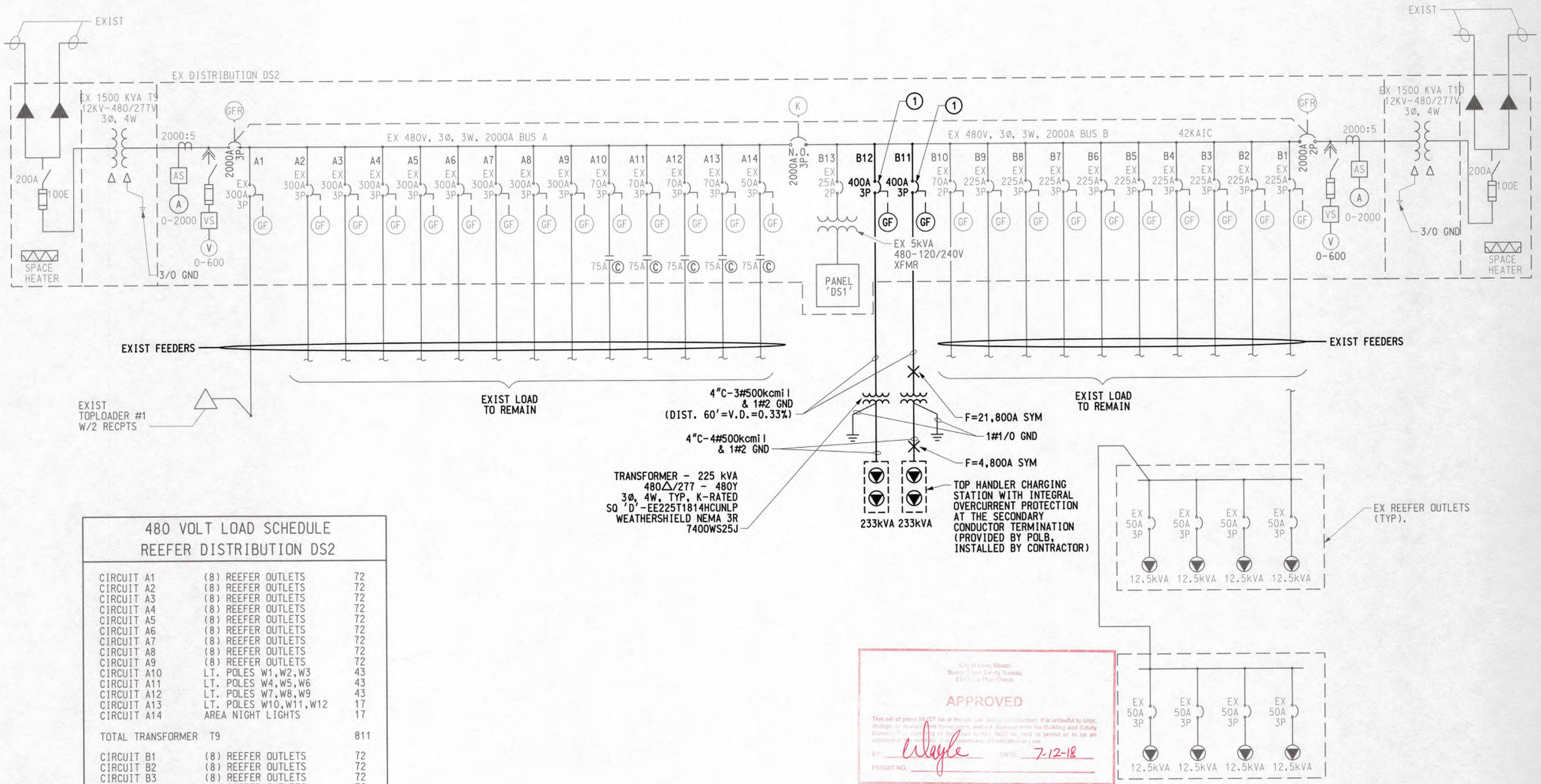
SPEC. NO: S3028	CONSTRUCTION REV: DATE:
CADD STD. VER: 1.5	CHECKED BY: RN DATE:
DWG. SCALE: 1"=5'	DRAWN BY: SC DATE: 04/24/2018
EPOCH: 2007.0	DESIGNED BY: TS POLB DM:
PROJECT MGR.:	DESIGN MGR.: POLB PM:
HORIZONTAL CONTROL: NAD83-VF	VERTICAL CONTROL: NGVD 29 MLLW

PIER J ZERO EMISSION PHASE 1
TOP HANDLER CHARGING STATIONS
ELECTRICAL LAYOUT PLAN

10-02316-EL003
SHEET 3 OF 5

12-JUL-2018 10:20

pw://PLBPWintSvr1.polb.local:projectwisedb01/Documents/2 Projects/HA1478/5.0 Drawings/5.2 Design/Project Consultants/02316-0-EL-PL-S003.dgn
VERSION 1



480 VOLT LOAD SCHEDULE
REEFER DISTRIBUTION DS2

CIRCUIT A1	(8) REEFER OUTLETS	72
CIRCUIT A2	(8) REEFER OUTLETS	72
CIRCUIT A3	(8) REEFER OUTLETS	72
CIRCUIT A4	(8) REEFER OUTLETS	72
CIRCUIT A5	(8) REEFER OUTLETS	72
CIRCUIT A6	(8) REEFER OUTLETS	72
CIRCUIT A7	(8) REEFER OUTLETS	72
CIRCUIT A8	(8) REEFER OUTLETS	72
CIRCUIT A9	(8) REEFER OUTLETS	72
CIRCUIT A10	LT. POLES W1,W2,W3	43
CIRCUIT A11	LT. POLES W4,W5,W6	43
CIRCUIT A12	LT. POLES W7,W8,W9	43
CIRCUIT A13	LT. POLES W10,W11,W12	17
CIRCUIT A14	AREA NIGHT LIGHTS	17
TOTAL TRANSFORMER	T9	811
CIRCUIT B1	(8) REEFER OUTLETS	72
CIRCUIT B2	(8) REEFER OUTLETS	72
CIRCUIT B3	(8) REEFER OUTLETS	72
CIRCUIT B4	(8) REEFER OUTLETS	72
CIRCUIT B5	(8) REEFER OUTLETS	72
CIRCUIT B6	(8) REEFER OUTLETS	72
CIRCUIT B7	(8) REEFER OUTLETS	72
CIRCUIT B8	(8) REEFER OUTLETS	72
CIRCUIT B9	(8) REEFER OUTLETS	72
CIRCUIT B10	LIGHTPOLE OUTLETS	12
CIRCUIT B11	**CHARGING STATION OUTLET**	**280**
CIRCUIT B12	**CHARGING STATION OUTLET**	**280**
CIRCUIT B13	5kVA TRANSFORMER	11
TOTAL TRANSFORMER	**T10**	**1231A**

City of Long Beach
Building and Safety Bureau
Electrical Plan Check

APPROVED

This set of plans MUST be at the job site during construction. It is unlawful to alter, change, or deviate from these plans, without approval from the Building and Safety Bureau. The stamping of this plan SHALL NOT be held to permit or to be an approval of the violation of any provisions of Ordinance or Law.

BY: Wayle DATE: 7-12-18

PERMIT NO.:

KEY NOTES

① PROVIDE AND INSTALL CIRCUIT BREAKER, 65KAIC.

ONE-LINE DIAGRAM

REEFER SUBSTATION DS2

MARK	DATE	BY	REVISION DESCRIPTION

TYLER W. SPARKS
E16039
EXP. 09-30-19

JOHN Y. CHUN, P.E. NO. C-58867
DIRECTOR OF ENGINEERING DESIGN
DATE

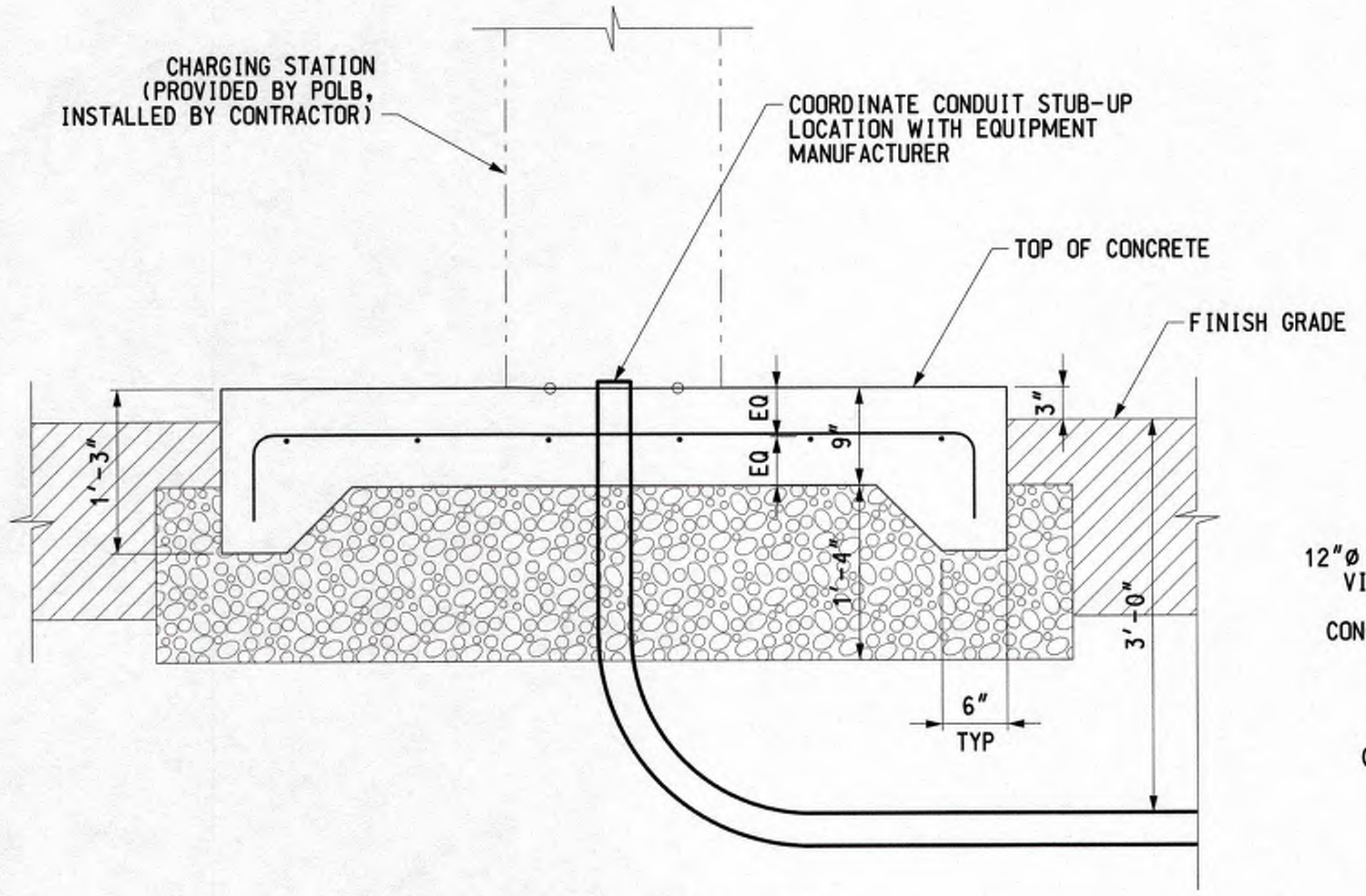
Port of
LONG BEACH
The Green Port

SPEC. NO: S3028	CONSTRUCTION REV: DATE:
CADD STD. VER: 1.5	CHECKED BY: RN DATE:
DWG. SCALE: NONE	DRAWN BY:SC DATE: 04/24/2018
EPOCH: 2007.0	DESIGNED BY:TS POLB DM:
PROJECT MGR.:	DESIGN MGR.: POLB PM:
HORIZONTAL CONTROL: NAD83-VF	VERTICAL CONTROL: NGVD 29 MLLW

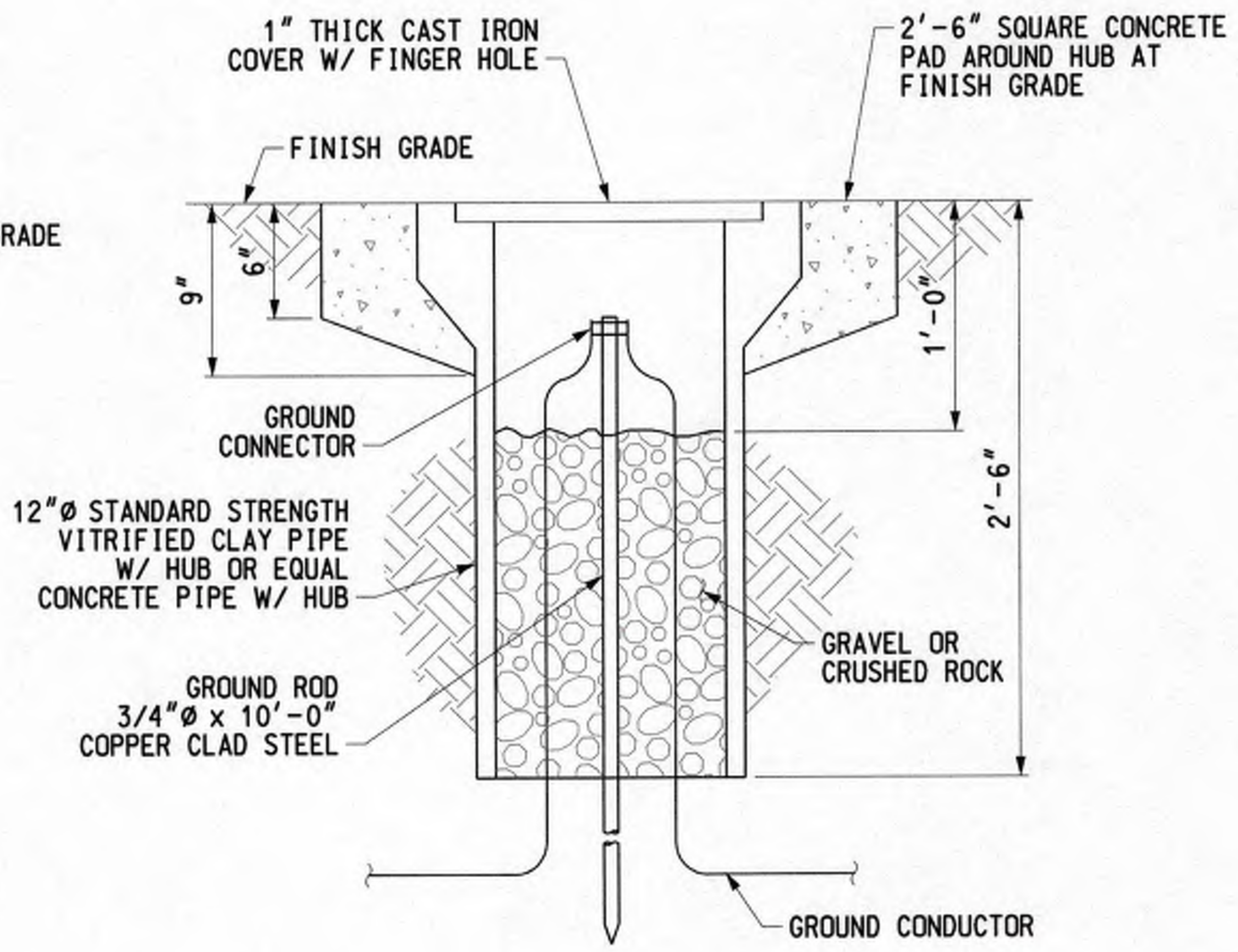
PIER J ZERO EMISSION PHASE 1
TOP HANDLER CHARGING STATIONS
SUBSTATION DS2
ONE-LINE DIAGRAM

10-02316-EL004
SHEET 4 OF 5

12-JUL-2018 10:20



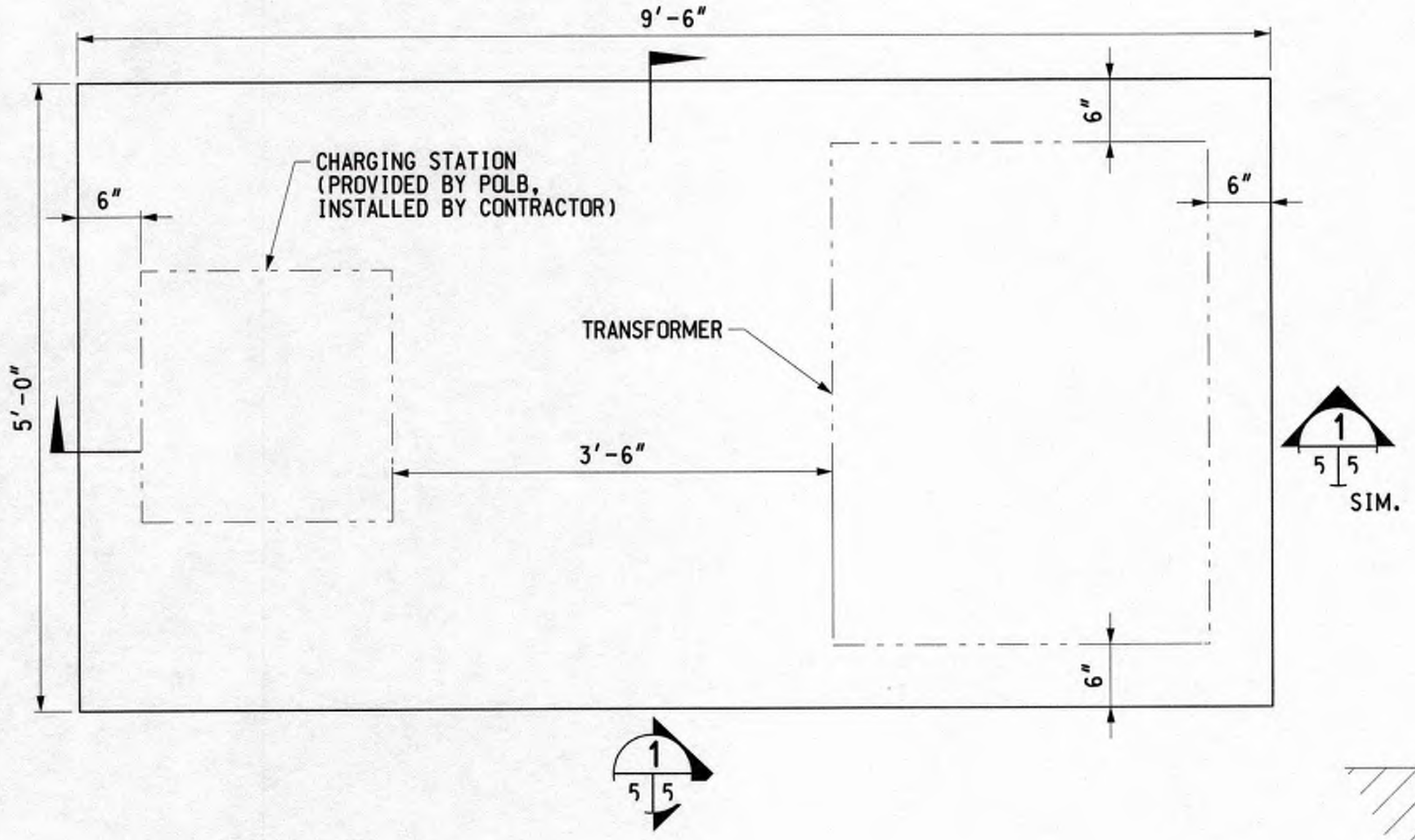
1 CONCRETE PAD SECTION
5 | 5
SCALE: 1"=1'



5 GROUND WELL DETAIL
4 | 5
SCALE: NONE

DUCT BANK TRENCH NOTES:

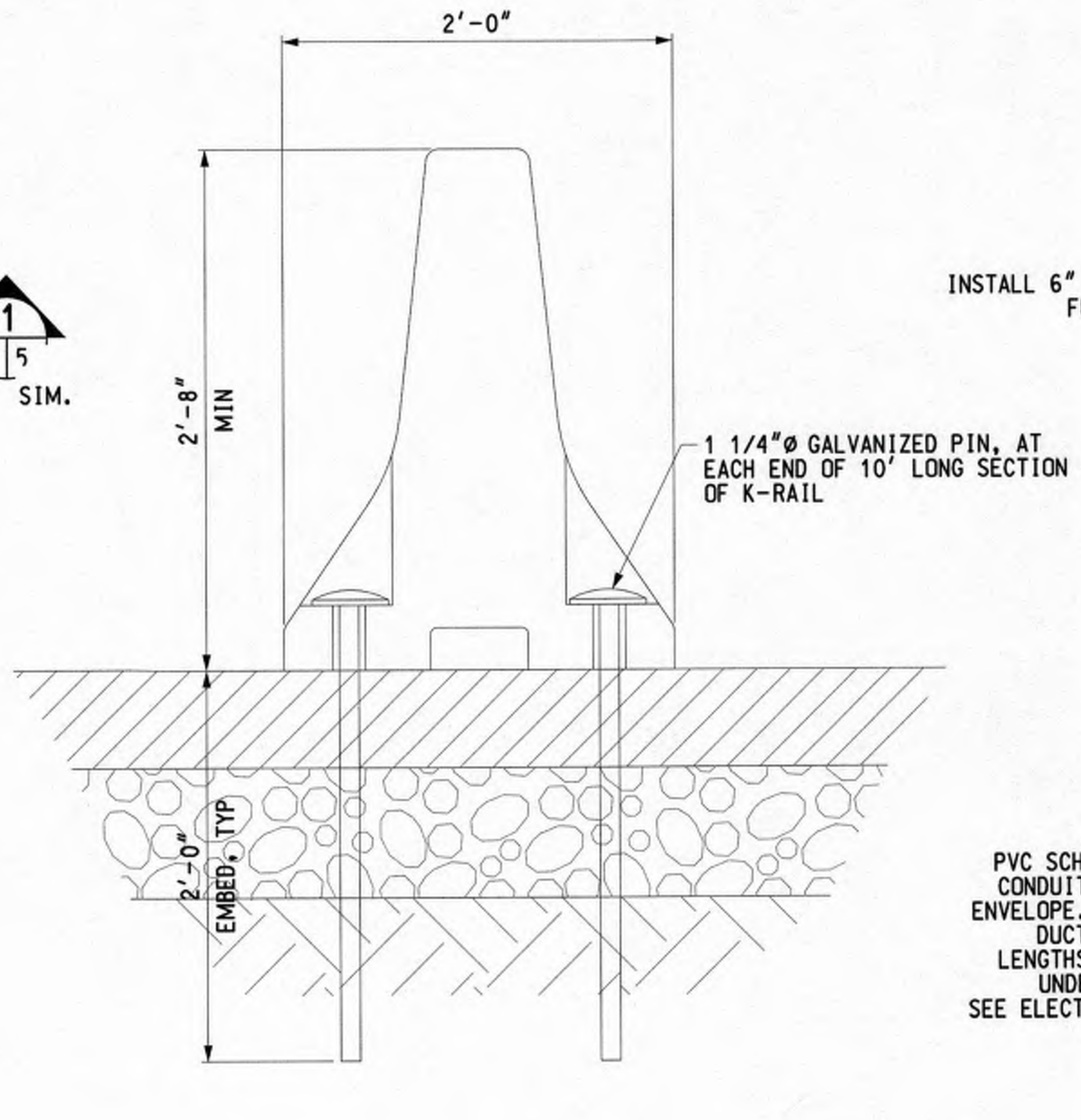
1. ALL WORK SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS PROVIDED IN THE STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION, CURRENT EDITION.
2. PERMANENT PAVEMENT RESTORATION SHALL COMMENCE WITHIN TEN WORKING DAYS FROM THE COMPLETION OF CONSTRUCTION.
3. ANY ASPHALT CUTTING METHOD OTHER THAN SAW CUTTING PROPOSED BY THE CONTRACTOR MUST BE APPROVED BY THE POLB ENGINEER PRIOR TO START OF CONSTRUCTION.
4. DURING CONSTRUCTION WHEN TEMPORARY ASPHALT IS USED, IT SHALL BE PLACED 4 INCHES THICK AND COMPACTED BY MEANS OF A SELF PROPELLED STEEL WHEEL ROLLER.
5. WHEN ANY TRENCH PAVEMENT RESTORATION OCCURS WITHIN 3 FEET OF A CONSTRUCTION JOINT, EXPANSION JOINT, COLD JOINT, OR EDGE, THE PAVEMENT BETWEEN THE TRENCH AND THE JOINT OR EDGE SHALL BE REMOVED AND REPLACED IN KIND WITH THE TRENCH PAVING.
6. COMPACTION TESTS SHALL BE PERFORMED DURING BACKFILL OPERATIONS, AT VARYING DEPTHS DETERMINED IN THE FIELD BY THE PORT OF LONG BEACH.



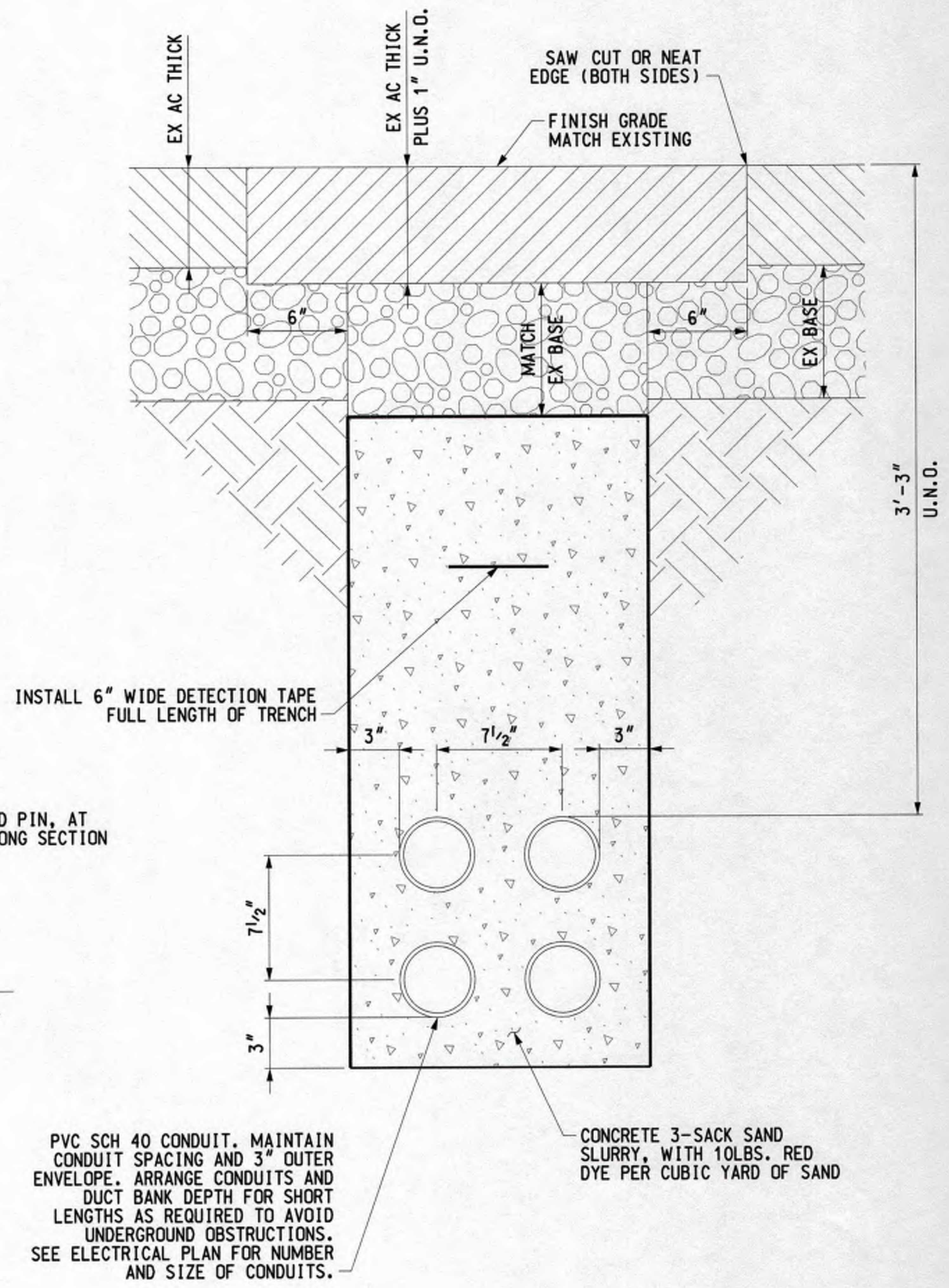
2 CONCRETE PAD DETAIL
3 | 5
SCALE: 1"=1'

CONCRETE PAD NOTES:

1. CONCRETE SHALL BE CLASS 560-C-3250 WITH A MAXIMUM SLUMP OF 5", UNLESS OTHERWISE NOTED.
2. WELDED WIRE FABRIC SHALL BE DEFORMED WIRE ASTM A496 OR A494, GRADE 60.
3. REINFORCING STEEL SHALL BE DEFORMED REBARS ASTM A615 OR ASTM A706, GRADE 60. PLACING OF REINFORCEMENT AND SPLICING LENGTH SHALL CONFORM TO ACI CODE 318-13.
4. EQUIPMENT ANCHORAGE SHALL BE PER EQUIPMENT MANUFACTURERS RECOMENDATIONS.



3 K-RAIL DETAIL
3 | 5
SCALE: NONE



4 DUCT BANK DETAIL
3 | 5
SCALE: NONE

MARK | DATE | BY | REVISION DESCRIPTION

REGISTERED PROFESSIONAL ENGINEER
TYLER W. SPARKS
E16039
EXP. 09-30-19
ELECTRICAL
STATE OF CALIFORNIA

JOHN Y. CHUN, P.E. NO. C-58867
DIRECTOR OF ENGINEERING DESIGN
DATE

Port of
LONG BEACH
The Green Port

SPEC. NO: S3028
CONSTRUCTION REV:
DATE:
CADD STD. VER: 1.5
CHECKED BY:
DATE:
DWG. SCALE: AS SHOWN
DRAWN BY:SC
DATE: 04/24/2018
EPOCH: 2007.0
DESIGNED BY:TS
POLB DM:
PROJECT MGR.:
DESIGN MGR.:
POLB PM:
HORIZONTAL CONTROL: NAD83-VF
VERTICAL CONTROL: NGVD 29 MLLW

PIER J ZERO EMISSION PHASE 1
TOP HANDLER CHARGING STATIONS
DETAILS

10-02316-ST005
SHEET 5 OF 5

12-JUL-2018 10:20

Port of
LONG BEACH
The Green Port

HARBOR DEVELOPMENT PERMIT

4801 AIRPORT PLAZA DRIVE LONG BEACH, CALIFORNIA 90815
TELEPHONE: 562-283-7100 FAX: 562-283-7148

PAGE 1 OF 3

PERMIT NUMBER	ISSUE DATE	EXPIRATION DATE	EXTENSION DATE	NOTE
HDP-17-084	12/21/2017	12/21/2019		

TYPE OF ACTION:

X CONFORMS TO CALIFORNIA COASTAL ACT OF 1976 AND CERTIFIED PORT MASTER PLAN
X PURSUANT TO SECTION 1215 OF THE LONG BEACH CITY CHARTER
LEVEL I HARBOR DEVELOPMENT PERMIT
___ APPEALABLE UNDER COASTAL ACT SECTION 30715

PERMITEE: Port of Long Beach
PERMITTEE PHONE: (562) 283-7100
LEGAL INTEREST: Owner
CONTACT PERSON: Chavdarian, Ben
PERMITEE ADDRESS
4801 Airport Plaza Drive
Long Beach, CA **ZIP** 90815
TITLE/AFFILIATION:
Electrical Engineer
PHONE: (562) 283-7100

DESCRIPTION OF APPROVED WORK:

Install two (2) electrical top pick charging stations.

LOCATION OF APPROVED WORK:

Pier J PCT, Reefer station, East of the Maintenance and Repair Building

Drawings: 1 Unnumbered drawing, Drawing # HD-10-1192-E4.0 (4 pages)

CALIFORNIA ENVIRONMENTAL QUALITY ACT DETERMINATION:

X CATEGORICALLY EXEMPT 3 [CLASS]
___ NEGATIVE DECLARATION, ADOPTED ___ [LEAD AGENCY] ___ [DATE]
___ ENVIRONMENTAL IMPACT REPORT, CERTIFIED BY ___ [LEAD AGENCY] ___ [DATE]

MANDATORY FINDINGS:

X THE PROJECT CONFORMS WITH THE ESTABLISHED POLICIES OF THE Southeast Harbor PLANNING DISTRICT
X THE PROJECT ___ WILL X WILL NOT HAVE ANY SIGNIFICANT ADVERSE ENVIRONMENTAL IMPACTS
X THE EXECUTIVE DIRECTOR AUTHORIZED ISSUANCE OF THIS PERMIT ON 12/21/2017
___ PUBLIC HEARING NOT REQUIRED PURSUANT TO THE PROVISIONS OF THE CERTIFIED PORT MASTER PLAN
___ A PUBLIC HEARING WAS HELD ON ___ AT ___
___ THE BOARD OF HARBOR COMMISSIONERS AUTHORIZED ISSUANCE OF THIS PERMIT ON ___
BY A ___ TO ___ VOTE
___ ___

THIS PERMIT IS ISSUED SUBJECT TO PERMITTEE OBTAINING THE FOLLOWING APPROVALS, AS NECESSARY, AND COMPLYING WITH STATED PERMIT TERMS AND CONDITIONS

X L.B. DEPARTMENT OF PLANNING AND BUILDING
___ L.B. BUREAU OF FIRE PREVENTION
___ REGIONAL WATER QUALITY CONTROL BOARD
___ AIR QUALITY MANAGEMENT DISTRICT
___ U.S. ARMY CORPS OF ENGINEERS
___ HOT PERMIT
X DIG ALERT ___
___ OTHER ___
X THOSE **STANDARD CONDITIONS** SHOWN ON THE ATTACHED **PAGE** OF THIS PERMIT
X THOSE **SPECIAL CONDITIONS** SHOWN ON THE ATTACHED **PAGE(S)** OF THIS PERMIT

ACKNOWLEDGEMENTS

Martha Cox
DIRECTOR OF ENVIRONMENTAL PLANNING

12/21/2017
DATE

I, Suzanne Plezia [PERMITTEE/AGENT] HEREBY ACKNOWLEDGE RECEIPT OF HDP-17-084 AND HAVE ACCEPTED ITS CONTENTS AND CONDITIONS.

SIGNATURE OF PERMITTEE/AGENT

1/9/18
DATE

Port of
LONG BEACH
The Green Port

HARBOR DEVELOPMENT PERMIT

4801 AIRPORT PLAZA DRIVE LONG BEACH, CALIFORNIA 90815
TELEPHONE: 562-283-7100 FAX: 562-283-7148

PAGE 2 OF 3

PERMIT NUMBER	ISSUE DATE	EXPIRATION DATE	EXTENSION DATE	NOTE
HDP-17-084	12/21/2017	12/21/2019		

STANDARD CONDITIONS:

1 Effective Date: This permit shall not become effective until the ORIGINAL has been returned to the Environmental Planning Division, fully signed by the permittee or agent(s) authorized in the permit application. Failure to return the original within thirty (30) days of approval shall render the permit invalid. Other conditions notwithstanding, if the project is appealable the permit shall not become until after the tenth (10th) working day following notification of approval, unless an appeal has been filed with the California Coastal Commission within that time. By executing this permit, permittee or its agent(s) acknowledge that they have received a copy of the fully-signed permit for its use and post said copy conspicuously at the project site.

2 Non-Waiver Condition and Assignment: Nothing in this permit shall be deemed or construed as a waiver of any term or condition contained in permittee lease, preferential assignment, permit, or other agreement with the Long Beach Harbor Commission. This permit shall not be assigned except as provided in the Board of Harbor Commissioners Port Master Plan Implementation Guidelines and in Section 13170 of Title 14 of the California Administrative code, to the extent applicable.

3 Permit Expiration: Work authorized by this permit must commence within two years of the effective date of this permit unless otherwise specified. If work has not commenced, this permit will expire two (2) years from its effective date. Any application for an extension of said commencement date must be made at least thirty (30) days prior to the expiration of this permit.

4 Compliance With Laws and Regulations: Permittee shall comply with all laws, statutes, rules, regulations, and orders of all governmental agencies having jurisdiction over the permittee's project. Permittee, at its own expense, shall obtain all requisite permits, approvals, and consents from the appropriate agencies, including but not limited to the City of Long Beach (COLB) Harbor Department, the COLB Development Services, COLB Fire Department, the South Coast Air Quality Management District, the California Department of Health Services, and the Regional Water Quality Control Board, and shall comply with any such permit, approval or consent. Copies of all requisite permits shall be available for inspection at the project site.

5 Construction Drawings: Final plans and specifications for construction (hard copies and CADD files in Bentley MicroStation format), incorporating any modifications made by the Harbor Department, shall be submitted to the Environmental Planning Division for review and approval prior to commencement of any portion of the development.

6 Notification: Permittee shall notify the Chief Harbor Engineer, in writing, of the anticipated start date of any construction at least ten (10) days in advance.

7 Permission from Property Owner: Permittee shall coordinate with all facilities which may be affected by the permitted project. Permittee shall not interfere with any facility operations. Permittee shall contact the Harbor Department Terminal Services Section at 562-283-7760 for assistance with notifications.

8 Subsurface Construction: Permittee shall consult with the Surveys and Mappings Section of the Harbor Department and Underground Service Alert of Southern California (Dig-Alert) regarding possible interference to underground utilities for all work involving excavation, a minimum of 48 hours in advance. Permittee shall conduct all subsurface work in accordance with Section 5 of the latest edition of Standard Specifications for Public Works Constructions (The "Green Book"). Permittee shall be responsible for all damage to underground structures and utility lines occurring as a result of project construction and shall restore all ground surfaces disturbed by excavation to original conditions, unless otherwise provided for by the permitted project design. This includes, but is not limited to, irrigation lines, water main lines, underground conduit, and surface landscaping. The alignment of any underground utilities that must be relocated as a result of the permitted project must be approved by the Director of Environmental Planning and the utility owner. Permittee, except as otherwise provided for or agreed to, is responsible for any costs associated with repairing, replacing, or relocating underground or surface utilities or landscaping disturbed or destroyed during the permitted project.

9 Conduct of Work: Permittee shall perform all work in strict accordance with the plans and specifications approved by the Harbor Department Environmental Planning Division. For project site preparation and construction activities the permittee shall utilize water trucks and sprinkler systems to minimize dust and releases of materials into harbor waters. Distribution and/or removal of surplus materials (fills, dirt, broken asphalt, etc.) generated by the construction on property under the jurisdiction of the Harbor Commission must have prior approval of the Chief Harbor Engineer.

10 As-built: As-built drawings for construction within the Harbor District (hard copies and CADD files in Bentley MicroStation format) shall be submitted to the Construction Management Division (562-590-4172) of the Harbor Department within thirty (30) days of the completion of work. Except in the case of underground work, final construction drawings may serve as as-builts provided a set of such drawings are submitted and stamped "as-built". For underground work, permittee shall submit to the Construction Mangement Division, within thirty (30) days of completion of the work, two (2) sets of as-built drawings and survey notes, signed by a licensed surveyor who shall certify to the accuracy of the horizontal and vertical alignment. All of said drawings shall be drawn to a scale of no more than one hundred (100) feet to the inch, shall show the accurate alignments by centerline traverses, shall be referenced to all intersections of street property lines and survey points furnished by the Harbor Department, and shall show the elevations of the tops of the pipelines and facilities. All surveys work shall be to the latest third order of accuracy as established by the National Oceanic and Atmospheric Administration surveys.

11 Traffic Management: For all projects that impact Harbor Department roads, permittee shall submit for approval a Traffic Control Plan. Permittee shall comply with all traffic warning and control devices, signs, and plans described in the Work Area Traffic Control Handbook or the Manual on Uniform Traffic Control Devices (MUTCD) 2003 California Supplement. At least 10 business days in advance of implementing traffic control measures the permittee shall contact trafficcontrol@polb.com and 562-283-7881 to coordinate lane closure dates and hours of work. Please indicate the Harbor Development Permit number in the subject and body of your email.

12 Non-Compliance Penalties: Violation of any provision or condition in this permit shall constitute grounds for revocation of this permit and shall render the permittee liable for civil penalties of up to $10,000.00. Any person who willfully and knowingly conducts work in the Harbor District in violation of the Port Master Plan Guidelines shall be liable for civil penalties of $5,000.00 per violation per day.

ACKNOWLEDGEMENTS

Martha
DIRECTOR OF ENVIRONMENTAL PLANNING

12/21/2017
DATE

SIGNATURE OF PERMITTEE/AGENT

1/9/18
DATE

HARBOR DEVELOPMENT PERMIT

4801 AIRPORT PLAZA DRIVE LONG BEACH, CALIFORNIA 90815
TELEPHONE: 562-283-7100 FAX: 562-283-7148

PAGE 3 OF 3

PERMIT NUMBER	ISSUE DATE	EXPIRATION DATE	EXTENSION DATE	NOTE
HDP-17-084	12/21/2017	12/21/2019		

13 Hazardous Material: If during the course of the permitted project permittee shall discover or have reason to believe that material being excavated at the project site contains extremely hazardous wastes or hazardous wastes as those terms are or have been defined by the administrator of the Environmental Protection Agency, the California Department of Toxic Substances Control, or any other person or agency having jurisdiction over the management of hazardous materials, permittee, at its cost, shall: (i) promptly notify the Director of Environmental Planning of the permittees discovery or belief; (ii) at the request of the Director of Environmental Planning, initiate chemical and or physical characterization of the material; (iii) promptly submit all laboratory and test results to the Director of Environmental Planning on receipt thereof; (iv) develop and submit for approval to the Director of environmental Planning a remediation plan providing for the appropriate disposal and or treatment of the contaminated material; (v) implement that plan in accordance with the regulations and orders of the governmental agencies having jurisdiction; (vi) if material is removed, replace all such material with clean fill material that is structurally suitable for the project, and cause the excavation to be backfilled and compacted; and (vii) promptly submit copies of all waste manifests to the Director of Environmental Planning.

14 Indemnity: Permittee shall indemnify the Harbor Department from and against any and all actions, suits, proceedings, claims, demands, damages, losses, liens, costs, expenses, or liabilities of any kind and nature whatsoever ("claims") which may be brought, made, filed against, imposed upon, or sustained by the Harbor Department, arising from, attributable to, caused by, in connection with, or pertaining to the activities described in this permit, except to the extent such claims are caused by the negligence or willful misconduct of the Harbor Department.

SPECIAL CONDITIONS:

1 Permittee shall employ stormwater Best Management Practices (BMP), as appropriate, to control runoff during construction activities. Permittee shall submit a completed stormwater BMP checklist (available at www.polb.com/hdp) to HDPdesk@polb.com prior to that start of ground disturbing activities. Refer to the Stormwater Best Management Practices handbook by the California Storm Water Quality Association (CASQA) for further details on appropriate BMP implementation.

2 Permittee shall notify Port of Long Beach Inspection by phone or email (562-283-7218, inspections@polb.com) a minimum 48 hours in advance of commencement of work or continuation after stoppage of work for 48 hours or more.

ACKNOWLEDGEMENTS

	12/21/2017		1/9/18
DIRECTOR OF ENVIRONMENTAL PLANNING	DATE	SIGNATURE OF PERMITTEE/AGENT	DATE

Port of
LONG BEACH
The Green Port

HARBOR DEVELOPMENT PERMIT

4801 AIRPORT PLAZA DRIVE LONG BEACH, CALIFORNIA 90815
TELEPHONE: 562-283-7100 FAX: 562-283-7148

PAGE 1 OF 3

PERMIT NUMBER	ISSUE DATE	EXPIRATION DATE	EXTENSION DATE	NOTE
HDP-17-081	12/21/2017	12/21/2019		Amendment 1

TYPE OF ACTION:

X CONFORMS TO CALIFORNIA COASTAL ACT OF 1976 AND CERTIFIED PORT MASTER PLAN
X PURSUANT TO SECTION 1215 OF THE LONG BEACH CITY CHARTER
LEVEL I HARBOR DEVELOPMENT PERMIT
____ APPEALABLE UNDER COASTAL ACT SECTION 30715

PERMITEE: Port of Long Beach	**PERMITTEE PHONE:** (562) 283-7100
LEGAL INTEREST: Owner **PERMITEE ADDRESS** 4801 Airport Plaza Drive Long Beach, CA **ZIP** 90815	**CONTACT PERSON:** Paulsen, Eric **TITLE/AFFILIATION:** Senior Program Manager **PHONE:** (562) 283-7100

DESCRIPTION OF APPROVED WORK:

Install one (1) electrical top pick charging station.

Amendment 1: includes installation of additional electrical infrastructures and charging stations at various locations on Pier E-LBCT Terminal for yard trucks and top picks.

LOCATION OF APPROVED WORK:

Pier E, LBCT Terminal. Two site areas: LBCT-1 (west of the rail area), and LBCT 2&3 (south of the Power Shop Building), Long Beach

Drawings: Drawing #501A (1 Page)

CALIFORNIA ENVIRONMENTAL QUALITY ACT DETERMINATION:

X CATEGORICALLY EXEMPT 3 [CLASS]
____ NEGATIVE DECLARATION, ADOPTED ____ [LEAD AGENCY] ____ [DATE]
____ ENVIRONMENTAL IMPACT REPORT, CERTIFIED BY ____ [LEAD AGENCY] ____ [DATE]

MANDATORY FINDINGS:

X THE PROJECT CONFORMS WITH THE ESTABLISHED POLICIES OF THE Middle Harbor PLANNING DISTRICT
X THE PROJECT ____ WILL X WILL NOT HAVE ANY SIGNIFICANT ADVERSE ENVIRONMENTAL IMPACTS
X THE EXECUTIVE DIRECTOR AUTHORIZED ISSUANCE OF THIS PERMIT ON 12/21/2017
____ PUBLIC HEARING NOT REQUIRED PURSUANT TO THE PROVISIONS OF THE CERTIFIED PORT MASTER PLAN
____ A PUBLIC HEARING WAS HELD ON ____ AT ____
____ THE BOARD OF HARBOR COMMISSIONERS AUTHORIZED ISSUANCE OF THIS PERMIT ON ____
BY A ____ TO ____ VOTE
X The Executive Director approved this amendment on 3/14/18.

THIS PERMIT IS ISSUED SUBJECT TO PERMITTEE OBTAINING THE FOLLOWING APPROVALS, AS NECESSARY, AND COMPLYING WITH STATED PERMIT TERMS AND CONDITIONS

X L.B. DEPARTMENT OF PLANNING AND BUILDING
____ L.B. BUREAU OF FIRE PREVENTION
____ REGIONAL WATER QUALITY CONTROL BOARD
____ AIR QUALITY MANAGEMENT DISTRICT
____ U.S. ARMY CORPS OF ENGINEERS
____ HOT PERMIT
X DIG ALERT ____
____ OTHER ____
X THOSE **STANDARD CONDITIONS** SHOWN ON THE ATTACHED **PAGE** OF THIS PERMIT
X THOSE **SPECIAL CONDITIONS** SHOWN ON THE ATTACHED **PAGE(S)** OF THIS PERMIT

ACKNOWLEDGEMENTS

Martha
DIRECTOR OF ENVIRONMENTAL PLANNING

3/20/2018
DATE

I, Suzanne Plezia [PERMITTEE/AGENT] HEREBY ACKNOWLEDGE RECEIPT OF HDP-17-081 AND HAVE ACCEPTED ITS CONTENTS AND CONDITIONS.

SIGNATURE OF PERMITTEE/AGENT

3/22/18
DATE

Port of
LONG BEACH
The Green Port

HARBOR DEVELOPMENT PERMIT

4801 AIRPORT PLAZA DRIVE LONG BEACH, CALIFORNIA 90815
TELEPHONE: 562-283-7100 FAX: 562-283-7148

PAGE 2 OF 3

PERMIT NUMBER	ISSUE DATE	EXPIRATION DATE	EXTENSION DATE	NOTE
HDP-17-081	12/21/2017	12/21/2019		Amendment 1

STANDARD CONDITIONS:

1 Effective Date: This permit shall not become effective until the ORIGINAL has been returned to the Environmental Planning Division, fully signed by the permittee or agent(s) authorized in the permit application. Failure to return the original within thirty (30) days of approval shall render the permit invalid. Other conditions notwithstanding, if the project is appealable the permit shall not become until after the tenth (10th) working day following notification of approval, unless an appeal has been filed with the California Coastal Commission within that time. By executing this permit, permittee or its agent(s) acknowledge that they have received a copy of the fully-signed permit for its use and post said copy conspicuously at the project site.

2 Non-Waiver Condition and Assignment: Nothing in this permit shall be deemed or construed as a waiver of any term or condition contained in permittee lease, preferential assignment, permit, or other agreement with the Long Beach Harbor Commission. This permit shall not be assigned except as provided in the Board of Harbor Commissioners Port Master Plan Implementation Guidelines and in Section 13170 of Title 14 of the California Administrative code, to the extent applicable.

3 Permit Expiration: Work authorized by this permit must commence within two years of the effective date of this permit unless otherwise specified. If work has not commenced, this permit will expire two (2) years from its effective date. Any application for an extension of said commencement date must be made at least thirty (30) days prior to the expiration of this permit.

4 Compliance With Laws and Regulations: Permittee shall comply with all laws, statutes, rules, regulations, and orders of all governmental agencies having jurisdiction over the permittee's project. Permittee, at its own expense, shall obtain all requisite permits, approvals, and consents from the appropriate agencies, including but not limited to the City of Long Beach (COLB) Harbor Department, the COLB Development Services, COLB Fire Department, the South Coast Air Quality Management District, the California Department of Health Services, and the Regional Water Quality Control Board, and shall comply with any such permit, approval or consent. Copies of all requisite permits shall be available for inspection at the project site.

5 Construction Drawings: Final plans and specifications for construction (hard copies and CADD files in Bentley MicroStation format), incorporating any modifications made by the Harbor Department, shall be submitted to the Environmental Planning Division for review and approval prior to commencement of any portion of the development.

6 Notification: Permittee shall notify the Chief Harbor Engineer, in writing, of the anticipated start date of any construction at least ten (10) days in advance.

7 Permission from Property Owner: Permittee shall coordinate with all facilities which may be affected by the permitted project. Permittee shall not interfere with any facility operations. Permittee shall contact the Harbor Department Terminal Services Section at 562-283-7760 for assistance with notifications.

8 Subsurface Construction: Permittee shall consult with the Surveys and Mappings Section of the Harbor Department and Underground Service Alert of Southern California (Dig-Alert) regarding possible interference to underground utilities for all work involving excavation, a minimum of 48 hours in advance. Permittee shall conduct all subsurface work in accordance with Section 5 of the latest edition of Standard Specifications for Public Works Constructions (The "Green Book"). Permittee shall be responsible for all damage to underground structures and utility lines occurring as a result of project construction and shall restore all ground surfaces disturbed by excavation to original conditions, unless otherwise provided for by the permitted project design. This includes, but is not limited to, irrigation lines, water main lines, underground conduit, and surface landscaping. The alignment of any underground utilities that must be relocated as a result of the permitted project must be approved by the Director of Environmental Planning and the utility owner. Permittee, except as otherwise provided for or agreed to, is responsible for any costs associated with repairing, replacing, or relocating underground or surface utilities or landscaping disturbed or destroyed during the permitted project.

9 Conduct of Work: Permittee shall perform all work in strict accordance with the plans and specifications approved by the Harbor Department Environmental Planning Division. For project site preparation and construction activities the permittee shall utilize water trucks and sprinkler systems to minimize dust and releases of materials into harbor waters. Distribution and/or removal of surplus materials (fills, dirt, broken asphalt, etc.) generated by the construction on property under the jurisdiction of the Harbor Commission must have prior approval of the Chief Harbor Engineer.

10 As-built: As-built drawings for construction within the Harbor District (hard copies and CADD files in Bentley MicroStation format) shall be submitted to the Construction Management Division (562-590-4172) of the Harbor Department within thirty (30) days of the completion of work. Except in the case of underground work, final construction drawings may serve as as-builts provided a set of such drawings are submitted and stamped "as-built". For underground work, permittee shall submit to the Construction Mangement Division, within thirty (30) days of completion of the work, two (2) sets of as-built drawings and survey notes, signed by a licensed surveyor who shall certify to the accuracy of the horizontal and vertical alignment. All of said drawings shall be drawn to a scale of no more than one hundred (100) feet to the inch, shall show the accurate alignments by centerline traverses, shall be referenced to all intersections of street property lines and survey points furnished by the Harbor Department, and shall show the elevations of the tops of the pipelines and facilities. All surveys work shall be to the latest third order of accuracy as established by the National Oceanic and Atmospheric Administration surveys.

11 Traffic Management: For all projects that impact Harbor Department roads, permittee shall submit for approval a Traffic Control Plan. Permittee shall comply with all traffic warning and control devices, signs, and plans described in the Work Area Traffic Control Handbook or the Manual on Uniform Traffic Control Devices (MUTCD) 2003 California Supplement. At least 10 business days in advance of implementing traffic control measures the permittee shall contact trafficcontrol@polb.com and 562-283-7881 to coordinate lane closure dates and hours of work. Please indicate the Harbor Development Permit number in the subject and body of your email.

12 Non-Compliance Penalties: Violation of any provision or condition in this permit shall constitute grounds for revocation of this permit and shall render the permittee liable for civil penalties of up to $10,000.00. Any person who willfully and knowingly conducts work in the Harbor District in violation of the Port Master Plan Guidelines shall be liable for civil penalties of $5,000.00 per violation per day.

ACKNOWLEDGEMENTS

Martha	3/20/2018		3/22/18
DIRECTOR OF ENVIRONMENTAL PLANNING	DATE	SIGNATURE OF PERMITTEE/AGENT	DATE

Port of
LONG BEACH
The Green Port

HARBOR DEVELOPMENT PERMIT

4801 AIRPORT PLAZA DRIVE LONG BEACH, CALIFORNIA 90815
TELEPHONE: 562-283-7100 FAX: 562-283-7148

PAGE 3 OF 3

PERMIT NUMBER	ISSUE DATE	EXPIRATION DATE	EXTENSION DATE	NOTE
HDP-17-081	12/21/2017	12/21/2019		Amendment 1

13 Hazardous Material: If during the course of the permitted project permittee shall discover or have reason to believe that material being excavated at the project site contains extremely hazardous wastes or hazardous wastes as those terms are or have been defined by the administrator of the Environmental Protection Agency, the California Department of Toxic Substances Control, or any other person or agency having jurisdiction over the management of hazardous materials, permittee, at its cost, shall: (i) promptly notify the Director of Environmental Planning of the permittees discovery or belief; (ii) at the request of the Director of Environmental Planning, initiate chemical and or physical characterization of the material; (iii) promptly submit all laboratory and test results to the Director of Environmental Planning on receipt thereof; (iv) develop and submit for approval to the Director of environmental Planning a remediation plan providing for the appropriate disposal and or treatment of the contaminated material; (v) implement that plan in accordance with the regulations and orders of the governmental agencies having jurisdiction; (vi) if material is removed, replace all such material with clean fill material that is structurally suitable for the project, and cause the excavation to be backfilled and compacted; and (vii) promptly submit copies of all waste manifests to the Director of Environmental Planning.

14 Indemnity: Permittee shall indemnify the Harbor Department from and against any and all actions, suits, proceedings, claims, demands, damages, losses, liens, costs, expenses, or liabilities of any kind and nature whatsoever ("claims") which may be brought, made, filed against, imposed upon, or sustained by the Harbor Department, arising from, attributable to, caused by, in connection with, or pertaining to the activities described in this permit, except to the extent such claims are caused by the negligence or willful misconduct of the Harbor Department.

SPECIAL CONDITIONS:

1 Permittee shall notify Port of Long Beach Inspection by phone or email (562-283-7218, inspections@polb.com) a minimum 48 hours in advance of commencement of work or continuation after stoppage of work for 48 hours or more.

2 Permittee shall employ stormwater Best Management Practices (BMP), as appropriate, to control runoff during construction activities. Permittee shall submit a completed stormwater BMP checklist (available at www.polb.com/hdp) to HDPdesk@polb.com prior to that start of ground disturbing activities. Refer to the Stormwater Best Management Practices handbook by the California Storm Water Quality Association (CASQA) for further details on appropriate BMP implementation.

ACKNOWLEDGEMENTS

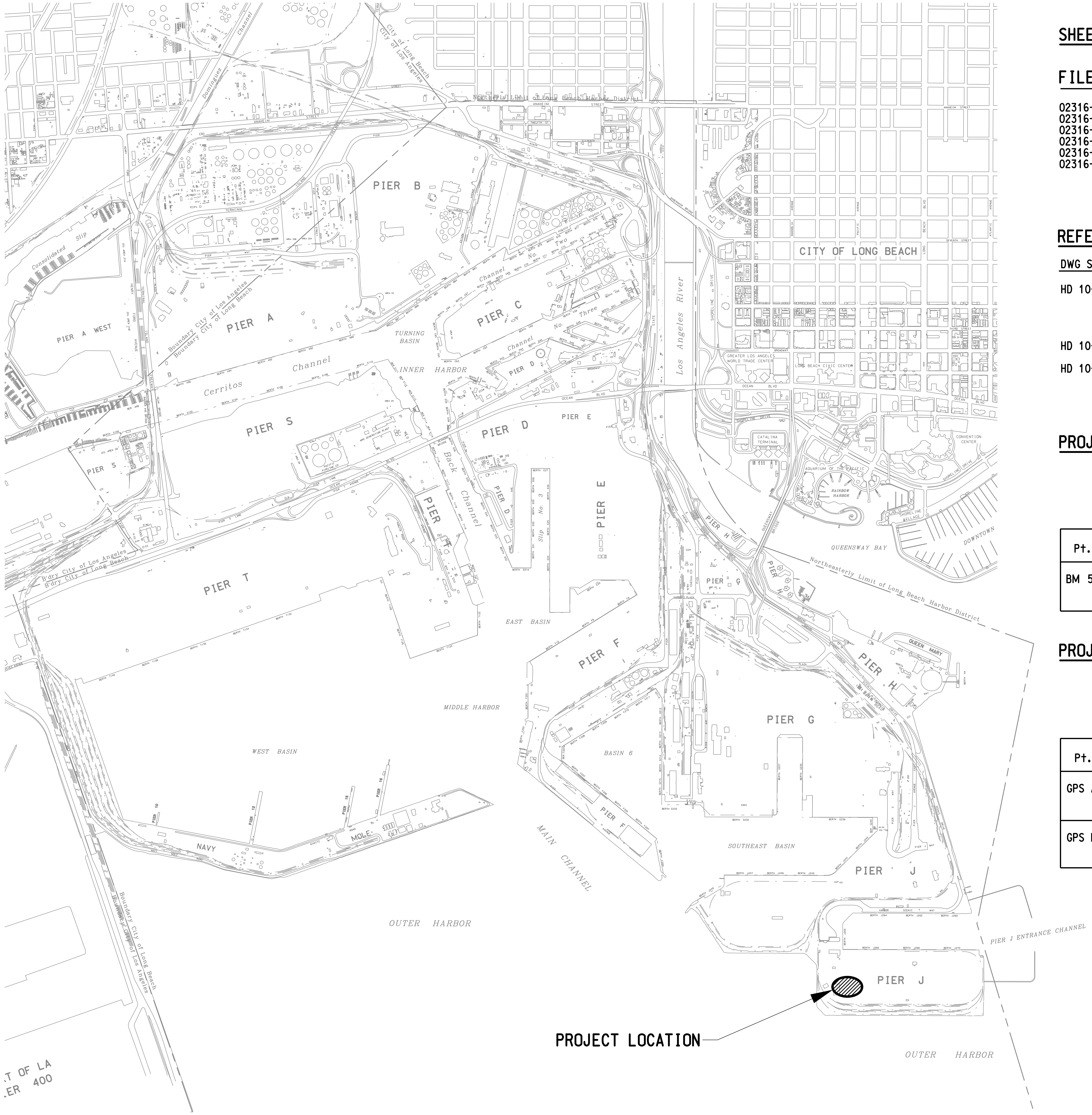
Martha Arm

DIRECTOR OF ENVIRONMENTAL PLANNING

3/20/2018
DATE

SIGNATURE OF PERMITTEE/AGENT

3/22/18
DATE



SHEET INDEX

FILE NAME	DRAWING NUMBER	SHEET NUMBER	SHEET TITLE
02316-0-GN-TT-S001	GN001	1	PROJECT LOCATION AND SHEET INDEX
02316-0-GN-FA-S002	GN002	2	FIRE ACCESS PLAN
02316-0-EL-NO-S003	EL003	3	GENERAL NOTES, SYMBOLS AND ABBREVIATIONS
02316-0-EL-PL-S004	EL004	4	ELECTRICAL LAYOUT PLAN
02316-0-EL-DI-S005	EL005	5	SUBSTATION DS2 ONE-LINE DIAGRAM
02316-0-EL-DT-S006	EL006	6	DETAILS

REFERENCE DRAWINGS

DWG SET NO.	TITLE	YEAR
HD 10-1741	PIERG, BERTHS 232-236 TERMINAL REDEVELOPEMENT BERTH 236 WHARF, LANDFILL AND BACK AREA	2005
HD 10-86	PIER J, BERTH 234 WHARF	1974
HD 10-1045	PIER J, BERTH 232-234 100 FOOT GAGE CRANE RAIL	1987

PROJECT VERTICAL DATUM

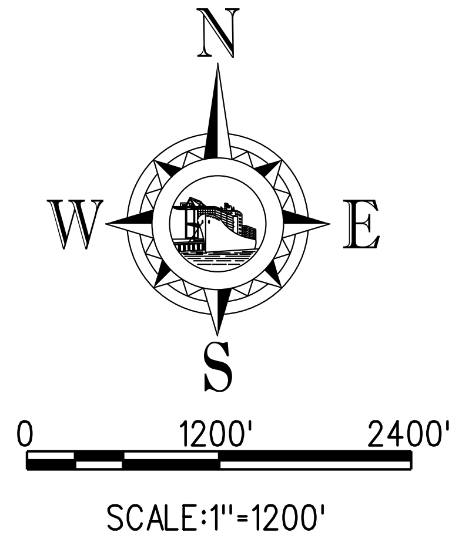
Pt. #	NORTHING	EASTING	ELEVATION	DESCRIPTION
BM 5150	1733309.01	6499658.16	36.06'	2-INCH BRASS DISK ON THE EAST SIDEWALK OF PIER G STREET NEAR THE NORTH ABUTMENT OF THE BRIDGE, APPROX. 200 FEET SOUTH OF HARBOR PLAZA

PROJECT HORIZONTAL DATUM

Pt. #	NORTHING	EASTING	DESCRIPTION
GPS A	1733309.01	6499658.16	POINT A - LOCATED ON EAST SIDEWALK OF PIER G STREET NEAR THE NORTH ABUTMENT OF THE BRIDGE, APPROX. 200 FEET SOUTH OF HARBOR PLAZA
GPS B	1731882.28	6496648.65	POINT B - LOCATED ON THE FACE OF A ROCK ON PIER J, AT THE MOST SOUTHEAST CORNER OF BERTH J260

DIGALERT

SECTION 4216/4217 OF THE GOVERNMENT CODE REQUIRES A DIG ALERT IDENTIFICATION NUMBER BE ISSUED BEFORE A "PERMIT TO EXCAVATE" WILL BE VALID. FOR YOUR DIG ALERT I.D. NUMBER CALL UNDERGROUND SERVICE ALERT TOLL FREE
1-800-422-4133
TWO WORKING DAYS BEFORE YOU DIG.



SCALE:1"=1200'

moffatt & nichol
3780 KILROY AIRPORT WAY
SUITE 600
LONG BEACH, CA 90806
TEL. (562) 426-9551

MARK	DATE	BY	REVISION DESCRIPTION

REGISTERED PROFESSIONAL ENGINEER
TYLER W. SPARKS
E16039
EXP. 09-30-19
ELECTRICAL
STATE OF CALIFORNIA

JOHN Y. CHUN, P.E. NO. C-58867
DIRECTOR OF ENGINEERING DESIGN
DATE

Port of
LONG BEACH
The Green Port

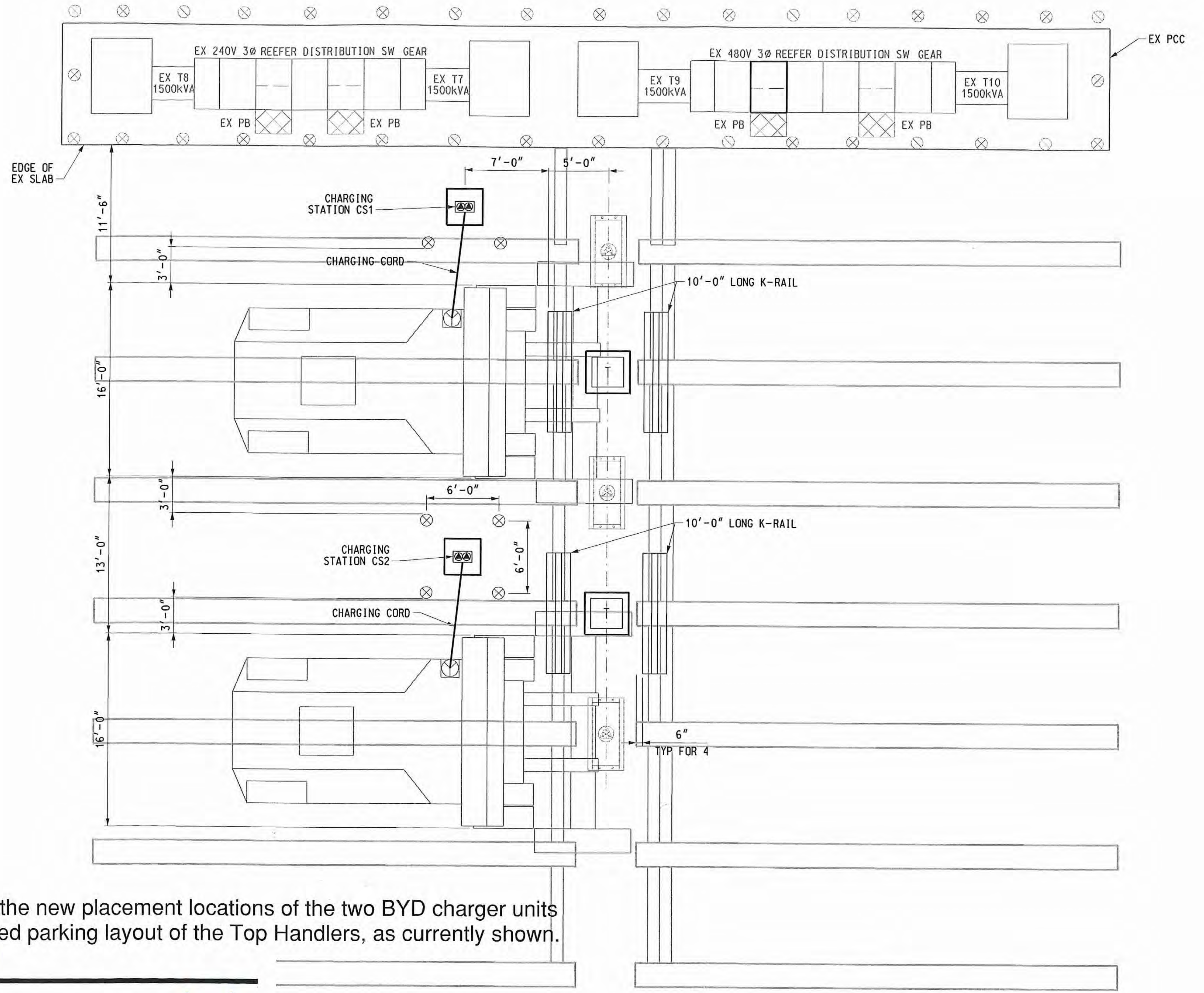
SPEC. NO: S3028
CONSTRUCTION REV:
DATE:
CADD STD. VER: 1.5
CHECKED BY: TS
DATE:
DWG. SCALE: 1"=1200'
DRAWN BY:SC
DATE: 09/27/2018
EPOCH: 2007.0
DESIGNED BY:RN
POLB DM: RG
PROJECT MGR.:
DESIGN MGR.:
POLB PM: FP
HORIZONTAL CONTROL: NAD83-VF
VERTICAL CONTROL: NGVD 29 MLLW

PIER J ZERO EMISSION PHASE 1
TOP HANDLER CHARGING STATIONS
PROJECT LOCATION AND SHEET INDEX

10-02316-GN001

SHEET 1 OF 6

20-SEP-2019 13:25



SSA Marine approves the new placement locations of the two BYD charger units with bollards and revised parking layout of the Top Handlers, as currently shown.

APPROVED BY:

SIGNATURE

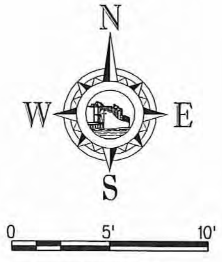
DATE 11/29/18

PRINT NAME Paul Gagnon

PRINT TITLE V.P. SSAT.

PLAN
SCALE: 1"=5'

MINIMUM CHARGING CORD
LENGTH REQUIRED =
5 METERS
NOTE: CORD MUST LAY ON
GROUND TO AVOID STRAIN AT
BOTH CONNECTED ENDS.



SCALE:1"=5'

moffatt & nichol
3780 KILROY AIRPORT WAY
SUITE 600
LONG BEACH, CA 90806
TEL. (562) 426-9551

MARK	DATE	BY	REVISION DESCRIPTION

REGISTERED PROFESSIONAL ENGINEER
TYLER W. SPARKS
E16039
EXP. 09-30-19
ELECTRICAL
STATE OF CALIFORNIA

JOHN Y. CHUN, P.E. NO. C-58867
DIRECTOR OF ENGINEERING DESIGN
DATE

Port of LONG BEACH
The Green Port

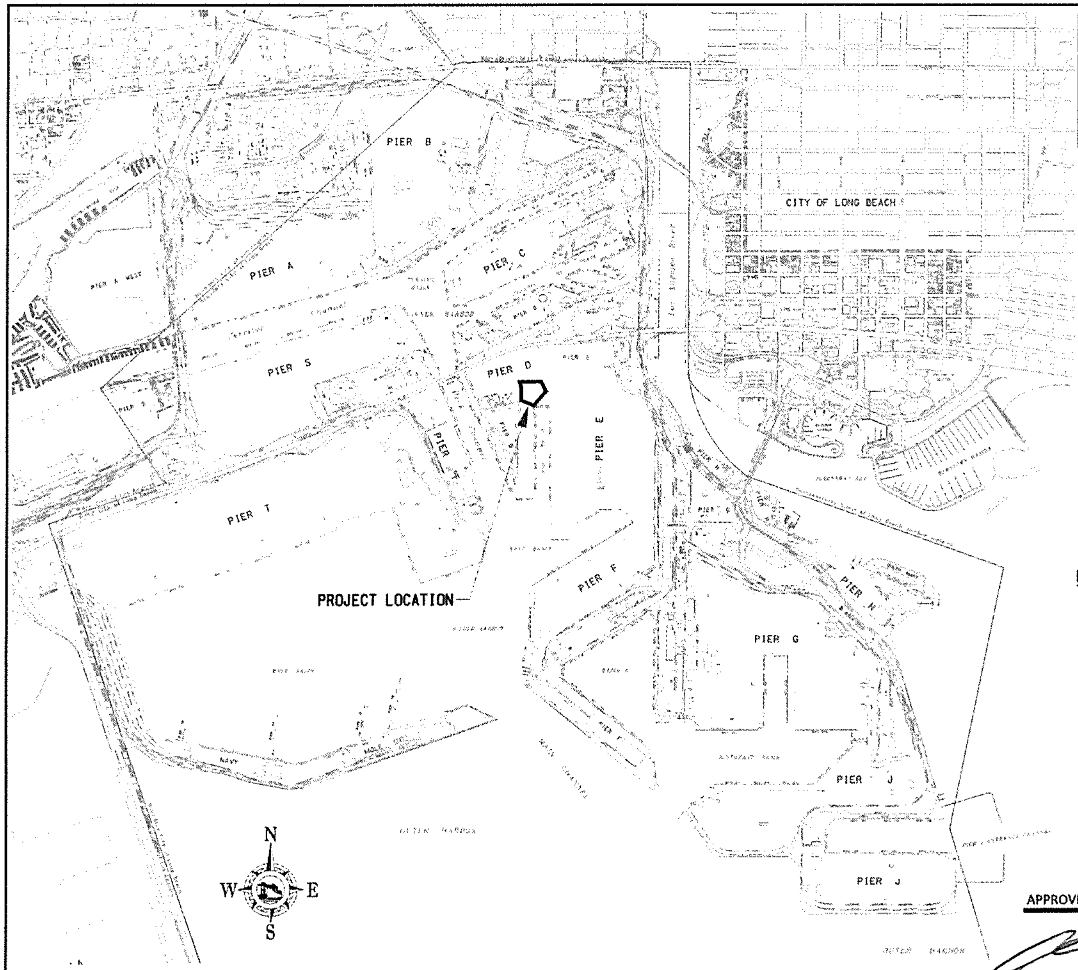
SPEC. NO: S3028
CONSTRUCTION REV:
DATE:
CADD STD. VER: 1.5
CHECKED BY: TS
DATE:
DWG. SCALE: 1"=5'
DRAWN BY:SC
DATE: 08/30/2018
EPOCH: 2007.0
DESIGNED BY:RN
POLB DM: RG
PROJECT MGR.:
DESIGN MGR.:
POLB PM: FP
HORIZONTAL CONTROL: NAD83-VF
VERTICAL CONTROL: NGVD 29 MLLW

PIER J ZERO EMISSION PHASE 1
TOP HANDLER CHARGING STATION
LAYOUT SKETCH

10-02316-SK001
SHEET 1 OF 2

19-NOV-2018 09:18

pw://plbv019.polb.local:POLBOI/Documents/2 Projects/HAI478/5.0 Drawings/5.2 Design/Project Consultants/02316-0-SK-PL-SK01.dgn



CONTRACTOR TO CONTACT UNDERGROUND SERVICE ALERT AT 811 TWO WORKING DAYS PRIOR TO EXCAVATION.

SCOPE OF WORK

PROJECT INCLUDES INSTALLATION OF CHARGING STATIONS FOR ELECTRIC YARD HOSTLERS AND TOP PICKS. THIS INCLUDES ALL EQUIPMENT REQUIRED TO SUPPLY POWER TO THE CHARGING STATIONS AND THE CONCRETE PADS FOR THE CHARGING STATIONS.

CODES AND STANDARDS

CALIFORNIA BUILDING CODE (CBC) - 2016
CALIFORNIA MECHANICAL CODE (CMC) - 2016
CALIFORNIA ELECTRICAL CODE (CEC) - 2016
CALIFORNIA PLUMBING CODE (CPC) - 2016
CALIFORNIA FIRE CODE (CFC) - 2016
CALIFORNIA ENERGY CODE - 2016

NFPA 72 - 2016

SHEET INDEX

DRAWING NUMBER	SHEET. NO.	SHEET TITLE
10-02314-EL001	001	PROJECT LOCATION, SHEET INDEX, AND NOTES
10-02314-EL002	002	GENERAL NOTES
10-02314-EL003	003	LEGEND AND ABBREVIATIONS
10-02314-EL004	004	SINGLE LINE DIAGRAM
10-02314-EL005	005	EQUIPMENT ELEVATIONS
10-02314-EL006	006	AREA PLAN
10-02314-EL007	007	ENLARGED AREA PLAN
10-02314-EL008	008	DETAILS
10-02314-EL009	009	FIRE ACCESS PLAN

REFERENCE DRAWING LIST

DWG. SET NO.	TITLE	YEAR
HD 10-1891	PIERS D, E, & F BERTHS D28-D31, E11-E27, F1-F6	2010
HD 10-02049	PIER E TERMINAL CONTAINER YARD/INTERMODAL RAILROAD PHASE 1.	2012
HD 10-02068	PIER E MIDDLE HARBOR TERMINAL MARINE OPS BLDG & POWER SHOP	2013

PROJECT DATUM

HORIZONTAL DATUM:

NORTH AMERICAN DATUM 1983 (NAD83) COORDINATES, CALIFORNIA COORDINATE SYSTEM ZONE 5 EPOCH 2007

VERTICAL DATUM:

CBM GPS 5320, ELEVATION=20.52 MLLW MAY 1990, FOUND 1" BRASS DISK STAMPED "5320" SOUTHEAST CORNER OF PIER E STREET AND PICO AVE ON NORTHEAST CORNER OF CATCH BASIN.

APPROVED BY: Kevin Hayes

SIGNATURE

DATE 19.08.2018

PRINT NAME Kevin Hayes

PRINT TITLE Sr. Vice President

LONG BEACH CONTAINER TERMINAL, INC.

P2S
Port of LONG BEACH The Green Port

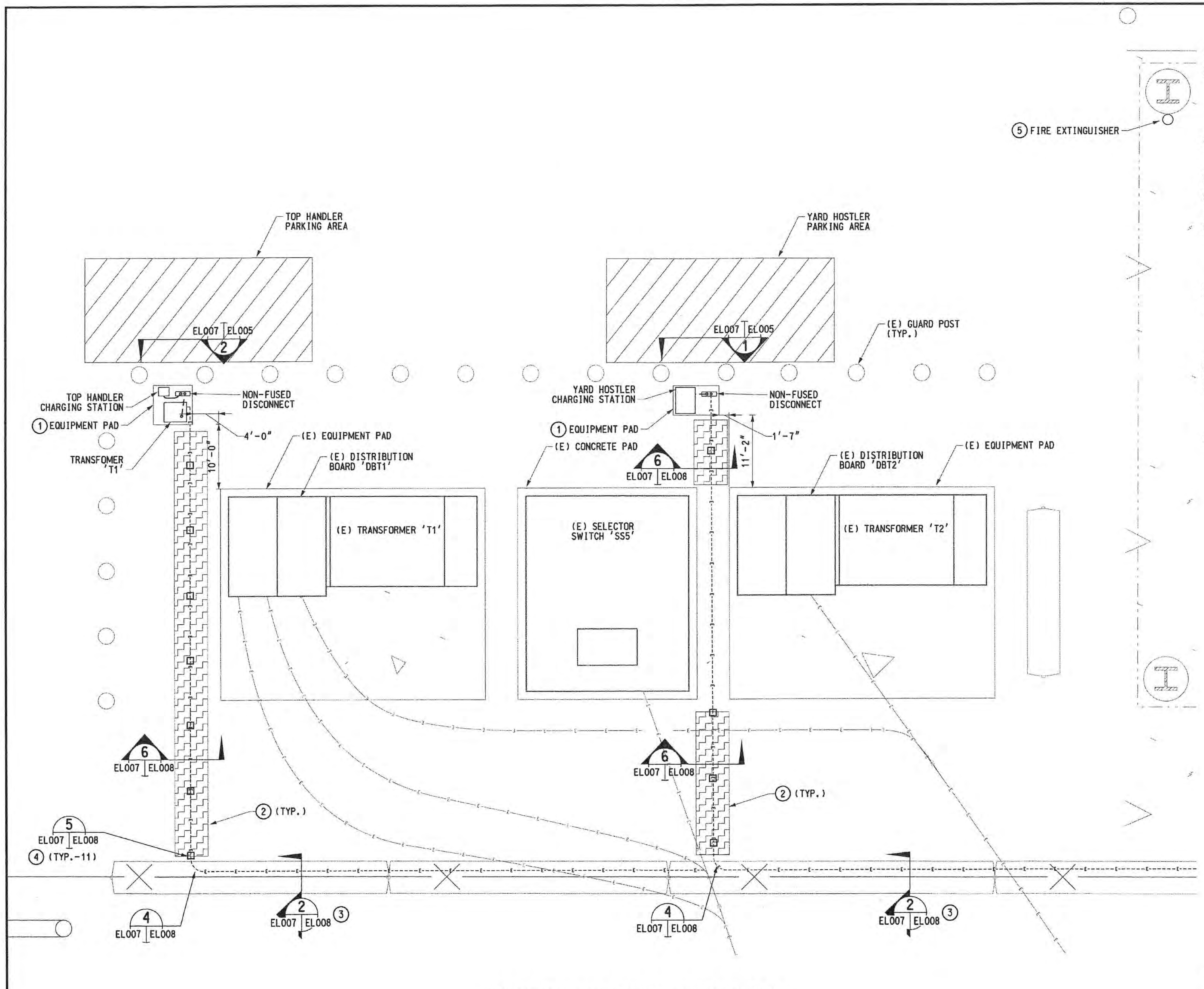
SPEC. NO: HD-S3032
CADD STD. VER: 1.5
DWG. SCALE: NONE
EPOCH: 2007
PROJECT MGR.: KS KS
HORIZONTAL CONTROL: NAD83 ZONE 5
CONSTRUCTION REV:
CHECKED BY: MC MC
DRAWN BY: JV JV
DESIGNED BY: DI DI
DESIGN MGR.: KS KS
VERTICAL CONTROL: NGVD 29 MLLW
DATE:
DATE: 07/03/2018
DATE: 07/03/2018
POLB DM: RG
POLB PM: FP

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
PROJECT LOCATION, SHEET INDEX, AND NOTES

10-02314-EL001
SHEET 001 OF 009

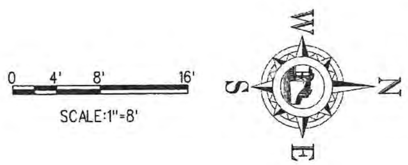
07-SEP-2018 10:14

001.CoverSheet.02314-C-EL-Fr-S00.dgn
VERSION 1



AGV TEST AREA - POWER & TELECOM PLAN

SCALE: 1/8"=1'



CONSTRUCTION NOTES:

① SAWCUT AND REMOVE (E) AC PAVING AND BASE FOR INSTALLATION OF CHARGING STATION CONCRETE PAD. CONSTRUCT (N) AC PAVING AND BASE TO MATCH THE (E) PAVING. SEE DETAIL 5, EL007 FOR EXISTING PAVING SECTION DETAILS.

② PROVIDE AND INSTALL 3/8" TREADPLATE HOSE RAMP. BEACON BFHCR 24-36-4-4H OR APPROVED EQUAL.

③ ATTACH CONDUITS TO (E) K-RAIL.

④ SAWCUT AND REMOVE (E) PAVING TO 12" DEEP AND FILL WITH CONCRETE.

⑤ INSTALL FIRE EXTINGUISHER IN WEATHERPROOF BOX ON (E) COLUMN.

GENERAL NOTES:

1. NEW WORK IS SHOWN BOLD. ALL OTHER EQUIPMENT IS EXISTING TO REMAIN AND SHALL BE PROTECTED IN PLACE, U.O.N.

FIRE ACCESS NOTES:

1. (E) ELECTRICAL EQUIPMENT IS IN LOCKED NEMA 3R ENCLOSURES AND NOT ACCESSIBLE BY UNQUALIFIED WORKERS, SO NO (E) FENCE IS INSTALLED.
2. SEE EL009 FOR FIRE ACCESS PLAN.

P2S ENG
Long Beach | Los Angeles
San Diego | San Jose
p2sinc.com

MARK	DATE	BY	REVISION DESCRIPTION

JOHN Y. CHUN, P.E. NO. C-58867
DIRECTOR OF ENGINEERING DESIGN
DATE 9/11/18

Port of LONG BEACH
The Green Port

SPEC. NO: HD-S3032
CADD STD. VER: 1.5
DWG. SCALE: AS NOTED
EPOCH: 2007
PROJECT MGR.:KS KS
HORIZONTAL CONTROL: NAD83 ZONE 5
CONSTRUCTION REV: DATE:
CHECKED BY: MC MC DATE: 07/03/2018
DRAWN BY: JV JV RL DATE: 07/03/2018
DESIGNED BY: DI DI POLB DM: RG RG
DESIGN MGR.:KS KS POLB PM: FP FP
VERTICAL CONTROL: NGVD 29 MLLW

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
ENLARGED AREA PLAN

10-02314-EL007
SHEET 007 OF 009

07-SEP-2018 10:15

_007_EnlargedAreaPlan_02314-0-EL-PL-0007.dgn
VERSION 1

CITY OF LONG BEACH

SI

DEPARTMENT OF DEVELOPMENT SERVICES
Website: www.lbds.info
333 W. OCEAN BLVD, 4TH FLOOR • LONG BEACH, CALIFORNIA 90802 • (562) 570 - 5237 FAX (562)570-6753
TDD (562)570-6793

24 Hour Inspection Request - Phone 570-6105

1521 PIER J BELE220716

Job Description

Job Address: 1521 PIER J AVE
Project Number: **BELE220716**
Description: Electrical: Install ation of electrical vehicle charging station for top pick handle

Present Bldg Use:	Terminal	Receipt Number:	03399200	Date:	11/12/201
Proposed Bldg Use:	Terminal	Valuation:	$ 0	Bldg Height:	
Type of Construction:		Occupancy Type:		Census Tract:	575600
Assessor Number	7436023905	Zone:	IP	Council District:	2
Historic Name:		Landmark Name:			

Leo - 714- 7303 / GABE 658-9530

Owner Information

Name: CITY OF LONG BEACH
Mailing Address: 4801 AIRPORT PLAZA, LONG BEACH CA 90815

Applicant Information

Name: CITY OF LONG BEACH

Contractor Information

Name:
Mailing Address:
State License No.:

Payor Information

Paid by: HARBOR ESCROW $293.86 Hansen Escrow (HE)

Fees Paid

PM Surcharge - Technology	$1.40	Electrical Permit	$191.50
PM Surcharge - General Plan Update	$12.06	Permit Filing	$44.90
Plan Retention	$44.00		
		Total Paid:	$293.86

11-13-18- 061 A/SI
03/15/19 210C Smm
03/19/19 061A/164 P Smm
8-15-19- 063/064/C/C/SI
10-2-19- 067/064/P/SI
11-4-19-069/0642/C/SI

FINAL
11-6-19- INGRAM

INSPECTOR'S OFFICE HOURS 3:30 – 4:15 P.M. DAILY

LONG BEACH DEVELOPMENT SERVICES

CITY of LONG BEACH

24-HOUR INSPECTION REQUEST 570-6105
BUILDING INSPECTION / INFO: 570-LBDS (5237)
CODE ENFORCEMENT INFO: 570-CODE (2633)

NOTICE OF INSPECTION

JOB ADDRESS: 201 S. PICO

CASE NUMBER: BELE 220717

PARTIAL ELECTRICAL INSPECTION
ELECTRICAL APPROVED
AND FINALED

1-2-2020
DATE

INGRAM
INSPECTOR'S SIGNATURE

☒ BUILDING ☐ CODE ENF.

PHONE # (562)570-6508

BL-84-V (5/17)

4-EL003	003	LEGEND AND ABBREVIATIONS
4-EL004	004	SINGLE LINE DIAGRAM
4-EL005	005	EQUIPMENT ELEVATIONS
4-EL006	006	AREA PLAN
4-EL007	007	ENLARGED AREA PLAN
4-EL008	008	DETAILS
4-EL009	009	FIRE ACCESS PLAN

REFERENCE DRAWING LIST

:	TITLE	YEAR
	PIERS D, E, & F BERTHS D28-D31, E11-E27, F1-F6	2010
	PIER E TERMINAL CONTAINER YARD/INTERMODAL RAILROAD PHASE 1.	2012
	PIER E MIDDLE HARBOR TERMINAL MARINE OPS BLDG & POWER SHOP	2013

PROJECT DATUM

DATUM:

CAN DATUM 1983 (NAD83)
, CALIFORNIA COORDINATE
Z 5 EPOCH 2007

VERTICAL DATUM:

CBM GPS 5320, ELEVATION=10.52 MLLW MAY 1990, FOUND 1" BRASS DISK STAMPED "5320" SOUTHEAST CORNER OF PIER E STREET AND PICO AVE ON NORTHEAST CORNER OF CATCH BASIN.

City of Long Beach
Building and Safety Bureau
Permit Plan Check

APPROVED

[illegible]

BY:
DATE: 3/25/18
PERMIT NO. BELE 220717

Port of
LONG BEACH
The Green Port

SPEC. NO: HD-S3032	CONSTRUCTION REV	DATE
CADD STD. VER: 1.5	CHECKED BY: MC	DATE: 01/01/2018
DWG. SCALE: NONE	DRAWN BY: JV	DATE: 01/05/2018
EPOCH: 2007	DESIGNED BY: DI	POLB ENG'RG
PROJECT MGR. KS	DESIGN MGR. KS	POLB PM: FP
HORIZONTAL CONTROL: NAD83 ZONE 5 VERTICAL CONTROL: NAVD 29 MLLW		

PIER E TERMINAL
ZERO EMISSION PHASE 1 - YARD HOSTLER
AND TOP HANDLER CHARGING STATIONS
PROJECT LOCATION, SHEET INDEX, AND NOTES

10-02314-EL001
SHEET 001 OF 009

BELE 220717

BELE 220717

CITY OF LONG BEACH
DEPARTMENT OF DEVELOPMENT SERVICES
333 West Ocean Blvd. 4th Floor • LONG BEACH, CALIFORNIA 90802 • (562)570 - 5237 FAX (562)570-6753
TDD (562)570-5794

December 13, 2019

CITY OF LONG BEACH
4801 AIRPORT PLAZA
LONG BEACH, CA 90815

SUBJECT: 1521 PIER J AVE, LONG BEACH, CA 90802

JOB DESCRIPTION: Electrical: Install ation of electrical vehicle charging station for top pick handlers.

This letter is to inform you that your permit for project # BELE220716, located at the above referenced address, received a final inspection on 11/6/2019 and has been approved.

We appreciate your efforts in improving the City of Long Beach and wish to thank you for the opportunity of serving you. If you have any comments or suggestions on how we might improve our service delivery, please do not hesitate to contact us at (562) 570-5237.

Sincerely,

David Khorram
Superintendent of Building and Safety

CITY OF LONG BEACH

DEPARTMENT OF DEVELOPMENT SERVICES

333 West Ocean Blvd. 4th Floor • LONG BEACH, CALIFORNIA 90802 • (562)570 - 5237 FAX (562)570-6753
TDD (562)570-5794

January 10, 2020

GRIFFITH COMPANY (PW)
12200 BLOOMFIELD AVE
SANTA FE SPRINGS, CA 90670

SUBJECT: 201 PICO AVE, LONG BEACH, CA 90802

JOB DESCRIPTION: Installation of electrical vehicle charging stations for top handlers and yard hostlers.

This letter is to inform you that your permit for project # BELE220717, located at the above referenced address, received a final inspection on 1/2/2020 and has been approved.

We appreciate your efforts in improving the City of Long Beach and wish to thank you for the opportunity of serving you. If you have any comments or suggestions on how we might improve our service delivery, please do not hesitate to contact us at (562) 570-5237.

Sincerely,

David Khorram
Superintendent of Building and Safety

TUV Rheinland of North America, Inc.
295 Foster Street, Suite 100

Littleton, MA 01460

Web: http://www.tuv.com

Equipment type: Electric Vehicle Charging Station
Manufacturer: BYD Motor Inc.
Model number: EVA200KS/01
Serial number: 010449DVJ10800015, 01449DVJ10800014

CLIENT:
BYD Motors Inc
1800 S Figueroa Street
Los Angeles, CA 9005

AUTHORITY HAVING JURISDICTION:
City of Long Beach
Department of Building and Safety

Permit # :
BELE220716

INSPECTION SITE:
Stevdoring Services of America
(SSA)
1521 Pier J Avenue
Long Beach, CA 90802

TRNA file Number (if applicable): 31973126.001
TRNA Project Number: 0234109933
TRNA field label number(s): TUVR-37601, TUVR-37602

Evaluated by:	Reviewed by:
Ivan Obelar October 11, 2019	Stephan Pochon October 11, 2019
Senior Test Engineer Field Evaluation Services Group	Test Engineering Manager TUV Field Evaluation Services Group
Email: iobelar@us.tuv.com	Email: spochon@us.tuv.com

GENERAL CONDITIONS OF ACCEPTANCE AND SCOPE OF INSPECTION

This test report contains only findings and results regarding the indicated equipment for installation at the particular inspection site. It is not intended as an endorsement of the equipment, nor an approval of similar or identical equipment at another location. If this equipment or any of its attendant parts, connections, or components are modified, changed, or replaced in any way after the inspection, the inspection and label are considered void. Re-inspection shall be required.

TRNA's label indicating the equipment as compliant does not relieve the owner/manufacturer of its responsibility for the safe operation of the equipment.

This inspection is intended to address only potential electrical fire and shock hazards to the standards defined in the body of this report. TUV makes no representations or warranties whatsoever regarding any other aspect of the facility or equipment at the facility. This inspection does not include inspection of the suitable operation of the unit and does not include emission tests and locations defined as hazardous by the US National Electrical Code, NFPA 70, current edition

If this evaluation is not performed at the final installation site, the AHJ may require an additional inspection and re-labeling

INSPECTION PROCEDURES

Please refer to the "Standards selected for the evaluation" for additional criteria.

Construction Inspection

The equipment's design was visually inspected with particular attention to the following areas:

- Use of Certified Components
- Proper Motor protection
- Proper Transformer protection
- Proper conductor protection
- Proper wire bending spaces
- Ground and bonding
- Accessibility of live parts
- Wiring ampacity
- Wiring methods
- Guarding of Live Parts
- Guarding of moving parts
- Pinching, crushing, cutting hazards
- Damaged Components
- Accessibility of moving parts
- Temperature, moisture, and UV exposure I conditions
- Sharp edges
- Availability of suitable markings
- Suitability of power connection

If a particular product, system, or component is not identified above, TUV did not separately evaluate or inspect that product, system, or component, and TUV makes no representation or warranties concerning the suitability of that product, system or component for use.

In detail, the following inspections were performed in accordance with the standards referenced or defined in this report.

(a) Grounding and Bonding

Exposed non-current carrying parts of the equipment were inspected for effective grounding and bonding

(b) Guarding of Live and Moving Parts:

All hazardous live electrical components were inspected for installation in a suitable enclosure. Moving parts were inspected for suitable guarding against pinching, crushing or cutting injuries.

(c) Overcurrent, Short Circuit and Overload Protection:

Overcurrent, short circuit and overload protection installed in this equipment were identified to be NRTL Listed or Recognized and of proper size, rating and location.

(d) Internal Wiring:

Internal wiring and wiring methods were evaluated for compliance with applicable provisions of the standards referenced or defined in this report. Wiring was verified to be, properly sized and rated, with a temperature rating suitable for the installed application. Securement, routing and segregation of circuit conductors was determined to be suitable.

(e) Electrical Testing

Non-Destructive Electrical Tests were performed to verify the suitability of operation and safety of the unit. Selection of tests, are dependent on the type of equipment and applicable provisions of the standards referenced or defined in this report. Test data sheets are attached to this report.

(f) Environmental Suitability:

The suitability of the specified equipment and components within known ordinary environmental contexts was evaluated. Outdoor-type equipment was evaluated for suitability for exposure to rain, dust, humidity, and splashing. Enclosures were required to be NEMA-rated. The suitability of the specified equipment and components was not evaluated to any standard, code or guideline not specifically referenced herein.

(g) Installation of the Unit:

It was verified the equipment was installed in accordance with the installation requirements as per NFPA 70 (US Electrical Code) for working areas and power connection. The equipment manufacturer's installation instructions were additionally referenced if provided during the inspection.

(h) **Functional Check:**

A function check of E-Stop, interlock and GFCI protection was made to confirm intended operation of the devices.

(i) Component List

The following safety relevant components were inspected for suitability of electrical rating and NRTL[1] approval. Discrepancies noted during Inspection are noted in the section detailing "Modifications for Compliance".

- Circuit Breakers
- Fuses
- Pushbuttons
- Relays
- Transformers
- Interlocks
- Internal Wires
- Power Cords
- Interconnecting cords
- Motor Controllers
- Motors
- Motor Overload
- Motor Contactors
- Lamps
- Receptacles
- Cables and Wires
- Disconnect Switches
- EMO's
- Power Supplies

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[1] NRTL: Nationally Recognized Testing Laboratory, e.g. TUV Rheinland, UL, CSA, etc.

Description of work ordered / Equipment:

The Field Evaluation of the 200 kW vehicle charger to ANSI/UL 2594 Standard for Safety Electric Vehicle Supply equipment, ANSI/UL 508A Standard for Industrial Control Panels and ANSI/UL 891 Standard for Deadfront switchboards for the evaluation of the bus bar construction aspect only. The 200 kW vehicle charger intent is to provide power to the Top Pick Handler manufactured by Taylor Machine Works, Inc, model ZLC-976. The charger will supply 480 Vac, 3 phase, 240 A for charging purposes through two charging guns (each charging gun is rated for 120 A, 3 phases) for the full capacity of the vehicle charger. The charger can supply the Top Pick Handler 200 kW through two charging guns or 100 kW through one charging gun. The Top Pick Handler has an on-board charger, which rectifies and charges the onboard Vdc batteries. The onboard equipment then converts the Vdc to a Vac for the operation of the electric motor. The Top Pick handler Vdc converter to Vac and the on-board charger, and controls on the Top Pick Handler are not part of this evaluation. Only the safely supplying the Top Pick Handler with 200 kw, 480Vac, 3 phase power to the Top Pick handler through the electric vehicle charger which is covered by this evaluation.
1. Main Listed Circuit Breaker 2. Listed branch circuit breakers 3. Contactor 4. 3R Enclosure – tested on site on a different project, identical enclosures 5. Surge protective devices 6. Vehicle coupler 7. Electric vehicle cable 8. Tin plated copper Bus bars (current density)
Equipment omitted from the Inspection: (If none omitted indicate N/A)
1. The entire Top Pick Handler, model ZLC-976 manufactured by Taylor Machine Works Inc. and all required safety requirements of the truck
2. The on-board charger on the Top Pick Handler
3. Any required bollards for physical protection of the chargers, this must be assessed and requirements enforced by the local AHJ (Authorities Having Jurisdiction).

Date of Inspection(s)

Initial review date:	June 5, 2019
Next review:	N/A
Final review date:	October 11, 2019 - Revised

Standard(s) selected for the Inspection

The below standards were referenced during our inspection. Note: If a standard, code, or guideline is not listed then TUV did not evaluate the equipment to it.

List of standards used by number and edition	
US NEC	NFPA 70: 2017 National Electrical Code
ANSI/UL	UL 2594 Standard for Safety Electric Vehicle Supply Equipment ANSI/UL 508A Standard for Industrial Control Panels ANSI/UL 50E Standard for Enclosures for Electrical Equipment, Environmental Considerations

	ANSI/UL 891 Deadfront Switchboards (for bus bar current density calculations)
NFPA	N/A

Subcontractor information (if applicable):

Company:	N/A
Evaluator:	N/A

DOCUMENTATION SUBMITTED

Installation Instructions:	☒ Provided	☐ Not available
Drawings:	☒ Provided	☐ Not available
Markings:	☒ Provided	☐ Not available
Other		

FIELD INSPECTION TEST DATA:

Total number of units/systems	1				
System or Unit	☐ System		☒ Unit		
Rated voltage:	480	☒ V AC Phase	☐ 1 Phase	☒ 3	☐ V DC
Rated current:	240	A			
Rated frequency:	60	Hz			
Control voltage:	24	☐ V AC	☒ V DC		
Alternate voltages:	N/A	☐ V AC	☐ V DC		
Largest motor:	N/A	☐ HP	☐ kW		
*AFC of Facility Mains:	<10	kA			
**SCCR of equipment	10	kA			
Hazardous location:	☐ Yes ☒ No				
Area classification:	Ordinary				
Location:	☐ Indoors		☒ Outdoors (Note 1)		

Test Parameters

	L_1-L_2	L_2-L_3	L_1-L_3		
Voltage:	Note 2	Note 2	Note 2		
	P(A)	P(B)	P(C)		
Current (amps, max):	Note 2	Note 2	Note 2		
Insulation resistance:	Note 2	MΩ	☐ 500 V DC	☒ 1,000 V DC	
Dielectric withstand test (Alternate) Vdc = Vac x 1.414	N/A	kV	☒ AC ☒ 1 Minute	☐ DC ☐ 1 Second	☒ Pass ☐ Fail
Ground continuity: <0.1Ω	Note 2	Ω	☒ Pass	☐ Fail	
Leakage current (max):	N/A	mA	☐ Pass	☐ Fail	
Branch circuit protection:	400	A	☒ Hardwired	☐ Cord Connected	
Enclosure class: ☒ Metallic ☐ Non-Metallic	☐ NEMA Type 1 ☐ NEMA Type 12		☒ NEMA Type 3 ☐ NEMA Type 4		
E-Stops/Interlocks:	☒ Pass	☐ Fail	☐ N/A		
Rain test:	☒ Pass	☐ Fail	☐ N/A		
GFCI test:	☐ Pass	☐ Fail	☒ N/A		
Additional tests:					
Note: Leakage current tests not required when equipment is hardwired.					

* Available Fault Current = AFC (at connection point of facility mains)
** Short Circuit Current Rating = SCCR, (of equipment)

Note 1 – the identical enclosure has been tested under Project No 163103, Report No 31874271.001, June 24, 2019.

Note 2 – for test results see Multiple Similar Units on Page 8 of this report.

Component Temperatures

Component	Temperature °C			
Serial No	010449DVJ10800015		010449DVJ10800014	
Main Disconnect	36.7	°C	34.7	°C
Contactor 1	31.7	°C	32.3	°C
Contactor 2	30.4	°C	33.9	°C
Circuit Breaker 1 (250A)	31.6	°C	33.8	°C
Circuit Breaker 2 (250A)	30.3	°C	31.5	°C
Bus Bars from Main 400A circuit breaker to 225 A circuit breaker	30.4	°C	34.7	°C
24 Vdc Power Supply	32.1	°C	36.9	°C
Branch circuit protection for 24Vdc power supply	35.8	°C	36.9	°C
Surge protective device branch circuit protection	31.0	°C	32.1	°C
Surge Protective Device	33.0	°C	35.5	°C
Bus Bar L1	30.2	°C	34.4	°C
Bus Bar L2	28.7	°C	30.9	°C
Bus Bar L3	31.0	°C	31.7	°C
Control board	33.1	°C	38.9	°C
EV Cord Bushing	27.9	°C	30.8	°C
Internal Wiring	32.3	°C	32.5	°C
Charging Gun 1	39.3	°C	37.6	°C
Charging Gun 1 EV Cable	34.7	°C	30.4	°C
Charging Gun 2	41.8	°C	45.4	°C
Charging Gun 2 EV Cable	45.7	°C	36.9	°C

Test Comments: Due to the battery status on the truck being greater than 56%, the electric vehicle charger charged the truck at 66% of the capacity of the charger station.

Note that when the truck batteries reach a predetermined charge value, the charger then decreases the full charging to a trickle charge of approximately less than 50% of the capacity of the electrical vehicle charger until truck batteries are fully charged.

Note that all power wire cables, contactor, circuit breakers and bus bars are sized for 120 amp, full load of equipment.

Note that all measured temperature are acceptable according to Table 22 in ANSI/UL 2594 Standard for Safety Electric Vehicle Supply.

Environmental Conditions (optional and for reference only):

Temperature 41.5 ºC Humidity 63 %.

Multiple Similar Units

Serial No.	IR (MΩ)	Leakage (mA)	Ground Cont. (Ω)	Current (amps)			Voltage			TUV RNA Label #
				A	B	C	L_1-L_2	L_2-L_3	L_1-L_3	
010449DVJ108 00015	2 G	N/A	0.02	162.7	163.9	160.5	477.8	478.3	478.6	TUVR-37601
010449DVJ108 00014	2G	N/A	0.03	166.4	165.9	166.6	477.4	475.3	476.1	TUVR-37602

If Batch/Lot Inspection and testing is conducted, specify the number of units in the batch and the number of units sampled. Sample selection shall be random, avoiding consecutive numbering if possible and taken from the beginning, middle and end of the lot or batch. If non-conformity is found in any of the units, the entire lot or batch shall be inspected and tested. A batch inspection is limited to 500 units of the same model at one time. See Annex B of NAM FES Procedure MS-0014396.

Number of units in the batch: 2

Number of units Sampled: 2

Test Equipment

Device	Manufacturer	Model	Serial Number	Calibration Due Date	Functionality Checked P/F
DMM TRMS Multimeter	Fluke	376	29720181WS	4/12/2020	P
Insulation Tester	Fluke	1503	28750204	4/12/2020	P
IR Thermometer	Fluke	568	28980021	4/18/2020	P
AC Voltage Module	Fluke	V3000FC	34410086	4/12/2020	P
AC Voltage Module	Fluke	V3000FC	34410082	4/12/2020	P
AC Voltage Module	Fluke	V3000FC	34410076	4/12/2020	P
AC Current Iflex Module	Fluke	A3001FC	32520017WS	4/12/2020	P
AC Current Iflex Module	Fluke	A3001FC	32520018WS	4/12/2020	P
AC Current Iflex Module	Fluke	A3001FC	32810170WS	4/12/2020	P
Notes:					

Required Markings:

1. Fuse replacement value (Warning - Risk of Fire. Replace only with same type and rating fuse)	☐ **Add** ☒ **Provided** ☐ **NA**
2. Door service caution (Caution – Risk of Electric Shock. Disconnect from Power Before Servicing)	☐ **Add** ☒ **Provided** ☐ **NA**
3. Nameplate/electrical ratings (Nameplate Ratings as measured/calculated from "Test Details")	☐ **Add** ☒ **Provided** ☐ **NA**
4. Arc flash warning (Danger – Arc flash and shock hazard. Appropriate PPE required.)	☐ **Add** ☒ **Provided** ☐ **NA**
5. Other: (Lockout , HV, Disconnect power warning labels required on all panel doors/covers)	☐ **Add** ☒ **Provided** ☐ **NA**
6. All Markings Shall be in English or symbols as indicated by the Standard	☒ **Pass** ☐ **Fail**

Modifications for Compliance: ☐ Open ☒ Completed and Accepted

General:

- Reference FES procedure and specified Standard for Safety identified on page 5.
- Hazardous voltage labels (permanent) shall applied to all electrical control panels with voltages 30 Vrms or higher. (See required Markings table above).
- Machine nameplate shall include the largest motor/or load rating, AIC or SCCR rating and enclosure type.
- The constructions issues listed below shall be resolved before receiving final Acceptance and Labeling.

1 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

Electric Vehicle Charger Cabinet/7.4.2.1 A polymeric material used for enclosures of live parts shall comply with Table 4.

Non-conformance -The acrylic dead front, which is installed to prevent contact with live un-insulated parts, is within ½ inch of the main 400 A UL Listed UL 489 circuit breaker. However the acrylic does not comply with Table 4 as required.

The acrylic shall be replaced with a polymeric material that has all the required CTI, HWI and HAI characteristics. Note that the voltage from phase to ground is 277 Vac.

Corrective Action – the acrylic deadfront replaced with a sheet metal deadfront forming an electrical enclosure preventing contact with live un-insulated parts as required.

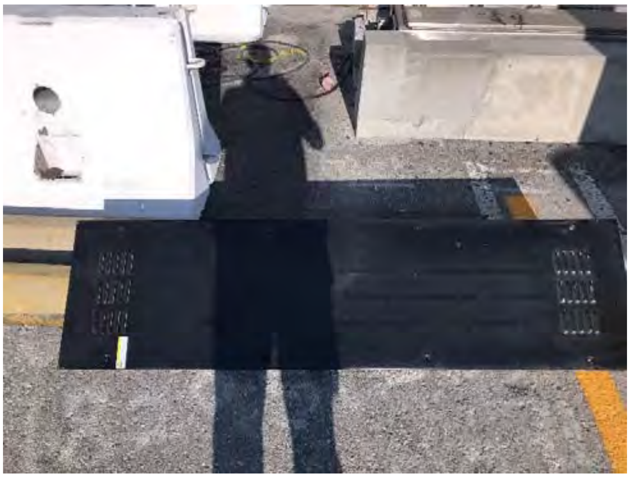
2 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

7.5.1.2 Enclosures, regardless of the materials, shall not be provided with ventilation openings unless designated as Type 1 or Type 2 enclosures.

Non-conformance -The Charging Station is provided with ventilation openings however the enclosure is not a Type 1 or Type 2, the enclosure is intended for a Type 3R.

A Type 3R shall not be provided with ventilation openings as per the ANSI/UL 2594.

Corrective Action - the ventilation openings have been closed and sealed from the inside of the enclosure panel.



3 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

7.7.1 All enclosures shall be rated for one of the enclosure types in Annex A, Ref. No. 20. The enclosure rating shall be appropriate for the intended conditions of use.

Non-conformance -The enclosure is not a Listed Enclosure to ANSI/U 50E Standard for Electrical Equipment Environmental Considerations.

Considerations for an outdoor application which is exposed to all the local weather conditions.

Corrective Action – The enclosure has been evaluated to ANSI/UL 50 Standard for Enclosures for Electrical Equipment, non-Environmental Considerations and tested as per ANSI/UL 50 E Standard for Electrical Equipment Environmental Considerations to assure the enclosure can be exposed to the local weather conditions. The testing on an identical design has been conducted with passing results. The results are documented on Report No 31874271.001 issued on Jun 24, 2019 Project No 163103.

4 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

8.2.1 To reduce the risk of unintentional contact that results in electric shock from an uninsulated live part or film-coated wire, an opening in an enclosure shall comply with either:

a) For an opening that has a minor dimension less than 25.4 mm (1 inch), such a part or wire shall not be contacted by the probe illustrated in Figure 6, or

b) For an opening that has a minor dimension of 25.4 mm (1 inch) or more, such a part or wire shall be spaced from the opening as specified in Table 8

Non-conformance -The acrylic dead front has large gaps, which allow access to live uninsulated bus bars.

The openings in the dead front shall not allow access to the live uninsulated parts.

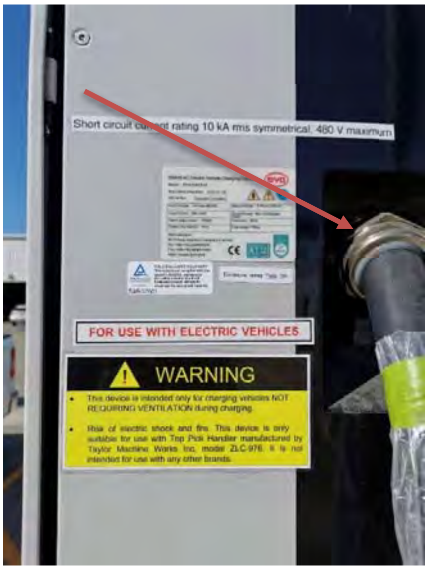
Corrective Action – The acrylic dead front was replaced with a sheet metal deadfront and also the gaps have been reduced such that live uninsulated parts could not come in contact.

5 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

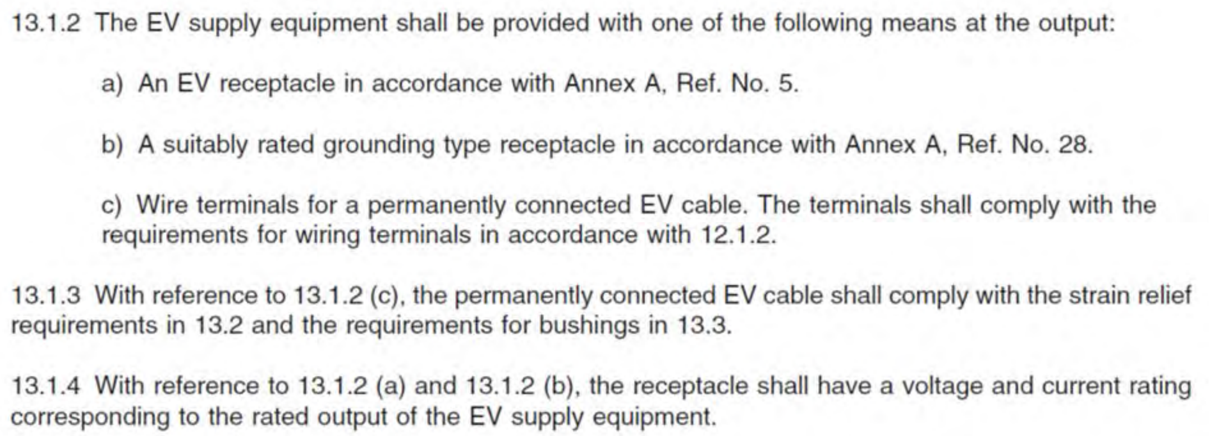
13.1.3 With reference to 13.1.2 (c), the permanently connected EV cable shall comply with the strain relief requirements in 13.2 and the requirements for bushings in 13.3.

Non-conformance -It cannot be confirmed that the bushing where the EV cable enters the enclosure complies with the strain relief requirements as required.

Corrective Action – The bushing has been confirmed that it complies with the strain relief requirements Paragraph 13.2.



6 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment



13.1.2 The EV supply equipment shall be provided with one of the following means at the output:

a) An EV receptacle in accordance with Annex A, Ref. No. 5.

b) A suitably rated grounding type receptacle in accordance with Annex A, Ref. No. 28.

c) Wire terminals for a permanently connected EV cable. The terminals shall comply with the requirements for wiring terminals in accordance with 12.1.2.

13.1.3 With reference to 13.1.2 (c), the permanently connected EV cable shall comply with the strain relief requirements in 13.2 and the requirements for bushings in 13.3.

13.1.4 With reference to 13.1.2 (a) and 13.1.2 (b), the receptacle shall have a voltage and current rating corresponding to the rated output of the EV supply equipment.

Non-conformance – The charging gun (vehicle coupler) is not a NRTL (Nationally Recognized Testing Laboratory) Listed device to ANSI/UL 2551 Standard for Electric Vehicles (EV) Charging System Equipment as required.

Either the device will need to be replaced with a NRTL (Nationally Recognized Testing Laboratory) Listed device or a separate project opened to be tested at a TUV Rheinland facility to the ANSI/UL Standard listed above.

Corrective Action – BYD has opened a separate project for a certification of the vehicle coupler in question. The vehicle coupler has completed the certification process with passing results and is now a Listed device. The BYD vehicle coupler is now part of the TUV Rheinland Follow-Up program as part of the TUV Certification.

The vehicle coupler has been replaced with a TUV Rheinland Listed vehicle coupler with the proper TUV Rheinland Listing Mark.

The TUV Certification is attached to the end of the report and can be verified on TUV Certipedia at https://www.certipedia.com/certificates/50422962?locale=en .

7 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.7 EV cables provided to complete the connection from the EV supply equipment to the vehicle shall be in accordance with Annex A, Ref. No. 3.

13.1.8 The EV cables shall be type EV, EVJ, EVE, EVJE, EVT, or EVJT, and shall have a minimum voltage rating corresponding to the overall output rating of the EV supply equipment.

Non-conformance – The EV cables for the connection of the electric vehicle is not a NRTL (Nationally Recognized Testing Laboratory) Listed to ANSI/UL 62 Standard for Flexible Cord Sets and Power Supply Cords as required.

Corrective Action – the cable has been tested by TUV Rheinland (separate project) to ANSI/UL 62 Standard for Flexible Cords and Power Supply Cords with passing results.

The cables have been replaced with cables that have been tested, inspected and properly labeled at the wire factory.

The TUV Certification is attached to the end of the report and can be verified on TUV Certipedia at https://www.certipedia.com/certificates/50422964?locale=en.

8 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.9 The EV cable shall contain conductors that are suitably sized for the intended output rating of the EV supply equipment.

Non-conformance – The output EV cable for the connection of the electric vehicle to the charger station is a marked 35mm² which is equivalent to 2 AWG. This cable is not properly sized for the output of the charging station gun which is 120 A (100kW, @480Vac, 3 phase, 4 wire plus ground, 60 Hz). The current cable is 4W + Gnd (4 current carrying conductors). Table 400.5(A)(2) in the 2017 National Electrical Code states that a 2 AWG cord with 3 current carrying conductors is suitable for 112 A.

However according to Article 400.5(A) of the National Electrical Code, since there are 4 current carrying conductors (neutral) an Adjustment Factor of 80% shall be applied to the 112A which equates to 112A x 80% = 90 ampacity.

The cable shall be replaced with a properly sized cable that has an ampacity of 120A with the properly adjustment factors applied.

Corrective Action – The 2 AWG cable has been found acceptable using Table 400.5(A)(2) by determining and assuring that the termination at both ends of the cable are rated for 90 °C conductors and the output cable has a Listed temperature rating of 105 °C.

In view of this Table 400.5(A)(2) for 2 AWG cord column F, has an ampacity of 152 Amps. With 4 current carrying conductors in the cable, 80% of 152 Amps = 121.6 Amps. The marked and measured load is 120 A (verified during testing) does not exceed the allowable ampacity of the cable with the adjustment factor.

9 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.14 External connections at the output of EV supply equipment or at the vehicle connector shall be protected by a means that de-energizes the cable conductors and vehicle connector upon exposure to a strain that results in a short circuit, separation of the cable from the EV supply equipment or the vehicle connector, or access to uninsulated hazardous live parts. In addition, there shall be no exposure to live parts after de-energization occurs. If breakaway couplings are used, they shall comply with Annex A, Ref. No. 5

Non-conformance – It cannot be determined if there is a circuit or a form of protection that will de-energize the cable conductors and vehicle connector upon exposure to a strain that results in a short circuit, separation of the cable from the EV supply equipment or the vehicle connector, or access to uninsulated hazardous parts. The above requirements shall be referred to for requirements.

Corrective Action - Objective evidence has been supplied in the form of a circuit analysis of the function of the electrical safety circuits and a video from the local factory in Lancaster, CA. Prior to the test a circuit analyses has been conducted and a test plan was developed to assure the de-energizing of the cable conductor upon strain to the cable.

Note that truck and the on board truck charger is not included in the Final Evaluation of the electric vehicle charger. However the charger is looking for specific signals in order to safely energize and de-energize the electric vehicle charger.

Circuit analysis and test results are acceptable and the compliance with this requirement is confirmed compliant.

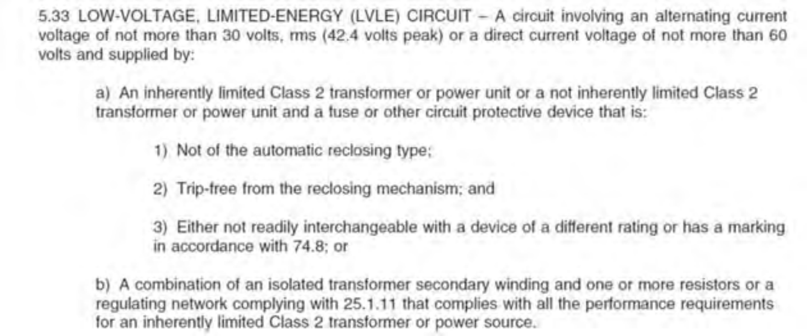
10 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.15 Any connection at the output that is not a power-carrying conductor (a signal wire) shall be LVLE.

Non-conformance – It cannot be determined that all signal wires are a LVLE circuit as defined in the ANSI/UL 2595 Electrical Vehicle Supply Equipment.

Note that the 24 Vdc power supply is a UL Listed Industrial Control Equipment power supply however the output of the power supply is 240W, 24Vdc and is not a Class 2 source as required.

Corrective Actions – Additional fusing of 4 amps fuses were added to the output of the 24 Vdc power supply limiting the signal power (to LVLE circuits) in the output power cable to the truck to be charged.



5.33 LOW-VOLTAGE, LIMITED-ENERGY (LVLE) CIRCUIT – A circuit involving an alternating current voltage of not more than 30 volts, rms (42.4 volts peak) or a direct current voltage of not more than 60 volts and supplied by:

a) An inherently limited Class 2 transformer or power unit or a not inherently limited Class 2 transformer or power unit and a fuse or other circuit protective device that is:

1) Not of the automatic reclosing type;

2) Trip-free from the reclosing mechanism; and

3) Either not readily interchangeable with a device of a different rating or has a marking in accordance with 74.8; or

b) A combination of an isolated transformer secondary winding and one or more resistors or a regulating network complying with 25.1.11 that complies with all the performance requirements for an inherently limited Class 2 transformer or power source.

11 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

18.2 Nonmetallic materials used to form enclosures shall have a minimum flammability rating in accordance with Table 13.

Non-conformance – The Acrylic cover which is utilized for personnel protection does not have a 5V flammability rating as required.

Note that the acrylic cover is in place to prevent users from contacting live uninsulated bus bars.

Corrective Action – The acrylic sheet has been replaced with a sheet metal dead utilized for personnel protection from coming in contact with live bus bars.

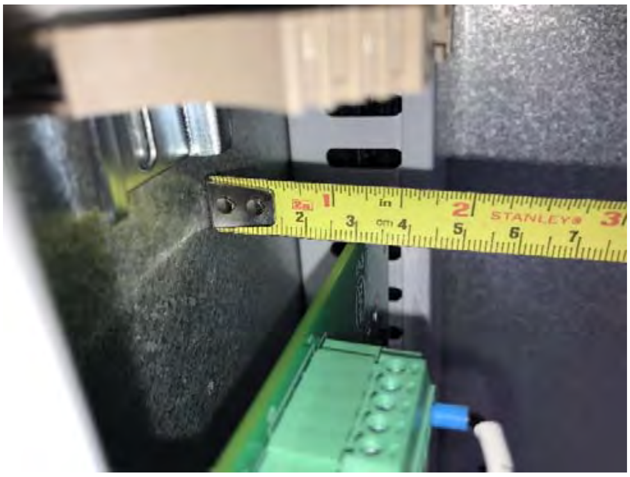
12 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

22.1.1 Except as indicated in 22.1.1.1, the spacings for a device shall not be less than the applicable values specified in Table 14 or as provided in Alternate Spacings – Clearances and Creepage Distances,

23. For spacings requirements where liners and barriers are used, see 22.2.1.

Non-conformance – The spacing from the uninsulated pins that are on the bottom of the printed circuit board which is carrying the line voltage which is 277 Vac to ground does not have the required spacing through air of 1/2 inches.

Corrective Actions – there has been metal spacers installed in the securement screws to increase the creepage and clearance distances from the live un-insulated parts on the printed circuit board.



13 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

24.1.1 Except as indicated in 24.1.1.1, insulated conductors of different circuits within a device, including wires in a terminal box or compartment, shall be either separated by barriers or segregated and shall be so separated or segregated from uninsulated live parts connected to different circuits.

Non-conformance – The 24Vdc control circuit's conductors are not segregated from the 480Vac circuit conductors and are not provided with any barriers.

It cannot be determined the voltage rating of the 24 vdc circuit conductors due to the small gauge conductor and no visible surface marking on the conductors

Reference:

24.1.1.1 For insulated conductors of different circuits, when each conductor is provided with insulation intended for the highest of the circuit voltages, no barriers or segregation are required.

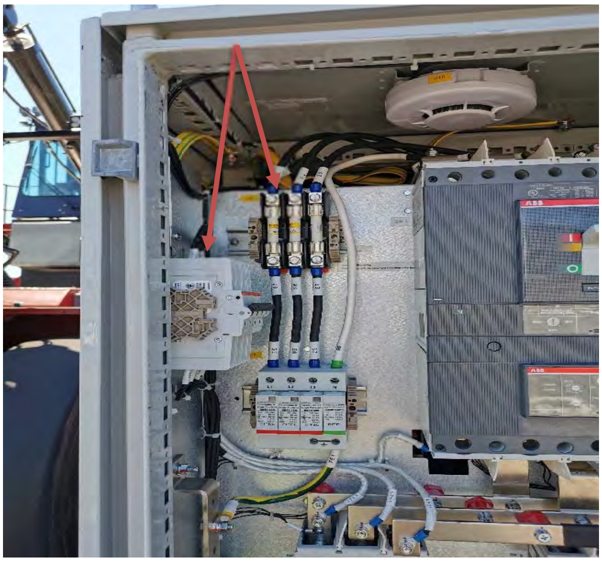
Corrective Action – Objective evidence has been provided showing that the conductor utilized in the 24 Vdc circuit is rated 600 V. No separation of conductors are necessary due to all the conductors are rated for the highest working voltage which is 480 Vac.

14 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

28.2.1 Supplementary protectors shall not be used for overcurrent protection of circuits defined as ″branch circuits″ as defined in Annex A, Ref. No. 1.

Non-conformance – There are supplementary protectors (UL Recognized Component UL 1077) used as overcurrent protection for branch circuits rather than a NRTL (Nationally Recognized Testing Laboratory) Listed UL 489 circuit breakers as required.

Corrective Action – The supplementary protector has been replaced with UL Listed 50 amp Class G fuses and UL Listed circuit breakers as required.



15 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

28.5.1 Circuit breakers incorporated as overcurrent protection shall comply with the applicable requirements in Annex A, Ref. No. 74.

Non-conformance – There are overcurrent protective devices that are not a NRTL (Nationally Recognized Testing Laboratory) Listed circuit breaker to ANSI/UL 489 Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures as required. The circuit breakers only carry a CE Mark.

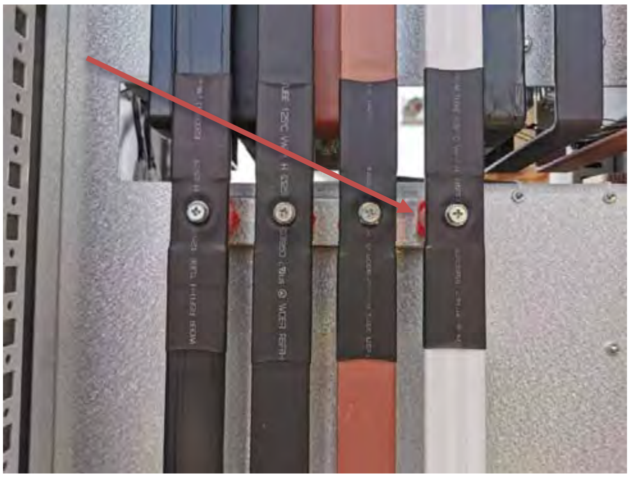
Corrective Action – The overcurrent devices that were not NRTL (Nationally Recognized Testing Laboratory) Listed circuit breaker to ANSI/UL 489 Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures, were replaced with UL Listed UL 489 circuit breakers or UL Listed branch circuit type fuses as required.

16 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

31.1 An insulating material used for supporting live parts and a barrier material shall be moisture-resistant and not be adversely affected by the temperature and stresses to which it is subjected under conditions of use.

Non-conformance – There is no information on the busbar isolators which are supporting the live uninsulated bus bars.

Corrective Action – Objective evidence has been supplied and verified that the insulating material supporting the bus bar is suitable for supporting live uninsulated busbars.

17 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

72.3 All EV supply equipment shall be marked with the words “For use with Electric Vehicles.” This marking shall be visible during intended use.

Non-conformance – The vehicle charging station is not marked with “For Use with Electric Vehicles” as required.

Corrective Action – The electric vehicle charger has a label affixed to the charger stating “For Use with Electric Vehicles” as required.

18 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

72.4 All EV supply equipment shall be marked with the words "Ventilation Not Required." This marking shall be visible during normal use.

Non-conformance – The Charging Station is not marked with "Ventilation Not required" were visible as required.

Corrective Action – The electric vehicle charger has a label affixed to the charger stating "Ventilation Not Required" as required.

19 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

73.1 A device enclosure shall be marked with the rated enclosure type.

Non-conformance – The enclosure is marked with IP54 rather than a Type as described in the ANSI/UL 2594 as required.

Corrective Action – The electric vehicle charger has a label affixed to the charger stating “3R”. Note that the electric vehicle charger was tested according to ANSI/UL 50E Standard for Safety of Enclosures for Electrical Equipment, Environmental Considerations with passing results.

20 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

74.12 EV cord sets and EV Charging Stations shall be marked with the word “WARNING” and the following or the equivalent: “This device is intended only for charging vehicles not requiring ventilation during charging.”

Non-conformance – The Charging Station is not marked with “WARNING – This device is intended only for charging vehicles not requiring ventilation during charging” as required.

Corrective Action – The electric vehicle charger has a label affixed to the charger stating “WARNING – This device is intended only for charging vehicles not requiring ventilation during charging”.

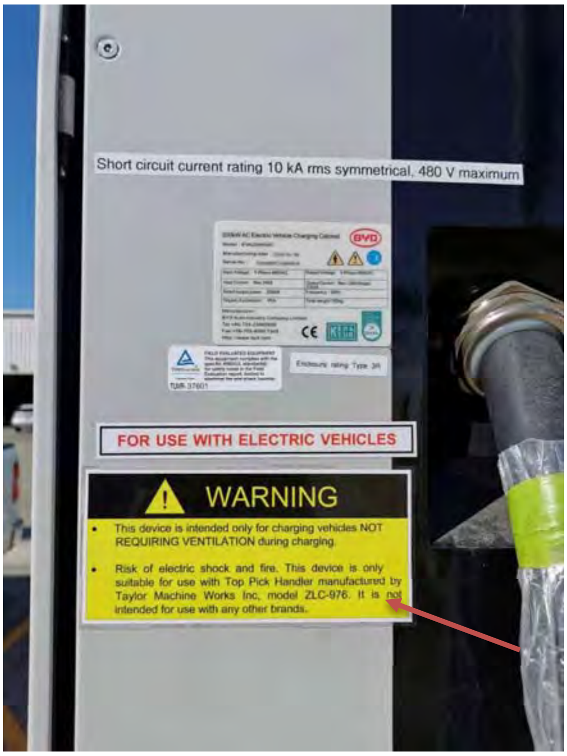
	

21 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

74.14 In accordance with 13.1.5, 13.1.11, and 13.1.12, devices that are intended for use with a specific vehicle shall be marked with the word "WARNING" and the following or the equivalent wording: "Risk of electric shock and fire. This device is only suitable for use with the (Make) (Model). It is not intended for use with any other vehicles." The "make" and "model" of the vehicle shall be added into the marking.

Non-conformance – The Charging Station is not marked with "WARNING – Risk of electric shock and fire. This device is only suitable for use with (Make and model). It is not intended for use with any other vehicles".

Corrective Action – The electric vehicle charger has been marked with "WARNING – Risk of electric shock and fire. This device is only suitable for use with Top Pick Hander manufactured by Taylor Machine Works Inc., model ZLC-976. It is not intended for use with any other brand.", as required.



22 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

(B) Ventilation Not Required. Where marking is required by

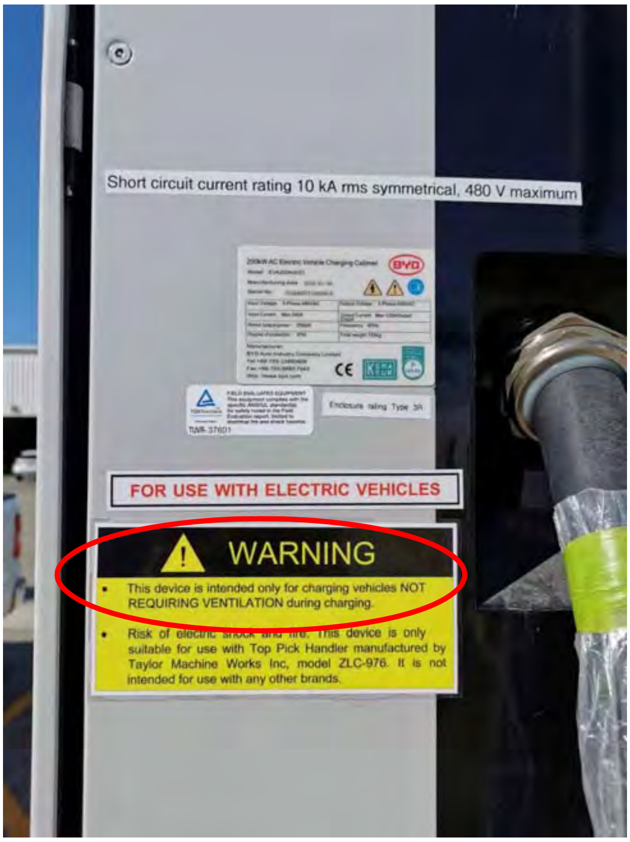
625.52(A), the equipment shall be clearly marked by the manufacturer as follows:

VENTILATION NOT REQUIRED

The marking shall be located so as to be clearly visible after installation.

Non-conformance – The Charging Station is not marked “Ventilation Not Required” as required by the National Electrical Code.

Corrective Action – The electric vehicle charger has been affixed with a label stating “Ventilation Not required” as required.



23 - Equipment/Deviations: 2017 National Electrical Code

625.17 Cords and Cables.

(A) Power-Supply Cord. The cable for cord-connected equipment shall comply with all of the following:

(1) Be any of the types specified in 625.17(B) or hard service cord, junior hard service cord, or portable power cable types in accordance with Table 400.4. Hard service cord junior hard service cord, or portable power cable types shall be listed, as applicable, for exposure to oil and damp and wet locations.

(2) Have an ampacity as specified in Table 400.5(A)(1) or, for 8 AWG and larger, in the 60°C columns of Table 400.5(A)(2).

Non-conformance – The output EV cable for the connection of the electric vehicle to the charger station is a marked 35mm² which is equivalent to 2 AWG. This cable is not properly sized for the output of the charging station gun which is 120 A (100kW, @480Vac, 3 phase, 4 wire plus ground, 60 Hz). The current cable is 4W + Gnd (4 current carrying conductors). Table 400.5(A)(2) in the 2017 National Electrical Code states that a 2 AWG cord with 3 current carrying conductors is suitable for 112 A.

However according to Article 400.5(A) of the National Electrical Code, since there are 4 current carrying conductors (neutral) an Adjustment Factor of 80% shall be applied to the 112A which equates to 112A x 80% = 90 ampacity.

The cable shall be replaced with a properly sized cable that has an ampacity of 120A with the properly adjustment factors applied.

Corrective Action – The 2 AWG cable has been found acceptable using Table 400.5(A)(2) by determining and assuring that the termination at both ends of the cable are rated for 90 °C conductors and the output cable has a Listed temperature rating of 105 °C.

In view of this Table 400.5(A)(2) for 2 AWG cord column F, has an ampacity of 152 Amps. With 4 current carrying conductors in the cable, 80% of 152 Amps = 121.6 Amps. The marked and measured load is 120 A (verified during testing) does not exceed the allowable ampacity of the cable with the adjustment factor.

24 - Equipment/Deviations: 2017 National Electrical Code

625.18 Interlock. Electric vehicle supply equipment shall be provided with an interlock that de-energizes the electric vehicle connector whenever the electrical connector is uncoupled from the electric vehicle. An interlock shall not be required for portable cord-and-plug-connected electric vehicle supply equipment intended for connection to receptacle outlets rated at 125 volts, single phase, 15 and 20 amperes. An interlock shall not be required for dc supplies less than 60 volts dc.

Non-conformance – It cannot be determined if Charging Station is provided with an interlock that de-energizes the electric vehicle connector whenever the electrical connector is uncoupled from the electric vehicle.

Corrective Action - Objective evidence has been supplied by circuit analysis of the function of the electrical safety circuits and a video from the local factory in Lancaster, CA. Prior to the test, a circuit analyses has been conducted and a test plan was developed to assure the de-energizing of the cable conductor upon the uncoupling of the vehicle connector.

Note that truck and the on board truck charger is not included in the Final Evaluation of the electric vehicle charger. However the charger is looking for specific signals in order to safely energize and de-energize the electric vehicle charger.

Circuit analysis and test results are acceptable and the compliance with this requirement is confirmed compliant.

25 - Equipment/Deviations: 2017 National Electrical Code

625.19 Automatic De-Energization of Cable. The electric vehicle supply equipment or the cable-connector combination of the equipment shall be provided with an automatic means to

de-energize the cable conductors and electric vehicle connector upon exposure to strain that could result in either cable rupture or separation of the cable from the electric connector and exposure of live parts. Automatic means to de-energize the cable conductors and electric vehicle connector shall not be required for portable electric vehicle supply equipment constructed in accordance with 625.44(A)

Non-conformance – It cannot be determined if the if the Charging Station is provided with an automatic means to de-energize the cable conductor or the electric vehicle connector upon exposure to strain that could result in the cable rupture or separation of the cable from the electrical connector.

Corrective Action - Objective evidence has been supplied by circuit analysis of the function of the electrical safety circuits and a video from the local factory in Lancaster, CA. Prior to the test a circuit analyses has been conducted and a test plan was developed to assure the de-energizing of the cable conductor upon strain to the cable.

Note that truck and the on board truck charger is not included in the Final Evaluation of the electric vehicle charger. However the charger is looking for specific signals in order to safely energize and de-energize the electric vehicle charger.

Circuit analysis and test results are acceptable and the compliance with this requirement is confirmed compliant.

26 - Equipment/Deviations: 2017 National Electrical Code

625.43 Disconnecting Means. For equipment rated more than 60 amperes or more than 150 volts to ground, the disconnecting means shall be provided and installed in a readily accessible location. The disconnecting means shall be lockable open in accordance with 110.25.

Non-conformance – The Charging Station may be provided with 200 A service and it cannot be confirmed that the disconnect means is in readily accessible and has an integral lockable method.

Corrective Action – the verification of the correct size and location of the disconnecting means is under direct supervision and enforcement of the Local Authority Having Jurisdiction.

27 - Equipment/Deviations: 2017 National Electrical Code

625.46 Loss of Primary Source. Means shall be provided such that, upon loss of voltage from the utility or other electrical system(s), energy cannot be back fed through the electric vehicle and the supply equipment to the premises wiring system unless permitted by 625.48.

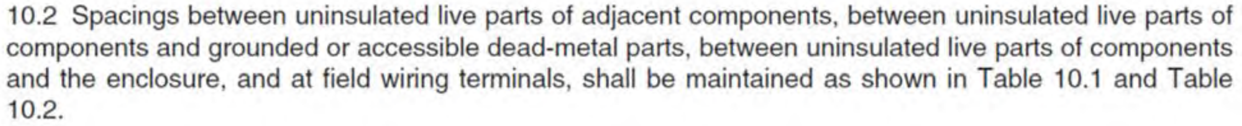
Non-conformance – It cannot be determined if the Charging Station is provided with a means to prevent the energy being back-fed to the utility or other electrical systems through the electric vehicle and the Charging Station.

Note that the Charging Station is not an Interactive System.

Corrective Action – Objective evidence has been supplied to support the circuit analysis to assure that upon loss of voltage from the utility. The electric vehicle cannot back feed the back to the utility.

This has been confirmed the operation of the electric vehicle charger.

28 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels



10.2 Spacings between uninsulated live parts of adjacent components, between uninsulated live parts of components and grounded or accessible dead-metal parts, between uninsulated live parts of components and the enclosure, and at field wiring terminals, shall be maintained as shown in Table 10.1 and Table 10.2.

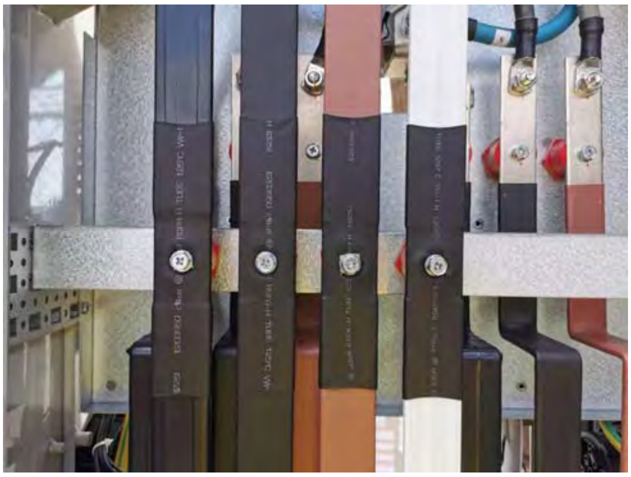
Non-conformance – The spacing between the uninsulated vertical feeder busabars of opposite polarity (Phase A, B and C) are spaced 5/8 in apart rather than a minimum of 1 inch as per table 10.2 for the Feeder circuit.

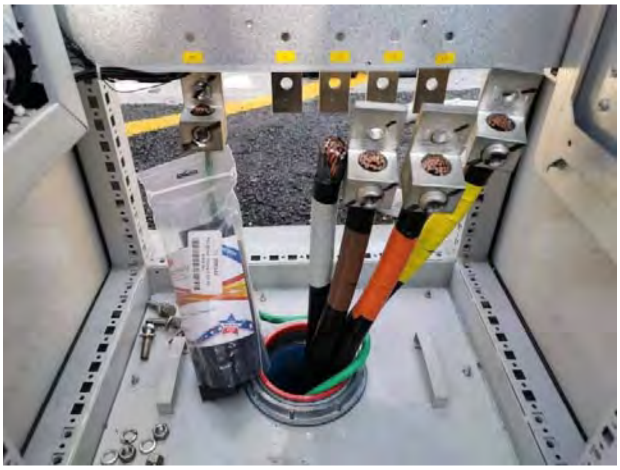
Note that the feeder circuit is defined as the “The conductors and circuitry on the supply side of the branch-circuit overcurrent device”.

See Table 10.1 at the end of this Report.

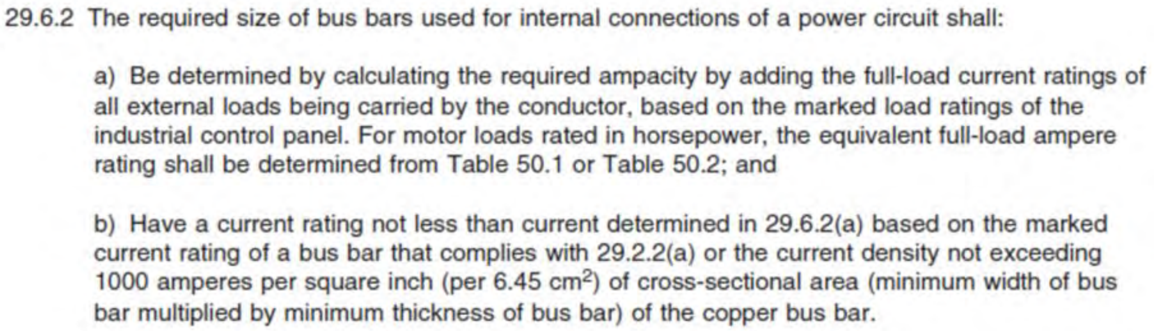
Corrective Action – Additional UL Recognized Component shrink tube rated 600 V 125 °C has been added to the uninsulated bus bars where the uninsulated busbars do not meet the minimum spacings between the live uninsulated bas bars. The addition of the shrink tube eliminates and requirement for spacings and can be treated as an insulated conductor. The UL Recognized Component certification is attached to the end of this report for review.

Note that the capsrew that is securing the busbars are greater than 1 inch apart.



29 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels



29.6.2 The required size of bus bars used for internal connections of a power circuit shall:

a) Be determined by calculating the required ampacity by adding the full-load current ratings of all external loads being carried by the conductor, based on the marked load ratings of the industrial control panel. For motor loads rated in horsepower, the equivalent full-load ampere rating shall be determined from Table 50.1 or Table 50.2; and

b) Have a current rating not less than current determined in 29.6.2(a) based on the marked current rating of a bus bar that complies with 29.2.2(a) or the current density not exceeding 1000 amperes per square inch (per 6.45 cm^2) of cross-sectional area (minimum width of bus bar multiplied by minimum thickness of bus bar) of the copper bus bar.

Non-conformance – during the initial review of the busbar current density cannot be determined if the bus bars exceed a 1000 A/in^2. Preliminary review indicates that the busbar current density are approximately:

1083.6 A/in^2 at the feeder vertical busbars in the line side of the main 400 A circuit breaker.

1176.5 A/in^2 at the horizontal busbar from the load side of the main circuit breaker to the line side of the branch circuit breakers.

1283 A/in^2 at the busbar output of the main 400 A circuit breaker to the horiszontal bus bar.

Either objective evidence shall be provided to prove that the busar current density does not exceed the 1000 A/in^2 or a temperature test must be conducted under full load.

However, please note, the temperature test cannot be conducted in the field due to safety issues during the test.

Corrective Action - After a careful review and correct measurement of the busbars in questions the busbar current density are 1032 A/in^2 at the feeder vertical busbars to the line side of the main circuit breaker and the bus bars from the output from the 400 A main circuit breaker to the horizontal bus bars.

Utilizing ANSI/UL 508A Standard for Industrial Control Panels and ANSI/UL 891 Standard for Safety Switchboards the cross section of the bus bars cannot reduced more than 5% due to rounding , shaping and dimensional tolerances. The 5% would equate to a 1032 A/in² bus bar current density.

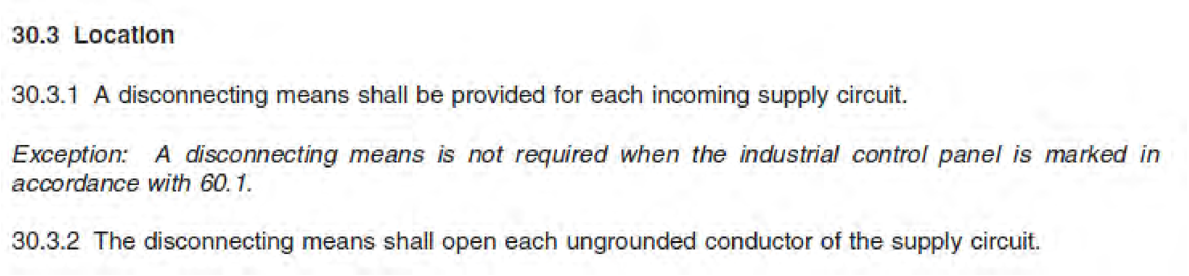
After careful analysis and measurements, the feeder vertical busbars on the load side of the 400 from the horizontal bus bar to the vertical bus bars have a current density of 967.7 A/in².

In conclusion, the bus bar that were in question are at maximum capacity and do not require a temperature test.

Reference Standard – ANSI/UL 891 Standard for Safety Switchboards Section 8.8.1.6 Ampacity

30 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels



30.3 Location

30.3.1 A disconnecting means shall be provided for each incoming supply circuit.

Exception: A disconnecting means is not required when the industrial control panel is marked in accordance with 60.1.

30.3.2 The disconnecting means shall open each ungrounded conductor of the supply circuit.

Non-Conformance – The electric vehicle charger is supplied with a main 400 A UL Listed circuit breaker however the circuit breaker is not able to be locked in the open (off) position. In view of this the main 400 A UL Listed circuit breaker cannot act as the disconnecting means.

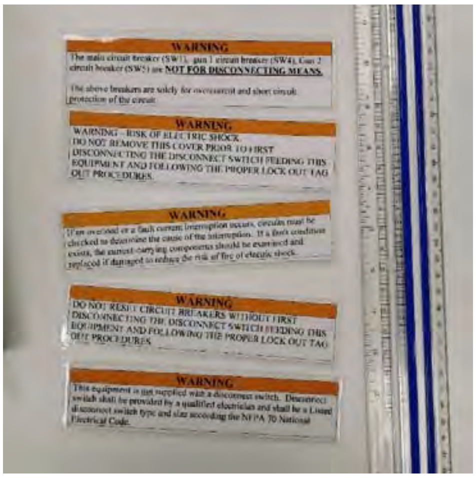
Corrective Action - the vehicle charger/industrial control panel is supplied with a deadfront for the sole purpose of protection of accessing live parts with the door open.

The main circuit breaker and branch circuit breakers (for charging guns) are for the sole purpose of providing overcurrent and short circuit protection only not for disconnecting means.

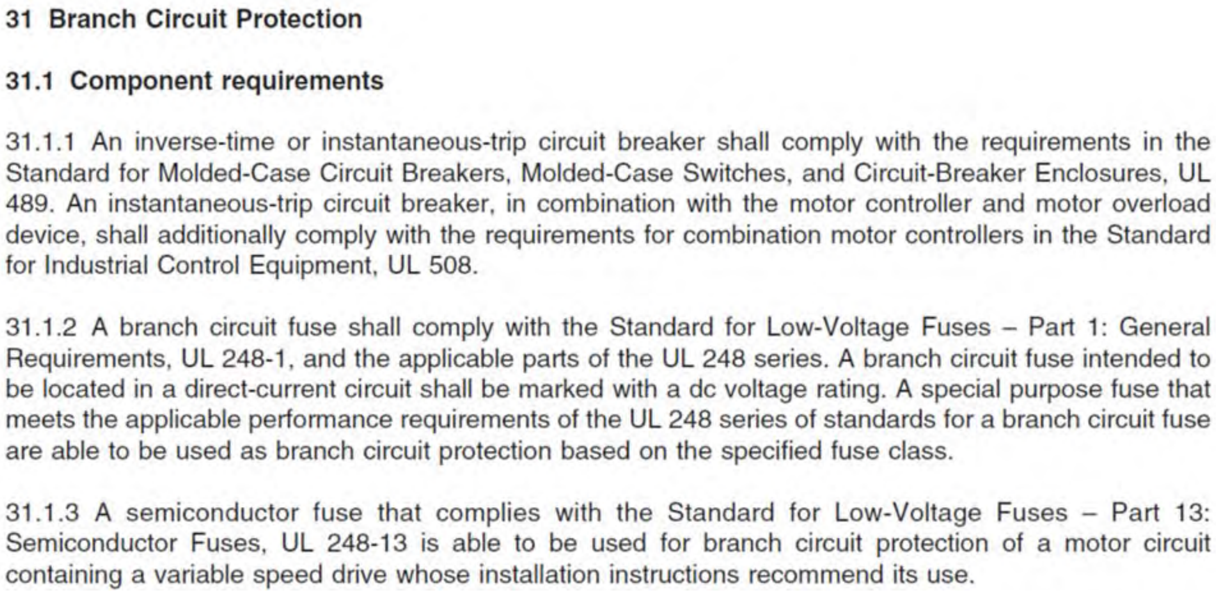
The proper marking was provided on the deadfront stating that the industrial control panel is not provided with a main disconnect and the main disconnect shall be provided by others. In addition, the marking indicated that the Listed disconnect switch shall be supplied by a qualified electrician.

Note that the local AHJ (Authorities Having Jurisdiction) will be required to assure that the electric vehicle charger is supplied with the properly size and type of disconnect switch in accordance with the National Electrical Code.



31 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels



31 Branch Circuit Protection

31.1 Component requirements

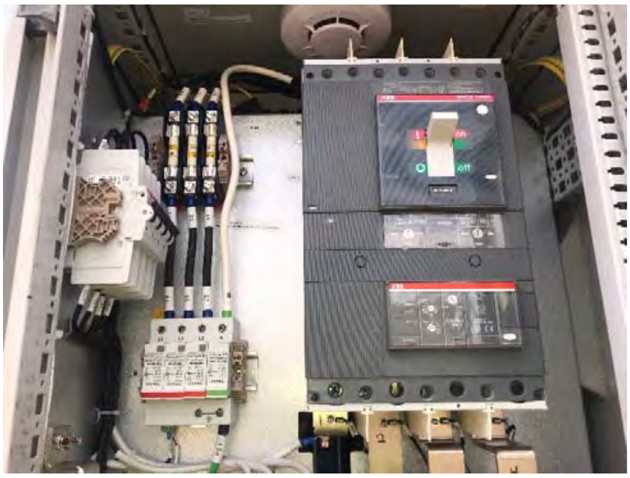
31.1.1 An inverse-time or instantaneous-trip circuit breaker shall comply with the requirements in the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489. An instantaneous-trip circuit breaker, in combination with the motor controller and motor overload device, shall additionally comply with the requirements for combination motor controllers in the Standard for Industrial Control Equipment, UL 508.

31.1.2 A branch circuit fuse shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, and the applicable parts of the UL 248 series. A branch circuit fuse intended to be located in a direct-current circuit shall be marked with a dc voltage rating. A special purpose fuse that meets the applicable performance requirements of the UL 248 series of standards for a branch circuit fuse are able to be used as branch circuit protection based on the specified fuse class.

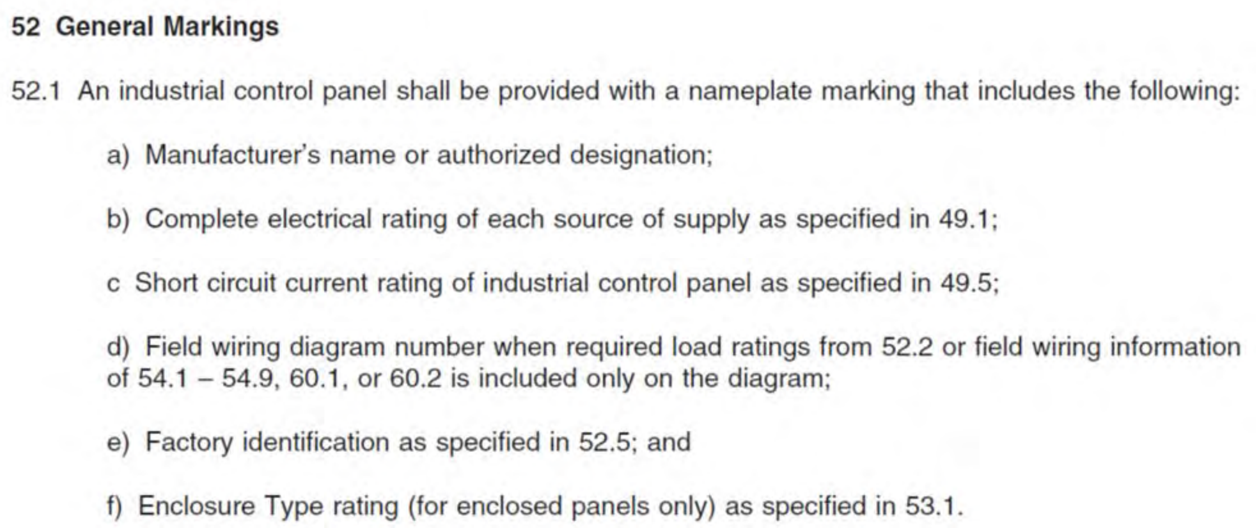
31.1.3 A semiconductor fuse that complies with the Standard for Low-Voltage Fuses – Part 13: Semiconductor Fuses, UL 248-13 is able to be used for branch circuit protection of a motor circuit containing a variable speed drive whose installation instructions recommend its use.

Non-conformance – The main 400 ampere circuit breaker and the two 250 ampere branch circuit breaker protecting the two charging gun circuits are not a NRTL (Nationally Recognized Testing Laboratory) Listed circuit breaker to ANSI/UL 489 Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures as required.

Corrective Actions – The non-Listed 400 ampere and 250 ampere rated circuit breakers have been replaced with UL Listed 400 A manufactured by ABB and a 250 A circuit breakers manufactured by Mitsubishi as required,



32 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels



52 General Markings

52.1 An industrial control panel shall be provided with a nameplate marking that includes the following:

a) Manufacturer's name or authorized designation;

b) Complete electrical rating of each source of supply as specified in 49.1;

c Short circuit current rating of industrial control panel as specified in 49.5;

d) Field wiring diagram number when required load ratings from 52.2 or field wiring information of 54.1 – 54.9, 60.1, or 60.2 is included only on the diagram;

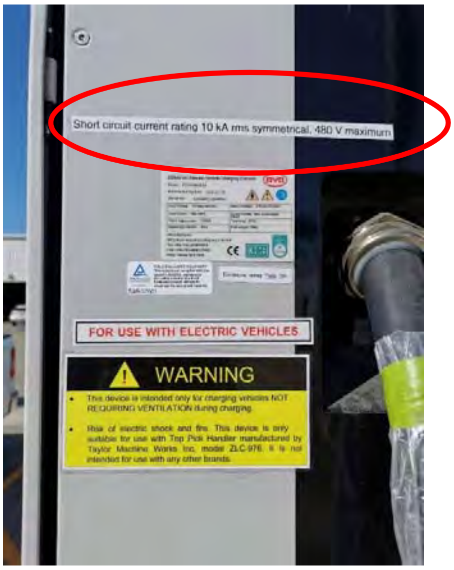
e) Factory identification as specified in 52.5; and

f) Enclosure Type rating (for enclosed panels only) as specified in 53.1.

Non-conformance – The industrial control panel/vehicle charger is not marked with the calculated short circuit current ratings as defined and calculated in Supplement SB – Short Circuit Current Ratings for Industrial Control Panel

Corrective Actions – The manufacturer has assessed the construction/design of the electrical circuits and power circuit components as required by the Supplment SB – Short Circuit Current Ratings for the industrial Control Panels in ANSI/UL 508A Standard for Industrial Control Panels.

After review of the power circuit and power circuit components It has been determined that the industrial control panel/vehicle charger has a short circuit current rating of a maximum of 10,000 A @ maximum 480 Vac RMS.

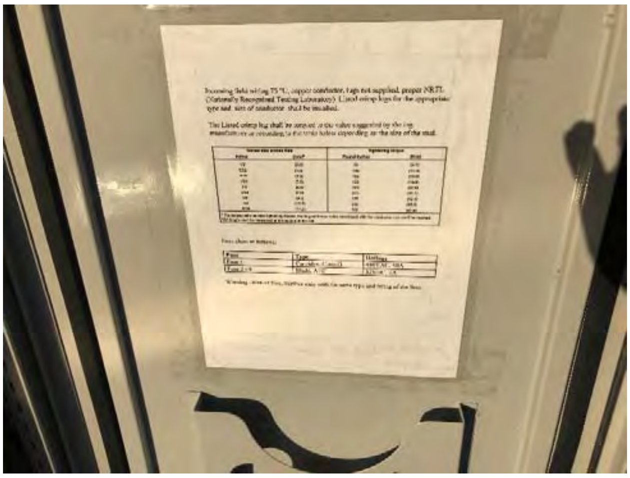


33 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels

56.1 A branch circuit fuseholder that accepts a fuse having a rating larger than the maximum specified rating and all control circuit fuseholders shall be marked with the voltage and current rating of the replacement fuse.

Non-conformance – the fuse holders can accept a fuse having a rating larger than the maximum rating of the control circuit and is missing the fuse replacement marking showing the voltage and current rating of the replacement fuse.

Corrective Action – There was a fuse replacement chart affixed to the front door indicating the fuse replacement marking indicating the voltage and current rating of the replacement fuse as required.



Terms and conditions of acceptability for the equipment inspected:

1. The Top Pick Handler manufactured by Taylor Machine Works, Inc, model ZLC-976 and all required safety requirements of the truck are not part of the scope of this project
2. The onboard charger on the Top Pick Handler manufactured by Taylor Machine Works, Inc, model ZLC-976 is not included in the scope of this project.
3. The type, size and location of the disconnecting means ahead of the vehicle charger shall comply with the National Electrical Code which is enforceable by the Local Authorities Having Jurisdiction.

Non-standard Inspection procedure used (if applicable):N/A

List of Critical and non-Recognized or un-Listed Components for Review

Component	Manufacturer	Model	Mark(s) of conformity
Main circuit breaker	ABB	SACE T5N 400	UL, CSA
Branch circuit breaker	Mitsubishi	NF250-HVU	cULus
Surge protective device	CITEL	DS40G-600, DS40-480	cURus
Surge protective device branch circuit protection	Cooper Bussmann	Class G	UL Listed
Main contactor	LS	GMC 180	cULus
Enclosure	BYD Motors Inc	Double ended door 500 mm x 400 mm x 2000mm	Previously Tested see Note 1 below
Current transformer	Carlo Gavazzi	CTD-2X.200.5A.XXX	cURus
24 Vdc power supply	Carlo Gavazzi	SPD242403	cULus
EV Cable	CHANGZHOU MARINE CABLE CO LTD	EV, VW-1, 105 °C, 2 AWG, 600 V	TUVus
Vehicle Coupler	BYD Motors Inc	KD2	cTUVus
Power Analyzer	SOCOMEC	DIRIS A10	cULus
Controller board	BYD	PCB-JLK-QDB-SQ	URus
Shrink Tube (used on bus bars)	E203950	VW-1, 125°C	cURus
Shrink Tube (used on bus bars)	E203950	RSFR-H	cURus
Main copper tin plated busbar (vertical bus bars, contactor and circuit breaker connector bus bar)	Various	Bus bar density ≤ 1000 A/in²	None – evaluated by construction. Bus bar cross sectional area/ampacity load less than or equal to 1000 A/in²

Other components are Listed or approved for the application

*EIA – Evaluated in Application (See also Notes Section on page 10)

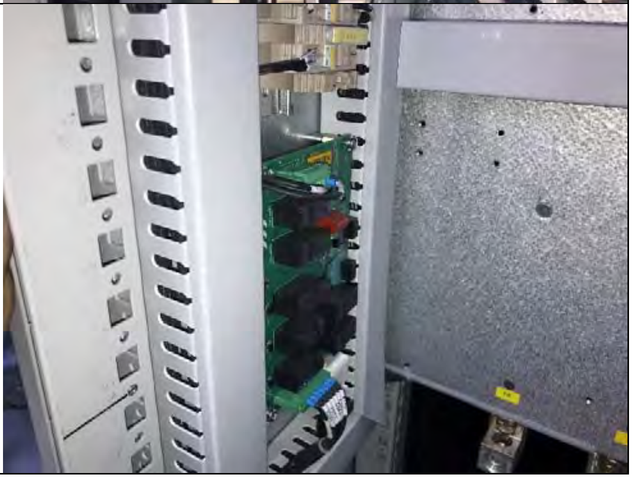
Note: Critical Components shall be Listed or Recognized, (example: Breakers, Fuses, motors etc.)

Note 1 - – the identical enclosure has been tested under Project No 163103, Report No 31874271.001, June 24, 2019.

Photo(s)

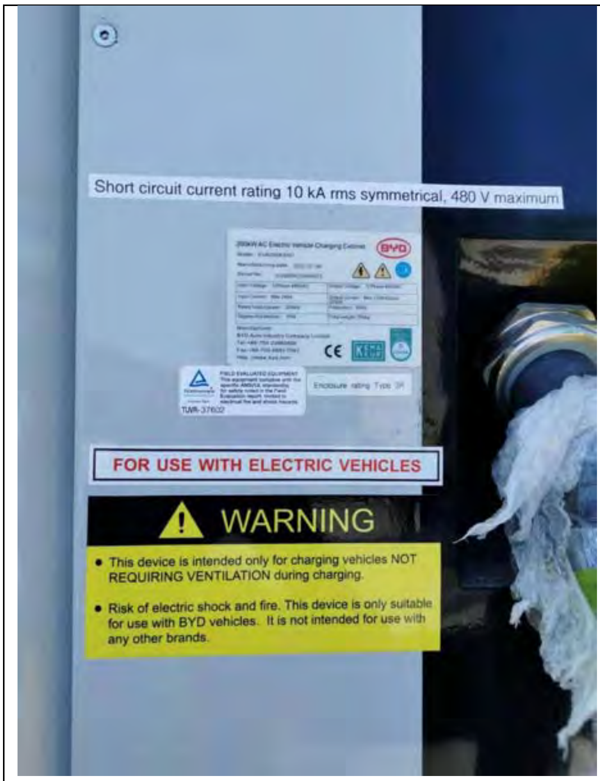

BYD
BYD Coach & Bus
KD2 Vehicle Connector
Rating: 480V~,120A,60Hz,AC Only
Type 3S

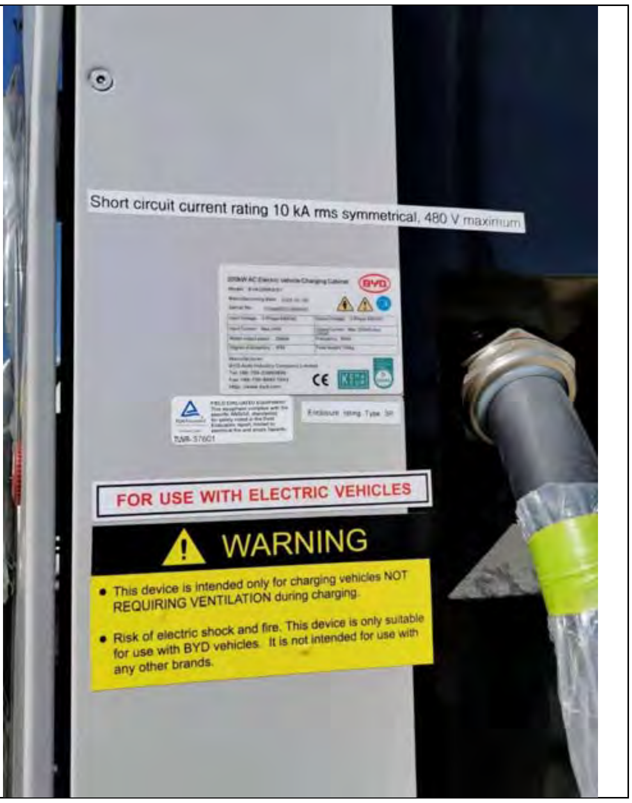

MEC
LS
MEC
LS




U5


502


Short circuit current rating 10 kA rms symmetrical, 480 V maximum
BYD
CE
TUVR-37602
Enclosure rating Type 3R
FOR USE WITH ELECTRIC VEHICLES
WARNING
This device is intended only for charging vehicles NOT REQUIRING VENTILATION during charging.
Risk of electric shock and fire. This device is only suitable for use with BYD vehicles. It is not intended for use with any other brands.


Short circuit current rating 10 kA rms symmetrical, 480 V maximum
BYD
CE
TUVR-37601
Enclosure rating Type 3R
FOR USE WITH ELECTRIC VEHICLES
WARNING
This device is intended only for charging vehicles NOT REQUIRING VENTILATION during charging.
Risk of electric shock and fire. This device is only suitable for use with BYD vehicles. It is not intended for use with any other brands.

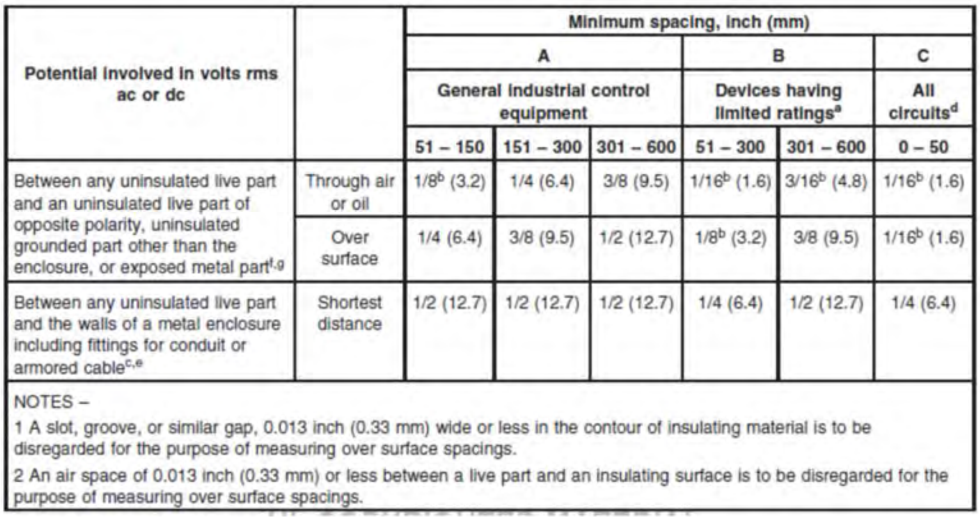
<table>
<tr>
<td>

Reference only 1(not part of this Field Evaluation)</td>
<td>

Reference only 2 (not part of this Field Evluation)</td>
</tr>
<tr>
<td>
TAYLOR MACHINE WORKS, INC.
LOUISVILLE, MISSISSIPPI, U.S.A.
MODEL [illegible] TYPE E SERIAL NO: [illegible] YEAR 2010
BASIC MODEL CAPACITY [illegible] LBS. @ 48 " LOAD CENTER
SAFE WORKING CAPACITY WITH EQUIPPED OPTIONS:
[illegible] LBS. @ [illegible] " LOAD CENTER -OR-
[illegible] LBS. @ 106 " CTR. LOAD TO CTR. DRIVE AXLE UP TO 582 " LIFT HEIGHT
SAFE CAPACITY WITH MAST VERTICAL, LOADS LATERALLY CENTERED, EVENLY DISTRIBUTED AND EQUIPPED AS SHOWN
DO NOT OVERLOAD. CAPACITY IS GREATLY REDUCED WHEN MAST IS TILTED FORWARD.
TOTAL VEHICLE WEIGHT [illegible] LBS. (±5%) STEER AXLE WEIGHT 58000 LBS. (±5%)
BATTERY TYPE E BATTERY MODEL [illegible] NOMINAL VOLTAGE [illegible] V
MAXIMUM AMPERE-HOUR CAPACITY [illegible] AH @ 6 HOURS
MIN. WEIGHT OF BATTERIES [illegible] LBS. MAX. WEIGHT OF BATTERIES [illegible] LBS.
TOTAL VEHICLE WEIGHT (WITHOUT BATTERIES) [illegible] LBS. (±5%)
TIRE SPECIFICATIONS
AXLE / SIZE / PLY RATING / PRESSURE
DRIVE / [illegible]X25 / [illegible] / 145
STEER / 1800X25 / 40 / 145
WHEEL LUG NUT TORQUE PROCEDURE
WHEEL AND MOUNTS REQUIRE RUN-IN PERIOD ON A NEW VEHICLE AND AFTER EACH TIRE CHANGE. TORQUE BEFORE VEHICLE IS PUT IN SERVICE AND EACH 10 HOURS UNTIL WHEELS ARE SEATED. CARE SHOULD BE TAKEN TO KEEP GREASE AND OTHER FOREIGN MATERIAL FROM RIM SEATING SURFACES.
⚠ CAUTION: DO NOT OVERTORQUE.
AXLE / STUD SIZE / WRENCH SIZE / TORQUE-FT. LBS.
DRIVE / M 18 - 2.0 / 1 1/16 / 275
STEER / 3/4 - 10 NC / 1 1/16 / 150
⚠ DANGER:— FIRST STEP IN TIRE DEMOUNTING OPERATIONS: ALWAYS REMOVE THE VALVE CORE AND EXHAUST ALL AIR FROM A SINGLE TIRE AND FROM BOTH TIRES OF A DUAL ASSEMBLY PRIOR TO REMOVING ANY RIM COMPONENTS OR ANY WHEEL COMPONENTS SUCH AS NUTS AND RIM CLAMPS. TO ENSURE THAT THE VALVE STEM IS NOT DAMAGED, RUN A PIECE OF WIRE THROUGH THE STEM TO MAKE SURE IT IS NOT PLUGGED AND ALL THE AIR IS EXHAUSTED.
PATENTS
Reference only 3 (not part of this Field Evaluation)</td>
<td></td>
</tr>
</table>

1 Table 10.1 and Table 10.2 from ANSI/UL 508A Standard for Industrial Control Panels.

Table 10.1
Minimum required spacings in branch and control circuits



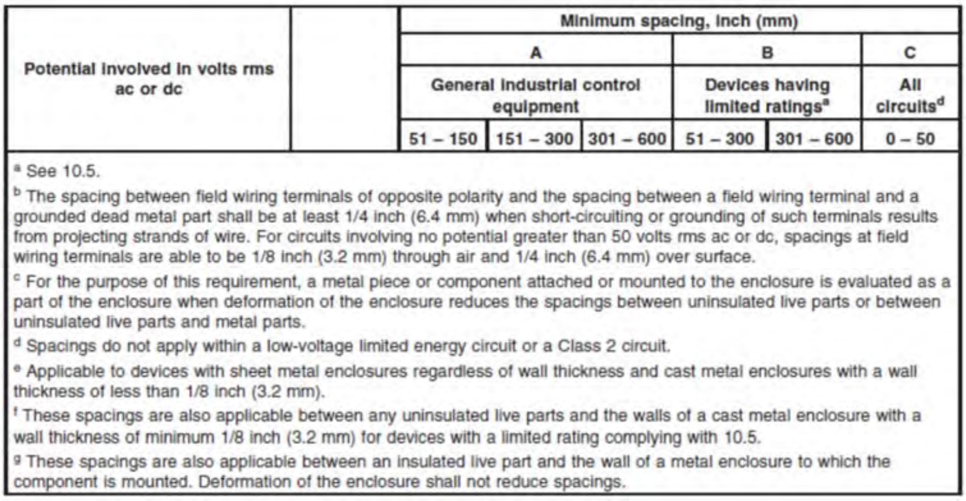
Potential involved in volts rms ac or dc		Minimum spacing, inch (mm)					
		A			B		C
		General industrial control equipment			Devices having limited ratings[a]		All circuits[d]
		51 – 150	151 – 300	301 – 600	51 – 300	301 – 600	0 – 50
Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part[f,g]	Through air or oil	1/8[b] (3.2)	1/4 (6.4)	3/8 (9.5)	1/16[b] (1.6)	3/16[b] (4.8)	1/16[b] (1.6)
	Over surface	1/4 (6.4)	3/8 (9.5)	1/2 (12.7)	1/8[b] (3.2)	3/8 (9.5)	1/16[b] (1.6)
Between any uninsulated live part and the walls of a metal enclosure including fittings for conduit or armored cable[c,e]	Shortest distance	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	1/4 (6.4)	1/2 (12.7)	1/4 (6.4)

NOTES –

1 A slot, groove, or similar gap, 0.013 inch (0.33 mm) wide or less in the contour of insulating material is to be disregarded for the purpose of measuring over surface spacings.

2 An air space of 0.013 inch (0.33 mm) or less between a live part and an insulating surface is to be disregarded for the purpose of measuring over surface spacings.

Table 10.1 Continued



Potential involved in volts rms ac or dc		Minimum spacing, inch (mm)					
		A			B		C
		General industrial control equipment			Devices having limited ratings[a]		All circuits[d]
		51 – 150	151 – 300	301 – 600	51 – 300	301 – 600	0 – 50

[a] See 10.5.

[b] The spacing between field wiring terminals of opposite polarity and the spacing between a field wiring terminal and a grounded dead metal part shall be at least 1/4 inch (6.4 mm) when short-circuiting or grounding of such terminals results from projecting strands of wire. For circuits involving no potential greater than 50 volts rms ac or dc, spacings at field wiring terminals are able to be 1/8 inch (3.2 mm) through air and 1/4 inch (6.4 mm) over surface.

[c] For the purpose of this requirement, a metal piece or component attached or mounted to the enclosure is evaluated as a part of the enclosure when deformation of the enclosure reduces the spacings between uninsulated live parts or between uninsulated live parts and metal parts.

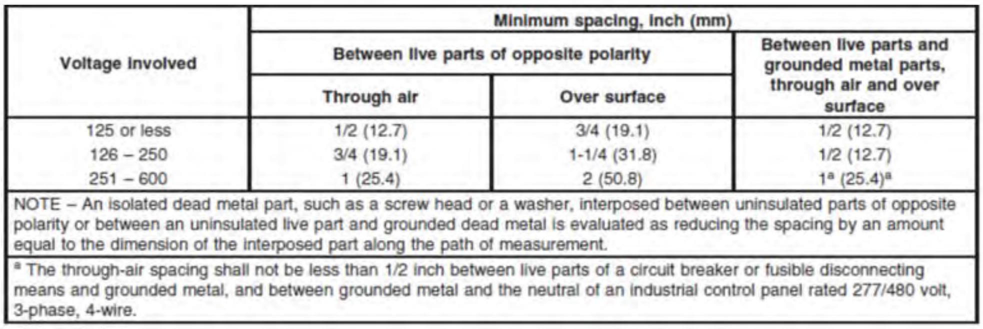
[d] Spacings do not apply within a low-voltage limited energy circuit or a Class 2 circuit.

[e] Applicable to devices with sheet metal enclosures regardless of wall thickness and cast metal enclosures with a wall thickness of less than 1/8 inch (3.2 mm).

[f] These spacings are also applicable between any uninsulated live parts and the walls of a cast metal enclosure with a wall thickness of minimum 1/8 inch (3.2 mm) for devices with a limited rating complying with 10.5.

[g] These spacings are also applicable between an insulated live part and the wall of a metal enclosure to which the component is mounted. Deformation of the enclosure shall not reduce spacings.

Table 10.2
Spacings in feeder circuit

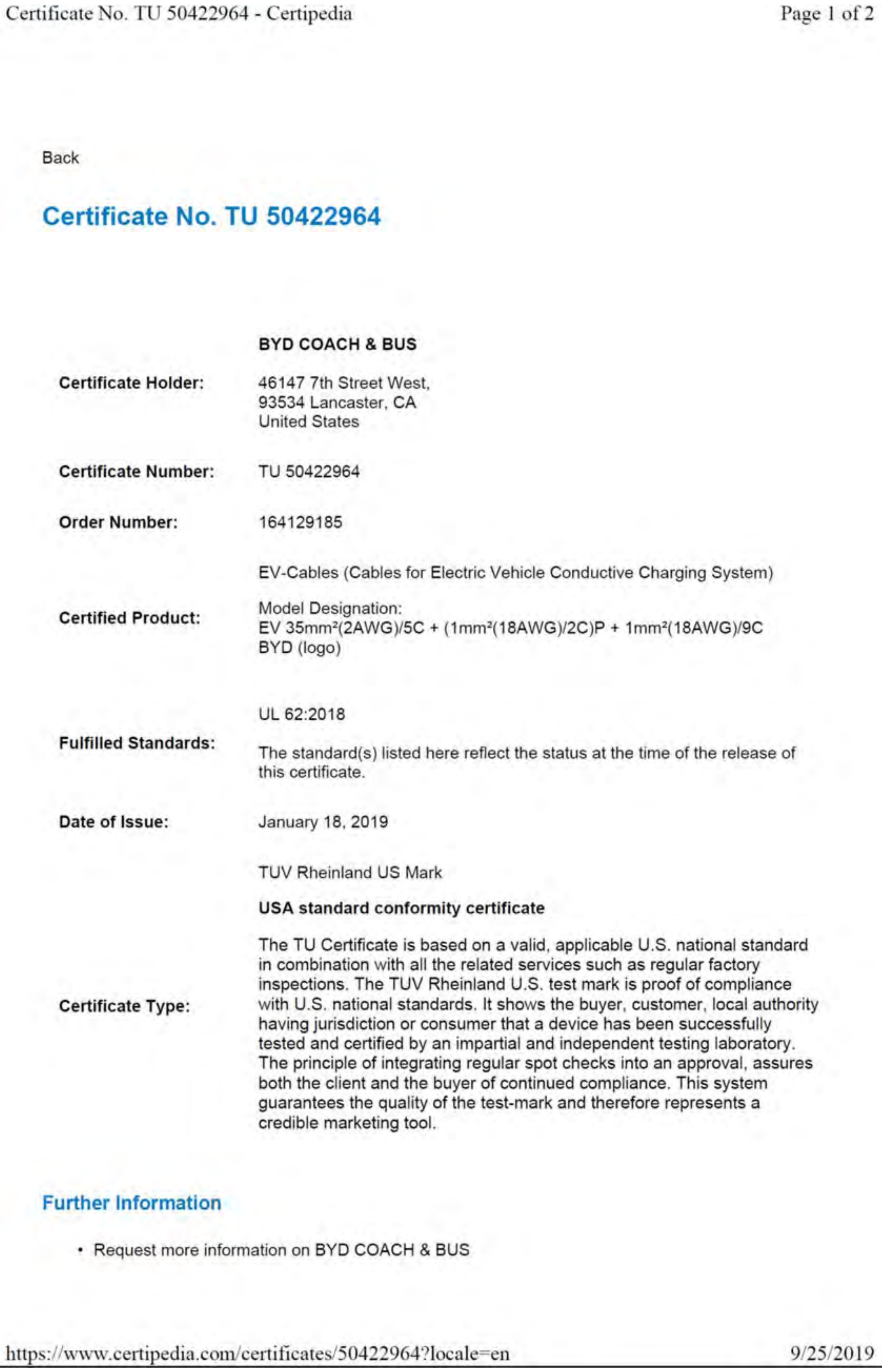


Voltage involved	Minimum spacing, inch (mm)		
	Between live parts of opposite polarity		Between live parts and grounded metal parts, through air and over surface
	Through air	Over surface	
125 or less	1/2 (12.7)	3/4 (19.1)	1/2 (12.7)
126 – 250	3/4 (19.1)	1-1/4 (31.8)	1/2 (12.7)
251 – 600	1 (25.4)	2 (50.8)	1[a] (25.4)[a]

NOTE – An isolated dead metal part, such as a screw head or a washer, interposed between uninsulated parts of opposite polarity or between an uninsulated live part and grounded dead metal is evaluated as reducing the spacing by an amount equal to the dimension of the interposed part along the path of measurement.

[a] The through-air spacing shall not be less than 1/2 inch between live parts of a circuit breaker or fusible disconnecting means and grounded metal, and between grounded metal and the neutral of an industrial control panel rated 277/480 volt, 3-phase, 4-wire.

2 EV Cable TUV Certification to ANSI/UL 62



Certificate No. TU 50422964 - Certipedia Page 1 of 2

Back

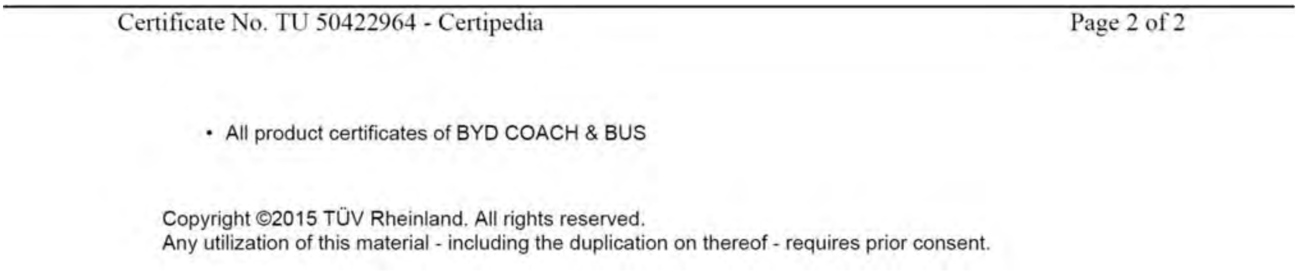
Certificate No. TU 50422964

	BYD COACH & BUS
Certificate Holder:	46147 7th Street West, 93534 Lancaster, CA United States
Certificate Number:	TU 50422964
Order Number:	164129185
Certified Product:	EV-Cables (Cables for Electric Vehicle Conductive Charging System) Model Designation: EV 35mm²(2AWG)/5C + (1mm²(18AWG)/2C)P + 1mm²(18AWG)/9C BYD (logo)
Fulfilled Standards:	UL 62:2018 The standard(s) listed here reflect the status at the time of the release of this certificate.
Date of Issue:	January 18, 2019
Certificate Type:	TUV Rheinland US Mark **USA standard conformity certificate** The TU Certificate is based on a valid, applicable U.S. national standard in combination with all the related services such as regular factory inspections. The TUV Rheinland U.S. test mark is proof of compliance with U.S. national standards. It shows the buyer, customer, local authority having jurisdiction or consumer that a device has been successfully tested and certified by an impartial and independent testing laboratory. The principle of integrating regular spot checks into an approval, assures both the client and the buyer of continued compliance. This system guarantees the quality of the test-mark and therefore represents a credible marketing tool.

Further Information

- Request more information on BYD COACH & BUS

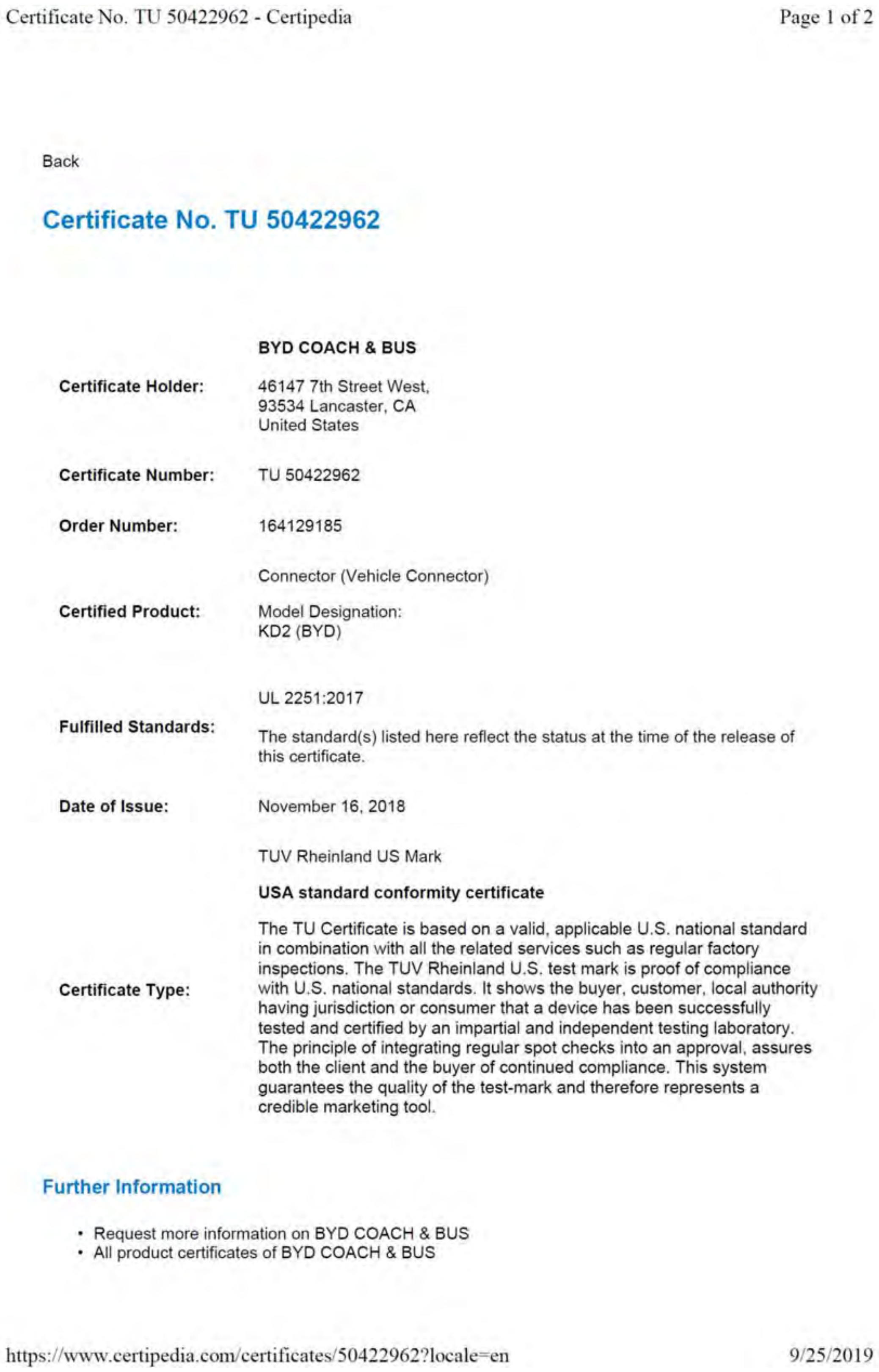
https://www.certipedia.com/certificates/50422964?locale=en 9/25/2019



Certificate No. TU 50422964 - Certipedia Page 2 of 2

- All product certificates of BYD COACH & BUS

3 Vehicle Coupler TUV Certifcation



Certificate No. TU 50422962 - Certipedia Page 1 of 2

Back

Certificate No. TU 50422962

BYD COACH & BUS

Certificate Holder:
46147 7th Street West,
93534 Lancaster, CA
United States

Certificate Number: TU 50422962

Order Number: 164129185

Certified Product:
Connector (Vehicle Connector)
Model Designation:
KD2 (BYD)

Fulfilled Standards:
UL 2251:2017

The standard(s) listed here reflect the status at the time of the release of this certificate.

Date of Issue: November 16, 2018

Certificate Type:
TUV Rheinland US Mark

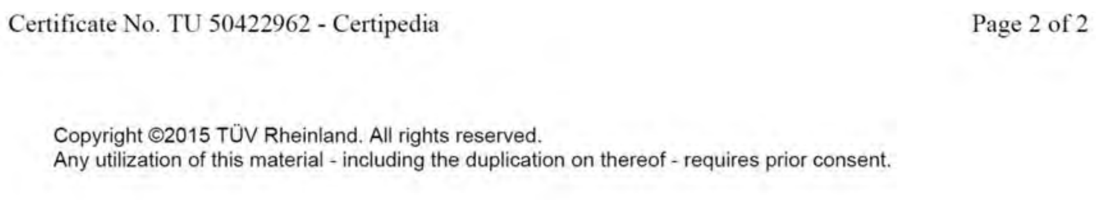
USA standard conformity certificate

The TU Certificate is based on a valid, applicable U.S. national standard in combination with all the related services such as regular factory inspections. The TUV Rheinland U.S. test mark is proof of compliance with U.S. national standards. It shows the buyer, customer, local authority having jurisdiction or consumer that a device has been successfully tested and certified by an impartial and independent testing laboratory. The principle of integrating regular spot checks into an approval, assures both the client and the buyer of continued compliance. This system guarantees the quality of the test-mark and therefore represents a credible marketing tool.

Further Information

- Request more information on BYD COACH & BUS
- All product certificates of BYD COACH & BUS

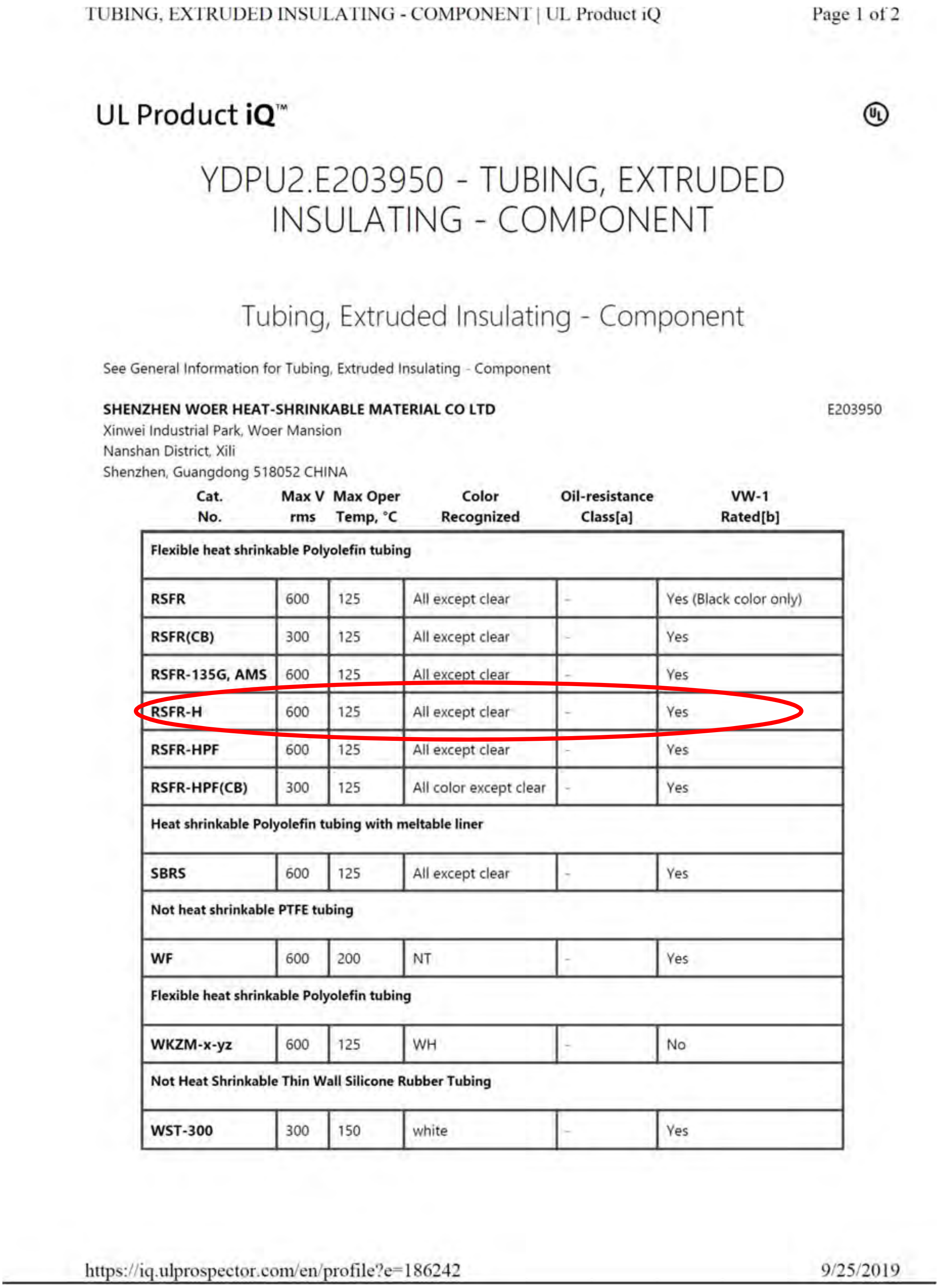
https://www.certipedia.com/certificates/50422962?locale=en 9/25/2019



Certificate No. TU 50422962 - Certipedia

Page 2 of 2

4 UL Recognized Component heat shrink tubing Certification



TUBING, EXTRUDED INSULATING - COMPONENT | UL Product iQ Page 1 of 2

UL Product iQ™

YDPU2.E203950 - TUBING, EXTRUDED INSULATING - COMPONENT

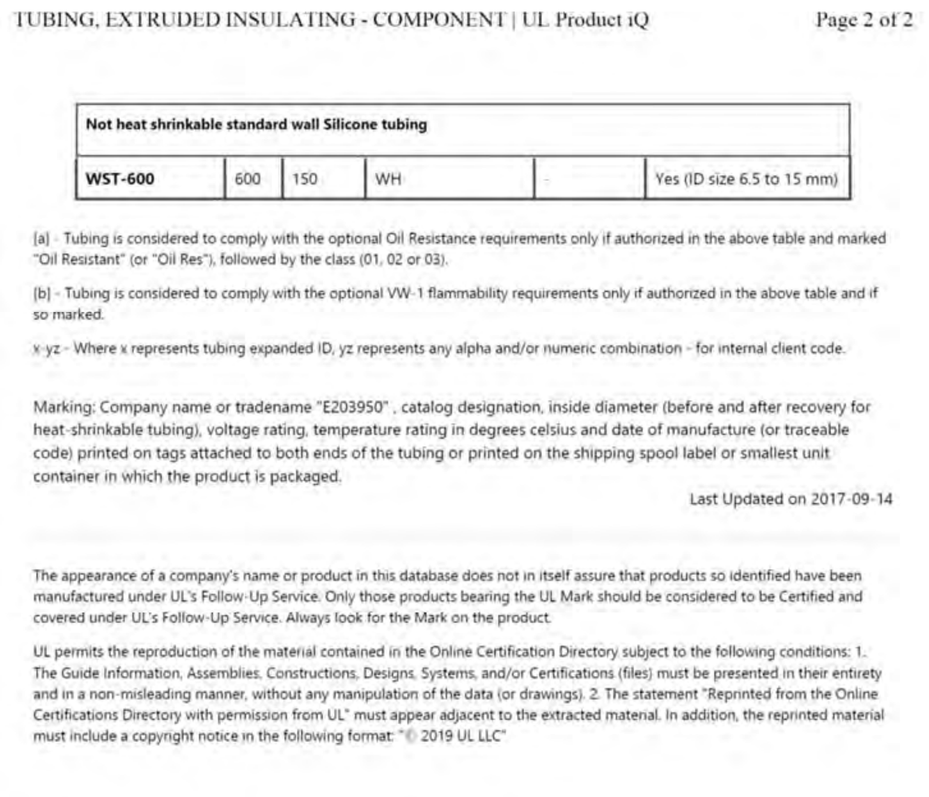
Tubing, Extruded Insulating - Component

See General Information for Tubing, Extruded Insulating - Component

SHENZHEN WOER HEAT-SHRINKABLE MATERIAL CO LTD E203950
Xinwei Industrial Park, Woer Mansion
Nanshan District, Xili
Shenzhen, Guangdong 518052 CHINA

Cat. No.	Max V rms	Max Oper Temp, °C	Color Recognized	Oil-resistance Class[a]	VW-1 Rated[b]
Flexible heat shrinkable Polyolefin tubing					
RSFR	600	125	All except clear	-	Yes (Black color only)
RSFR(CB)	300	125	All except clear	-	Yes
RSFR-135G, AMS	600	125	All except clear	-	Yes
RSFR-H	600	125	All except clear	-	Yes
RSFR-HPF	600	125	All except clear	-	Yes
RSFR-HPF(CB)	300	125	All color except clear	-	Yes
Heat shrinkable Polyolefin tubing with meltable liner					
SBRS	600	125	All except clear	-	Yes
Not heat shrinkable PTFE tubing					
WF	600	200	NT	-	Yes
Flexible heat shrinkable Polyolefin tubing					
WKZM-x-yz	600	125	WH	-	No
Not Heat Shrinkable Thin Wall Silicone Rubber Tubing					
WST-300	300	150	white	-	Yes

https://iq.ulprospector.com/en/profile?e=186242 9/25/2019



TUBING, EXTRUDED INSULATING - COMPONENT | UL Product iQ   Page 2 of 2

Not heat shrinkable standard wall Silicone tubing					
WST-600	600	150	WH	-	Yes (ID size 6.5 to 15 mm)

[a] - Tubing is considered to comply with the optional Oil Resistance requirements only if authorized in the above table and marked "Oil Resistant" (or "Oil Res"), followed by the class (01, 02 or 03).

[b] - Tubing is considered to comply with the optional VW-1 flammability requirements only if authorized in the above table and if so marked.

x-yz - Where x represents tubing expanded ID, yz represents any alpha and/or numeric combination - for internal client code.

Marking: Company name or tradename "E203950" , catalog designation, inside diameter (before and after recovery for heat-shrinkable tubing), voltage rating, temperature rating in degrees celsius and date of manufacture (or traceable code) printed on tags attached to both ends of the tubing or printed on the shipping spool label or smallest unit container in which the product is packaged.

Last Updated on 2017-09-14

The appearance of a company's name or product in this database does not in itself assure that products so identified have been manufactured under UL's Follow-Up Service. Only those products bearing the UL Mark should be considered to be Certified and covered under UL's Follow-Up Service. Always look for the Mark on the product.

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End of Report

Short circuit current rating 10 kA rms symmetrical, 480 V maximum

200kW AC Electric Vehicle Charging Cabinet
Model : EVA200KS/01
Manufacturing date : 2018-01-08
Serial No : 010449DVJ10800014

Input Voltage : 3-Phase 480VAC	Output Voltage : 3-Phase 480VAC
Input Current : Max.240A	Output Current : Max.120A/Output Circuit
Rated output power : 200kW	Frequency : 60Hz
Degree of protection : IP54	Total weight:155kg

Manufacturer:
BYD Auto Industry Company Limited
Tel:+86-755-23860806
Fax:+86-755-8993 7043
http://www.byd.com

PIER J TUV STICKER

FIELD EVALUATED EQUIPMENT
This equipment complies with the specific ANSI/UL standard(s) for safety noted in the Field Evaluation report, limited to electrical fire and shock hazards.
TUVR-37602

Enclosure rating Type 3R

FOR USE WITH ELECTRIC VEHICLES

WARNING

- This device is intended only for charging vehicles NOT REQUIRING VENTILATION during charging.
- Risk of electric shock and fire. This device is only suitable for use with BYD vehicles. It is not intended for use with any other brands.

Field Evaluation Report (Long Form)

TUV Rheinland of North America, Inc.
295 Foster Street, Suite 100

Littleton, MA 01460

Web: http://www.tuv.com

Equipment type:	Electric Vehicle Charging Station
Manufacturer:	BYD Motor Inc.
Model number:	EVA200KS/01
Serial number:	010449DVHA0100007

CLIENT:
BYD Motors Inc
1800 S Figueroa Street
Los Angeles, CA 9005

AUTHORITY HAVING JURISDICTION:
City of Long Beach
Department of Building and Safety

Permit # :
Electrical Permit No BELE220717

INSPECTION SITE:
Long Beach Container Terminal
(LBCT)
201 S. Pico Ave
Long Beach, CA 90802

TRNA file Number (if applicable):	31975487.001
TRNA Project Number:	0234116175
TRNA field label number(s):	TUVR-37592

Evaluated by:	Reviewed by:
Ivan Obelar December 28, 2019	Ryan Braman December 28, 2019
Senior Test Engineer Field Evaluation Services Group	Test Engineering Manager TUV Field Evaluation Services Group
Email: iobelar@us.tuv.com	Email: rbraman@us.tuv.com

GENERAL CONDITIONS OF ACCEPTANCE AND SCOPE OF INSPECTION

This test report contains only findings and results regarding the indicated equipment for installation at the particular inspection site. It is not intended as an endorsement of the equipment, nor an approval of similar or identical equipment at another location. If this equipment or any of its attendant parts, connections, or components are modified, changed, or replaced in any way after the inspection, the inspection and label are considered void. Re-inspection shall be required.

TRNA's label indicating the equipment as compliant does not relieve the owner/manufacturer of its responsibility for the safe operation of the equipment.

This inspection is intended to address only potential electrical fire and shock hazards to the standards defined in the body of this report. TUV makes no representations or warranties whatsoever regarding any other aspect of the facility or equipment at the facility. This inspection does not include inspection of the suitable operation of the unit and does not include emission tests and locations defined as hazardous by the US National Electrical Code, NFPA 70, current edition

If this evaluation is not performed at the final installation site, the AHJ may require an additional inspection and re-labeling

INSPECTION PROCEDURES

Please refer to the "Standards selected for the evaluation" for additional criteria.

Construction Inspection

The equipment's design was visually inspected with particular attention to the following areas:

- Use of Certified Components
- Proper Motor protection
- Proper Transformer protection
- Proper conductor protection
- Proper wire bending spaces
- Ground and bonding
- Accessibility of live parts
- Wiring ampacity
- Wiring methods
- Guarding of Live Parts
- Guarding of moving parts
- Pinching, crushing, cutting hazards
- Damaged Components
- Accessibility of moving parts
- Temperature, moisture, and UV exposure I conditions
- Sharp edges
- Availability of suitable markings
- Suitability of power connection

If a particular product, system, or component is not identified above, TUV did not separately evaluate or inspect that product, system, or component, and TUV makes no representation or warranties concerning the suitability of that product, system or component for use.

In detail, the following inspections were performed in accordance with the standards referenced or defined in this report.

(a) **Grounding and Bonding**

Exposed non-current carrying parts of the equipment were inspected for effective grounding and bonding

(b) **Guarding of Live and Moving Parts:**

All hazardous live electrical components were inspected for installation in a suitable enclosure. Moving parts were inspected for suitable guarding against pinching, crushing or cutting injuries.

(c) **Overcurrent, Short Circuit and Overload Protection:**

Overcurrent, short circuit and overload protection installed in this equipment were identified to be NRTL Listed or Recognized and of proper size, rating and location.

(d) **Internal Wiring:**

Internal wiring and wiring methods were evaluated for compliance with applicable provisions of the standards referenced or defined in this report. Wiring was verified to be, properly sized and rated, with a temperature rating suitable for the installed application. Securement, routing and segregation of circuit conductors was determined to be suitable.

(e) **Electrical Testing**

Non-Destructive Electrical Tests were performed to verify the suitability of operation and safety of the unit. Selection of tests, are dependent on the type of equipment and applicable provisions of the standards referenced or defined in this report. Test data sheets are attached to this report.

(f) **Environmental Suitability:**

The suitability of the specified equipment and components within known ordinary environmental contexts was evaluated. Outdoor-type equipment was evaluated for suitability for exposure to rain, dust, humidity, and splashing. Enclosures were required to be NEMA-rated. The suitability of the specified equipment and components was not evaluated to any standard, code or guideline not specifically referenced herein.

(g) **Installation of the Unit:**

It was verified the equipment was installed in accordance with the installation requirements as per NFPA 70 (US Electrical Code) for working areas and power connection. The equipment manufacturer’s installation instructions were additionally referenced if provided during the inspection.

(h) **Functional Check:**

A function check of E-Stop, interlock and GFCI protection was made to confirm intended operation of the devices.

(i) **Component List**

The following safety relevant components were inspected for suitability of electrical rating and NRTL[1] approval. Discrepancies noted during Inspection are noted in the section detailing “Modifications for Compliance”.

- Circuit Breakers
- Fuses
- Pushbuttons
- Relays
- Transformers
- Interlocks
- Internal Wires
- Power Cords
- Interconnecting cords
- Motor Controllers
- Motors
- Motor Overload
- Motor Contactors
- Lamps
- Receptacles
- Cables and Wires
- Disconnect Switches
- EMO’s
- Power Supplies

---

[1] NRTL: Nationally Recognized Testing Laboratory, e.g. TUV Rheinland, UL, CSA, etc.

Description of work ordered / Equipment:

The Field Evaluation of the 200 kW vehicle charger to ANSI/UL 2594 Standard for Safety Electric Vehicle Supply equipment, ANSI/UL 508A Standard for Industrial Control Panels and ANSI/UL 891 Standard for Deadfront switchboards for the evaluation of the bus bar construction aspect only. The 200 kW vehicle charger intent is to provide power to the Top Pick Handler manufactured by Taylor Machine Works, Inc, model ZLC-976. The charger will supply 480 Vac, 3 phase, 240 A for charging purposes through two charging guns (each charging gun is rated for 120 A, 3 phases) for the full capacity of the vehicle charger. The charger can supply the Top Pick Handler 200 kW through two charging guns or 100 kW through one charging gun. The Top Pick Handler has an on-board charger, which rectifies and charges the onboard Vdc batteries. The onboard equipment then converts the Vdc to a Vac for the operation of the electric motor. The Top Pick handler Vdc converter to Vac and the on-board charger, and controls on the Top Pick Handler are not part of this evaluation. Only the safely supplying the Top Pick Handler with 200 kw, 480Vac, 3 phase power to the Top Pick handler through the electric vehicle charger which is covered by this evaluation.

1. Main Listed Circuit Breaker
2. Listed branch circuit breakers
3. Contactor
4. 3R Enclosure – tested on site on a different project, identical enclosures
5. Surge protective devices
6. Vehicle coupler
7. Electric vehicle cable
8. Tin plated copper Bus bars (current density)

Equipment omitted from the Inspection: (If none omitted indicate N/A)

1. The entire Top Pick Handler, model ZLC-976 manufactured by Taylor Machine Works Inc. and all required safety requirements of the truck
2. The on-board charger on the Top Pick Handler
3. Any required bollards for physical protection of the chargers, this must be assessed and requirements enforced by the local AHJ (Authorities Having Jurisdiction).

Date of Inspection(s)

Initial review date:	June 5, 2019
Next review:	N/A
Final review date:	December 19, 2019

Standard(s) selected for the Inspection

The below standards were referenced during our inspection. Note: If a standard, code, or guideline is not listed then TUV did not evaluate the equipment to it.

List of standards used by number and edition	
US NEC	NFPA 70: 2017 National Electrical Code
ANSI/UL	UL 2594 Standard for Safety Electric Vehicle Supply Equipment ANSI/UL 508A Standard for Industrial Control Panels ANSI/UL 50E Standard for Enclosures for Electrical Equipment, Environmental Considerations

	ANSI/UL 891 Deadfront Switchboards (for bus bar current density calculations)
NFPA	N/A

Subcontractor information (if applicable):

Company:	N/A
Evaluator:	N/A

DOCUMENTATION SUBMITTED

Installation Instructions:	☒ Provided	☐ Not available
Drawings:	☒ Provided	☐ Not available
Markings:	☒ Provided	☐ Not available
Other		

FIELD INSPECTION TEST DATA:

Total number of units/systems	1	
System or Unit	☐ System ☒ Unit	
Rated voltage:	480	☒ V AC ☐ 1 Phase ☒ 3 Phase ☐ V DC
Rated current:	240	A
Rated frequency:	60	Hz
Control voltage:	24	☐ V AC ☒ V DC
Alternate voltages:	N/A	☐ V AC ☐ V DC
Largest motor:	N/A	☐ HP ☐ kW
*AFC of Facility Mains:	<10	kA
**SCCR of equipment	10	kA
Hazardous location:	☐ Yes ☒ No	
Area classification:	Ordinary	
Location:	☐ Indoors ☒ Outdoors (Note 1)	

Test Parameters

Voltage:	L_1-L_2	L_2-L_3	L_1-L_3	
	486.5	487.6	486.4	
Current (amps, max):	P(A)	P(B)	P(C)	
	238.7	235.1	237.8	
Insulation resistance:	1700	MΩ	☐ 500 V DC	☒ 1,000 V DC
Dielectric withstand test (Alternate) Vdc = Vac x 1.414	N/A	kV	☒ AC ☐ DC ☒ Pass ☐ Fail ☒ 1 Minute ☐ 1 Second	
Ground continuity: <0.1Ω	0.03	Ω	☒ Pass ☐ Fail	
Leakage current (max):	N/A	mA	☐ Pass ☐ Fail	
Branch circuit protection:	400	A	☒ Hardwired ☐ Cord Connected	
Enclosure class: ☒ Metallic ☐ Non-Metallic	☐ NEMA Type 1 ☐ NEMA Type 12		☒ NEMA Type 3 ☐ NEMA Type 4	
E-Stops/Interlocks:	☒ Pass	☐ Fail	☐ N/A	
Rain test:	☒ Pass	☐ Fail	☐ N/A	
GFCI test:	☐ Pass	☐ Fail	☒ N/A	
Additional tests:				
Note: Leakage current tests not required when equipment is hardwired.				

* Available Fault Current = AFC (at connection point of facility mains)
** Short Circuit Current Rating = SCCR, (of equipment)

Note 1 – the identical enclosure has been tested under Project No 163103, Report No 31874271.001, June 24, 2019.

Component Temperatures

Component	**Temperature °C**
Main Disconnect	42.9
Contactor 1	40.5
Contactor 2	39.4
Circuit Breaker 1 (250 A)	39.6
Circuit Breaker 2 (250 A)	39.4
Bus bars from Main 400 A circuit breaker to 225 circuit breakers.	49.2
24 Vdc Power Supply	36.3
Branch circuit protection for 24Vdc power supply	44.4
Surge protective device branch circuit protection	45.4
Surge Protective Device	44.5
Bus Bar L1	52.4
Bus Bar L2	47.9
Bus Bar L3	44.6
Control board	42.1
Cord Bushing	27.4
Internal Wiring	29.1
Charging Gun 1	21.5
Charging Gun 1 cable	44.7
Charging Gun 2	22.1
Charging Gun 2 cable	27.9

Test Comments: Due to the battery status on the Top Pick Handler being less than 50%, the electric vehicle charger charged the truck at 100% of the capacity of the charger station.

Note that when the truck batteries reach a predetermined charge value, the charger then decreases the full charging to a trickle charge of approximately less than 50% of the capacity of the electrical vehicle charger until truck batteries are fully charged.

Note that all power wire cables, contactor, circuit breakers and bus bars are sized for 120 amp, full load of equipment.

Note that all measured temperature are acceptable according to Table 22 in ANSI/UL 2594 Standard for Safety Electric Vehicle Supply.

Environmental Conditions (optional and for reference only):

Temperature 13.3 ºC Humidity N/A %.

Multiple Similar Units

Serial No.	IR (MΩ)	Leakage (mA)	Ground Cont. (Ω)	Current (amps)			Voltage			TUV RNA Label #
				A	B	C	L_1-L_2	L_2-L_3	L_1-L_3	
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

If Batch/Lot Inspection and testing is conducted, specify the number of units in the batch and the number of units sampled. Sample selection shall be random, avoiding consecutive numbering if possible and taken from the beginning, middle and end of the lot or batch. If non-conformity is found in any of the units, the entire lot or batch shall be inspected and tested. A batch inspection is limited to 500 units of the same model at one time. See Annex B of NAM FES Procedure MS-0014396.

Number of units in the batch: 1

Number of units Sampled: 1

Test Equipment

Device	Manufacturer	Model	Serial Number	Calibration Due Date	Functionality Checked P/F
DMM TRMS Multimeter	Fluke	376	29720181WS	4/12/2020	P
Insulation Tester	Fluke	1503	28750204	4/12/2020	P
IR Thermometer	Fluke	568	28980021	4/18/2020	P
AC Voltage Module	Fluke	V3000FC	34410086	4/12/2020	P
AC Voltage Module	Fluke	V3000FC	34410082	4/12/2020	P
AC Voltage Module	Fluke	V3000FC	34410076	4/12/2020	P
AC Current Iflex Module	Fluke	A3001FC	32520017WS	4/12/2020	P
AC Current Iflex Module	Fluke	A3001FC	32520018WS	4/12/2020	P
AC Current Iflex Module	Fluke	A3001FC	32810170WS	4/12/2020	P
Notes:					

Required Markings:

1. Fuse replacement value (Warning - Risk of Fire. Replace only with same type and rating fuse)	☐ **Add** ☒ **Provided** ☐ **NA**
2. Door service caution (Caution – Risk of Electric Shock. Disconnect from Power Before Servicing)	☐ **Add** ☒ **Provided** ☐ **NA**
3. Nameplate/electrical ratings (Nameplate Ratings as measured/calculated from "Test Details")	☐ **Add** ☒ **Provided** ☐ **NA**
4. Arc flash warning (Danger – Arc flash and shock hazard. Appropriate PPE required.)	☐ **Add** ☒ **Provided** ☐ **NA**
5. Other: (Lockout , HV, Disconnect power warning labels required on all panel doors/covers)	☐ **Add** ☒ **Provided** ☐ **NA**
6. All Markings Shall be in English or symbols as indicated by the Standard	☒ **Pass** ☐ **Fail**

Modifications for Compliance: ☐ **Open** ☒ **Completed and Accepted**

General:

- Reference FES procedure and specified Standard for Safety identified on page 5.
- Hazardous voltage labels (permanent) shall applied to all electrical control panels with voltages 30 Vrms or higher. (See required Markings table above).
- Machine nameplate shall include the largest motor/or load rating, AIC or SCCR rating and enclosure type.
- The constructions issues listed below shall be resolved and noted as corrected before receiving final Acceptance and Labeling.

1 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

Electric Vehicle Charger Cabinet/7.4.2.1 A polymeric material used for enclosures of live parts shall comply with Table 4.

Non-conformance -The acrylic dead front, which is installed to prevent contact with live un-insulated parts, is within ½ inch of the main 400 A UL Listed UL 489 circuit breaker. However the acrylic does not comply with Table 4 as required.

The acrylic shall be replaced with a polymeric material that has all the required CTI, HWI and HAI characteristics. Note that the voltage from phase to ground is 277 Vac.

Corrective Action – the acrylic deadfront replaced with a sheet metal deadfront forming an electrical enclosure preventing contact with live un-insulated parts as required.

2 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

7.5.1.2 Enclosures, regardless of the materials, shall not be provided with ventilation openings unless designated as Type 1 or Type 2 enclosures.

Non-conformance -The Charging Station is provided with ventilation openings however the enclosure is not a Type 1 or Type 2, the enclosure is intended for a Type 3R.

A Type 3R shall not be provided with ventilation openings as per the ANSI/UL 2594.

Corrective Action - the ventilation openings have been closed and sealed from the inside of the enclosure panel.

3 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

7.7.1 All enclosures shall be rated for one of the enclosure types in Annex A, Ref. No. 20. The enclosure rating shall be appropriate for the intended conditions of use.

Non-conformance -The enclosure is not a Listed Enclosure to ANSI/U 50E Standard for Electrical Equipment Environmental Considerations.

Considerations for an outdoor application which is exposed to all the local weather conditions.

Corrective Action – The enclosure has been evaluated to ANSI/UL 50 Standard for Enclosures for Electrical Equipment, non-Environmental Considerations and tested as per ANSI/UL 50 E Standard for Electrical Equipment Environmental Considerations to assure the enclosure can be exposed to the local weather conditions. The testing on an identical design has been conducted with passing results. The results are documented on Report No 31874271.001 issued on June 24, 2019 Project No 163103.

4 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

8.2.1 To reduce the risk of unintentional contact that results in electric shock from an uninsulated live part or film-coated wire, an opening in an enclosure shall comply with either:

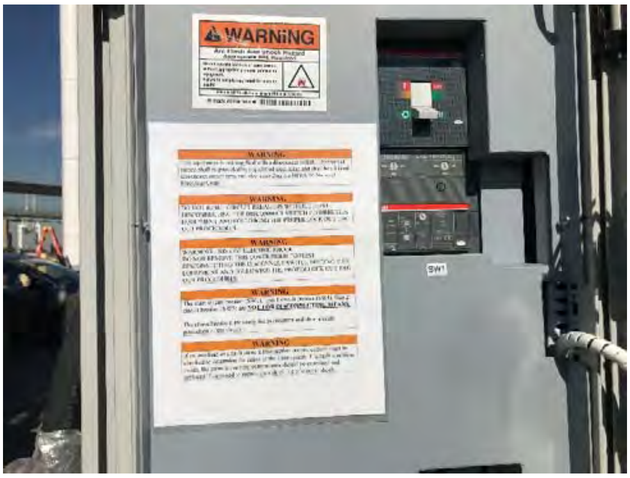
a) For an opening that has a minor dimension less than 25.4 mm (1 inch), such a part or wire shall not be contacted by the probe illustrated in Figure 6, or

b) For an opening that has a minor dimension of 25.4 mm (1 inch) or more, such a part or wire shall be spaced from the opening as specified in Table 8

Non-conformance -The acrylic dead front has large gaps, which allow access to live uninsulated bus bars.

The openings in the dead front shall not allow access to the live uninsulated parts.

Corrective Action – The acrylic dead front was replaced with a sheet metal deadfront and also the gaps have been reduced such that live uninsulated parts could not come in contact.

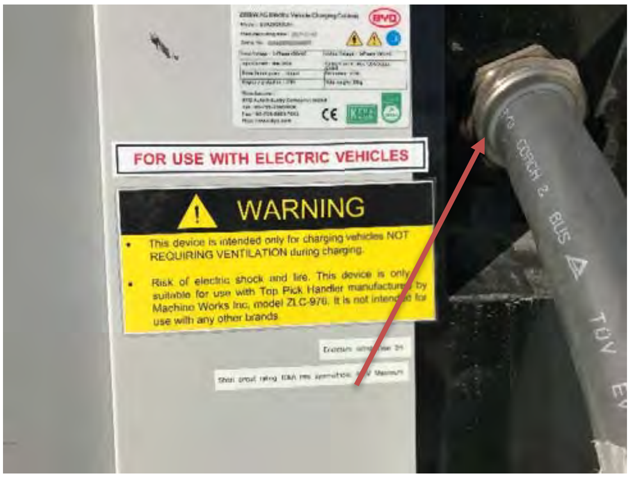


5 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.3 With reference to 13.1.2 (c), the permanently connected EV cable shall comply with the strain relief requirements in 13.2 and the requirements for bushings in 13.3.

Non-conformance -It cannot be confirmed that the bushing where the EV cable enters the enclosure complies with the strain relief requirements as required.

Corrective Action – The bushing has been confirmed that it complies with the strain relief requirements Paragraph 13.2.



6 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.2 The EV supply equipment shall be provided with one of the following means at the output:

a) An EV receptacle in accordance with Annex A, Ref. No. 5.

b) A suitably rated grounding type receptacle in accordance with Annex A, Ref. No. 28.

c) Wire terminals for a permanently connected EV cable. The terminals shall comply with the requirements for wiring terminals in accordance with 12.1.2.

13.1.3 With reference to 13.1.2 (c), the permanently connected EV cable shall comply with the strain relief requirements in 13.2 and the requirements for bushings in 13.3.

13.1.4 With reference to 13.1.2 (a) and 13.1.2 (b), the receptacle shall have a voltage and current rating corresponding to the rated output of the EV supply equipment.

Non-conformance – The charging gun (vehicle coupler) is not a NRTL (Nationally Recognized Testing Laboratory) Listed device to ANSI/UL 2551 Standard for Electric Vehicles (EV) Charging System Equipment as required.

Either the device will need to be replaced with a NRTL (Nationally Recognized Testing Laboratory) Listed device or a separate project opened to be tested at a TUV Rheinland facility to the ANSI/UL Standard listed above.

Corrective Action – BYD has opened a separate project for a certification of the vehicle coupler in question. The vehicle coupler has completed the certification process with passing results and is now a Listed device. The BYD vehicle coupler is now part of the TUV Rheinland Follow-Up program as part of the TUV Certification.

The vehicle coupler has been replaced with a TUV Rheinland Listed vehicle coupler with the proper TUV Rheinland Listing Mark.

The TUV Certification is attached to the end of the report and can be verified on TUV Certipedia at https://www.certipedia.com/certificates/50422962?locale=en .

7 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.7 EV cables provided to complete the connection from the EV supply equipment to the vehicle shall be in accordance with Annex A, Ref. No. 3.

13.1.8 The EV cables shall be type EV, EVJ, EVE, EVJE, EVT, or EVJT, and shall have a minimum voltage rating corresponding to the overall output rating of the EV supply equipment.

Non-conformance – The EV cables for the connection of the electric vehicle is not a NRTL (Nationally Recognized Testing Laboratory) Listed to ANSI/UL 62 Standard for Flexible Cord Sets and Power Supply Cords as required.

Corrective Action – the cable has been tested by TUV Rheinland (separate project) to ANSI/UL 62 Standard for Flexible Cords and Power Supply Cords with passing results.

The cables have been replaced with cables that have been tested, inspected and properly labeled at the wire factory.

The TUV Certification is attached to the end of the report and can be verified on TUV Certipedia at https://www.certipedia.com/certificates/50422964?locale=en.

8 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.9 The EV cable shall contain conductors that are suitably sized for the intended output rating of the EV supply equipment.

Non-conformance – The output EV cable for the connection of the electric vehicle to the charger station is a marked 35mm² which is equivalent to 2 AWG. This cable is not properly sized for the output of the charging station gun which is 120 A (100kW, @480Vac, 3 phase, 4 wire plus ground, 60 Hz). The current cable is 4W + Gnd (4 current carrying conductors). Table 400.5(A)(2) in the 2017 National Electrical Code states that a 2 AWG cord with 3 current carrying conductors is suitable for 112 A.

However according to Article 400.5(A) of the National Electrical Code, since there are 4 current carrying conductors (neutral) an Adjustment Factor of 80% shall be applied to the 112A which equates to 112A x 80% = 90 ampacity.

The cable shall be replaced with a properly sized cable that has an ampacity of 120A with the properly adjustment factors applied.

Corrective Action – The 2 AWG cable has been found acceptable using Table 400.5(A)(2) by determining and assuring that the termination at both ends of the cable are rated for 90 °C conductors and the output cable has a Listed temperature rating of 105 °C.

In view of this Table 400.5(A)(2) for 2 AWG cord column F, has an ampacity of 152 Amps. With 4 current carrying conductors in the cable, 80% of 152 Amps = 121.6 Amps. The marked and measured load is 120 A (verified during testing) does not exceed the allowable ampacity of the cable with the adjustment factor.

9 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.14 External connections at the output of EV supply equipment or at the vehicle connector shall be protected by a means that de-energizes the cable conductors and vehicle connector upon exposure to a strain that results in a short circuit, separation of the cable from the EV supply equipment or the vehicle connector, or access to uninsulated hazardous live parts. In addition, there shall be no exposure to live parts after de-energization occurs. If breakaway couplings are used, they shall comply with Annex A, Ref. No. 5

Non-conformance – It cannot be determined if there is a circuit or a form of protection that will de-energize the cable conductors and vehicle connector upon exposure to a strain that results in a short circuit, separation of the cable from the EV supply equipment or the vehicle connector, or access to uninsulated hazardous parts. The above requirements shall be referred to for requirements.

Corrective Action - Objective evidence has been supplied in the form of a circuit analysis of the function of the electrical safety circuits and a video from the local factory in Lancaster, CA. Prior to the test a circuit analyses has been conducted and a test plan was developed to assure the de-energizing of the cable conductor upon strain to the cable.

Note that truck and the on board truck charger is not included in the Final Evaluation of the electric vehicle charger. However the charger is looking for specific signals in order to safely energize and de-energize the electric vehicle charger.

Circuit analysis and test results are acceptable and the compliance with this requirement is confirmed compliant.

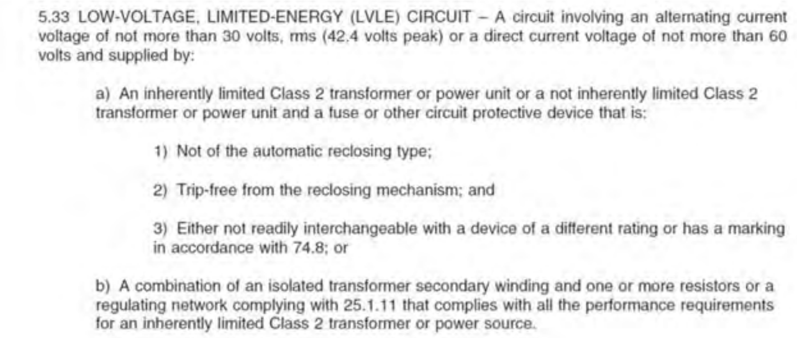
10 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

13.1.15 Any connection at the output that is not a power-carrying conductor (a signal wire) shall be LVLE.

Non-conformance – It cannot be determined that all signal wires are a LVLE circuit as defined in the ANSI/UL 2595 Electrical Vehicle Supply Equipment.

Note that the 24 Vdc power supply is a UL Listed Industrial Control Equipment power supply however the output of the power supply is 240W, 24Vdc and is not a Class 2 source as required.

Corrective Actions – Additional fusing of 4 amps fuses were added to the output of the 24 Vdc power supply limiting the signal power (to LVLE circuits) in the output power cable to the truck to be charged.



5.33 LOW-VOLTAGE, LIMITED-ENERGY (LVLE) CIRCUIT – A circuit involving an alternating current voltage of not more than 30 volts, rms (42.4 volts peak) or a direct current voltage of not more than 60 volts and supplied by:

a) An inherently limited Class 2 transformer or power unit or a not inherently limited Class 2 transformer or power unit and a fuse or other circuit protective device that is:

1) Not of the automatic reclosing type;

2) Trip-free from the reclosing mechanism; and

3) Either not readily interchangeable with a device of a different rating or has a marking in accordance with 74.8; or

b) A combination of an isolated transformer secondary winding and one or more resistors or a regulating network complying with 25.1.11 that complies with all the performance requirements for an inherently limited Class 2 transformer or power source.

11 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

18.2 Nonmetallic materials used to form enclosures shall have a minimum flammability rating in accordance with Table 13.

Non-conformance – The Acrylic cover which is utilized for personnel protection does not have a 5V flammability rating as required.

Note that the acrylic cover is in place to prevent users from contacting live uninsulated bus bars.

Corrective Action – The acrylic sheet has been replaced with a sheet metal dead utilized for personnel protection from coming in contact with live bus bars.

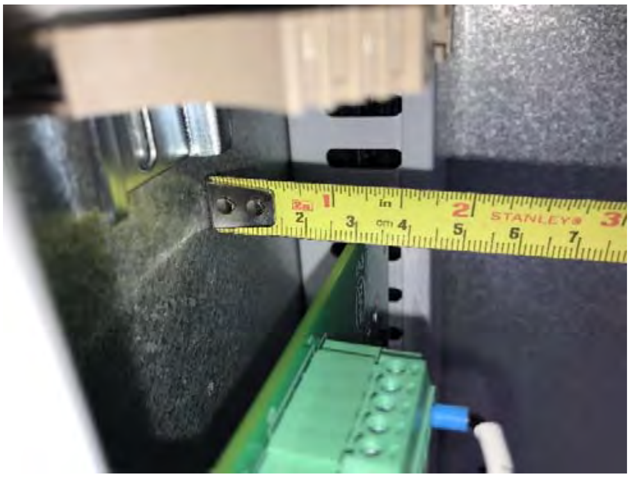
12 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

22.1.1 Except as indicated in 22.1.1.1, the spacings for a device shall not be less than the applicable values specified in Table 14 or as provided in Alternate Spacings – Clearances and Creepage Distances,

23. For spacings requirements where liners and barriers are used, see 22.2.1.

Non-conformance – The spacing from the uninsulated pins that are on the bottom of the printed circuit board which is carrying the line voltage which is 277 Vac to ground does not have the required spacing through air of 1/2 inches.

Corrective Actions – there has been metal spacers installed in the securement screws to increase the creepage and clearance distances from the live un-insulated parts on the printed circuit board.



13 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

24.1.1 Except as indicated in 24.1.1.1, insulated conductors of different circuits within a device, including wires in a terminal box or compartment, shall be either separated by barriers or segregated and shall be so separated or segregated from uninsulated live parts connected to different circuits.

Non-conformance – The 24Vdc control circuit's conductors are not segregated from the 480Vac circuit conductors and are not provided with any barriers.

It cannot be determined the voltage rating of the 24 vdc circuit conductors due to the small gauge conductor and no visible surface marking on the conductors

Reference:

24.1.1.1 For insulated conductors of different circuits, when each conductor is provided with insulation intended for the highest of the circuit voltages, no barriers or segregation are required.

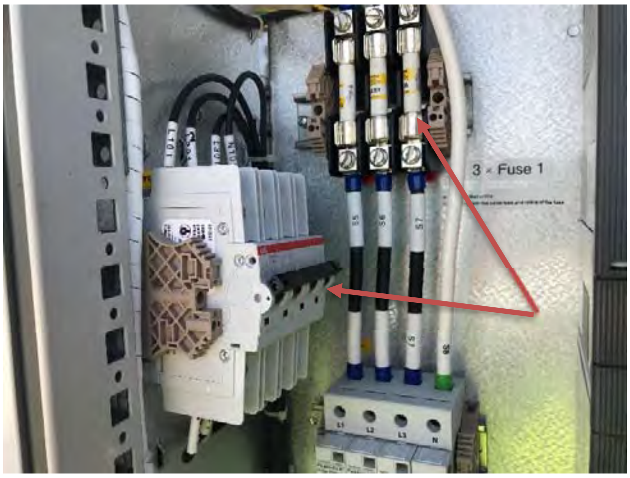
Corrective Action – Objective evidence has been provided showing that the conductor utilized in the 24 Vdc circuit is rated 600 V. No separation of conductors are necessary due to all the conductors are rated for the highest working voltage which is 480 Vac.

14 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

28.2.1 Supplementary protectors shall not be used for overcurrent protection of circuits defined as "branch circuits" as defined in Annex A, Ref. No. 1.

Non-conformance – There are supplementary protectors (UL Recognized Component UL 1077) used as overcurrent protection for branch circuits rather than a NRTL (Nationally Recognized Testing Laboratory) Listed UL 489 circuit breakers as required.

Corrective Action – The supplementary protector has been replaced with UL Listed 50 amp Class G fuses and UL Listed circuit breakers as required.



15 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

28.5.1 Circuit breakers incorporated as overcurrent protection shall comply with the applicable requirements in Annex A, Ref. No. 74.

Non-conformance – There are overcurrent protective devices that are not a NRTL (Nationally Recognized Testing Laboratory) Listed circuit breaker to ANSI/UL 489 Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures as required. The circuit breakers only carry a CE Mark.

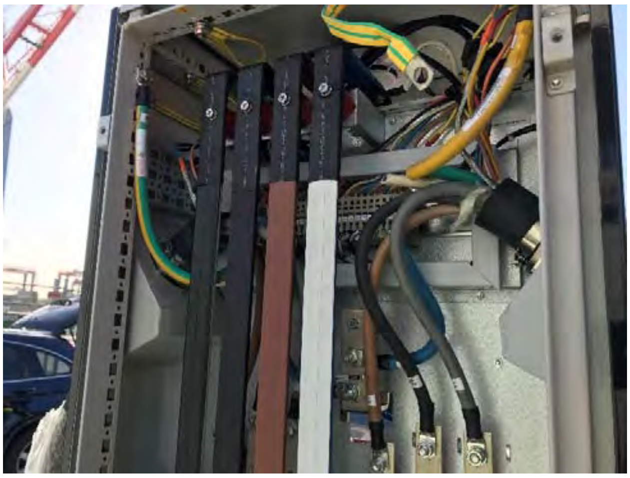
Corrective Action – The overcurrent devices that were not NRTL (Nationally Recognized Testing Laboratory) Listed circuit breaker to ANSI/UL 489 Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures, were replaced with UL Listed UL 489 circuit breakers or UL Listed branch circuit type fuses as required.

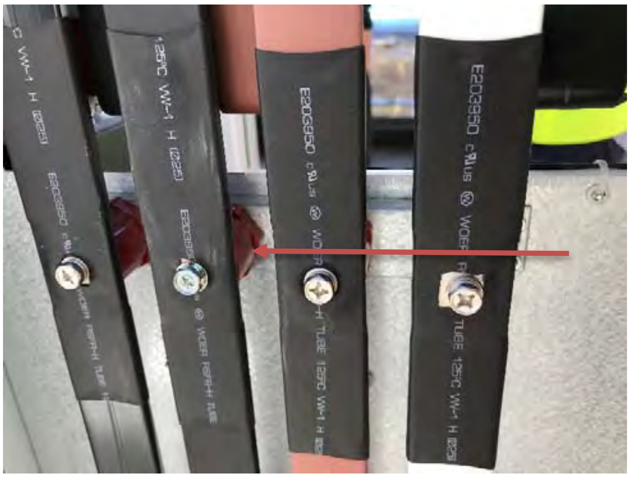
16 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

31.1 An insulating material used for supporting live parts and a barrier material shall be moisture-resistant and not be adversely affected by the temperature and stresses to which it is subjected under conditions of use.

Non-conformance – There is no information on the busbar isolators, which are supporting the live uninsulated bus bars.

Corrective Action – Objective evidence has been supplied and verified that the insulating material supporting the bus bar is suitable for supporting live uninsulated busbars.



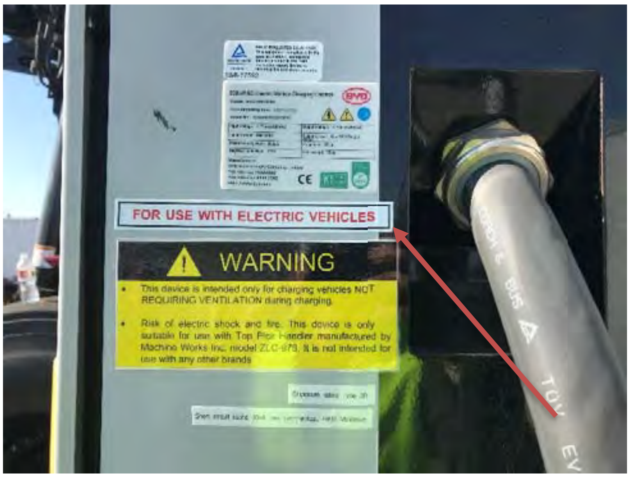


17 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

72.3 All EV supply equipment shall be marked with the words “For use with Electric Vehicles.” This marking shall be visible during intended use.

Non-conformance – The vehicle charging station is not marked with “For Use with Electric Vehicles” as required.

Corrective Action – The electric vehicle charger has a label affixed to the charger stating “For Use with Electric Vehicles” as required.

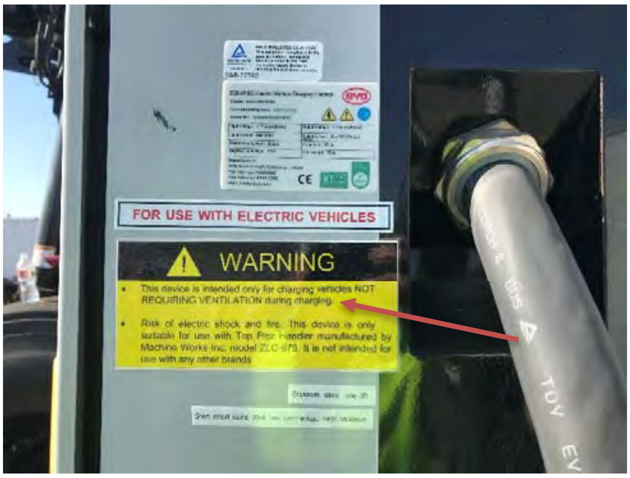


18 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

72.4 All EV supply equipment shall be marked with the words "Ventilation Not Required." This marking shall be visible during normal use.

Non-conformance – The Charging Station is not marked with "Ventilation Not required" were visible as required.

Corrective Action – The electric vehicle charger has a label affixed to the charger stating "Ventilation Not Required" as required.

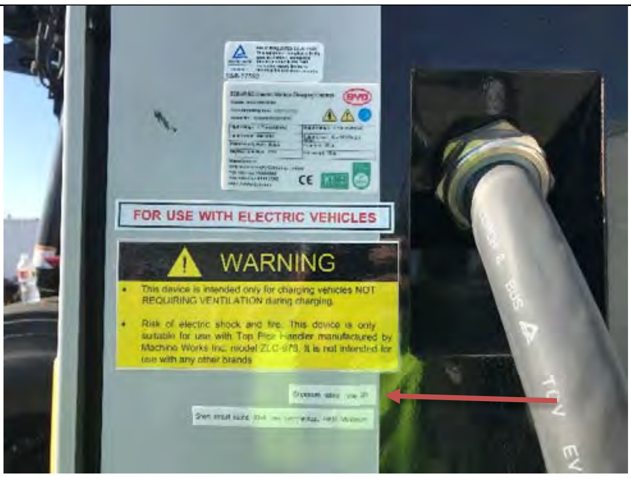


19 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

73.1 A device enclosure shall be marked with the rated enclosure type.

Non-conformance – The enclosure is marked with IP54 rather than a Type as described in the ANSI/UL 2594 as required.

Corrective Action – The electric vehicle charger has a label affixed to the charger stating "3R". Note that the electric vehicle charger was tested according to ANSI/UL 50E Standard for Safety of Enclosures for Electrical Equipment, Environmental Considerations with passing results.

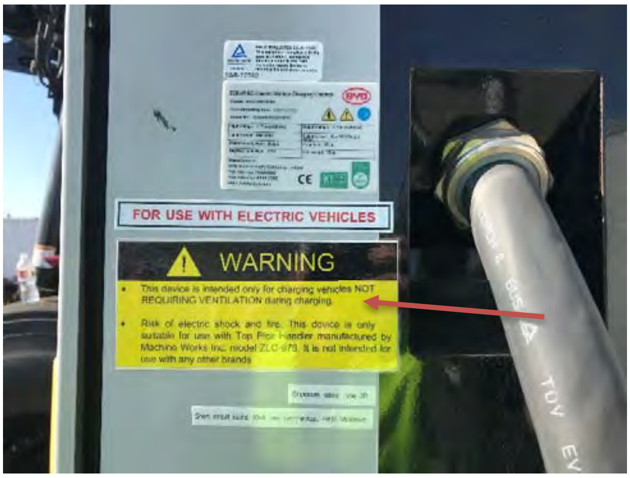


20 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

74.12 EV cord sets and EV Charging Stations shall be marked with the word “WARNING” and the following or the equivalent: “This device is intended only for charging vehicles not requiring ventilation during charging.”

Non-conformance – The Charging Station is not marked with “WARNING – This device is intended only for charging vehicles not requiring ventilation during charging” as required.

Corrective Action – The electric vehicle charger has a label affixed to the charger stating “WARNING – This device is intended only for charging vehicles not requiring ventilation during charging”.

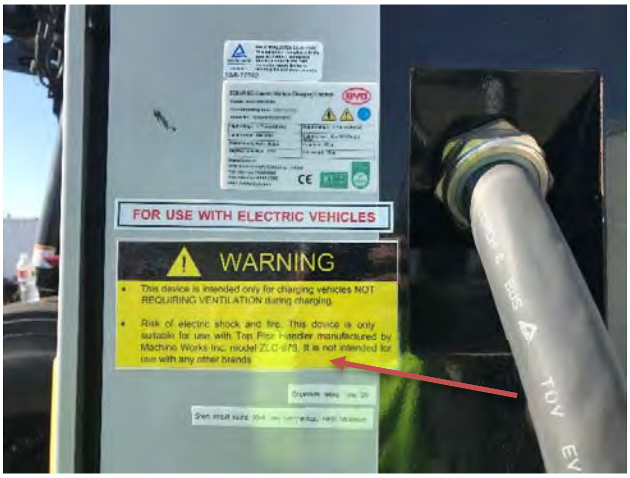


21 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

74.14 In accordance with 13.1.5, 13.1.11, and 13.1.12, devices that are intended for use with a specific vehicle shall be marked with the word “ WARNING” and the following or the equivalent wording: “Risk of electric shock and fire. This device is only suitable for use with the (Make) (Model). It is not intended for use with any other vehicles.” The “make” and “model” of the vehicle shall be added into the marking.

Non-conformance – The Charging Station is not marked with "WARNING – Risk of electric shock and fire. This device is only suitable for use with (Make and model). It is not intended for use with any other vehicles". This EV connector is specific to the BVD vehicles.

Corrective Action – The electric vehicle charger has been marked with "WARNING – Risk of electric chock and fire. This vehicle is only suitable for use with Top Pick Handler manufactured by Taylor Machine Works Inc., model ZLC-976. It is not intended for use with any other vehicles" as required.



22 - Equipment/Deviations: ANSI/UL 2594 Standard for Safety Electric Vehicle Supply Equipment

(B) Ventilation Not Required. Where marking is required by

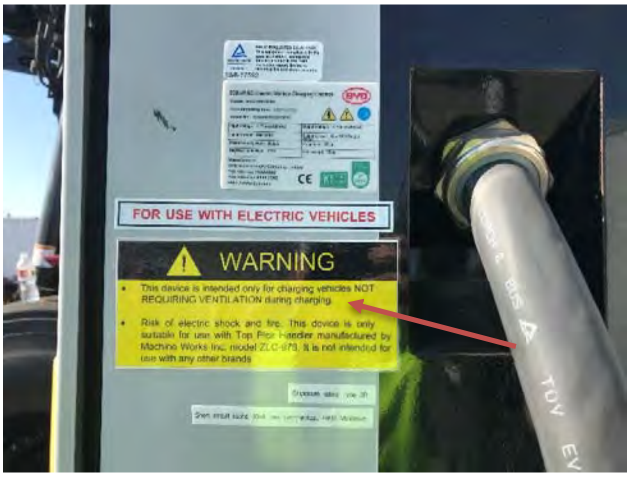
625.52(A), the equipment shall be clearly marked by the manufacturer as follows:

VENTILATION NOT REQUIRED

The marking shall be located so as to be clearly visible after installation.

Non-conformance – The Charging Station is not marked "Ventilation Not Required" as required by the National Electrical Code.

Corrective Action – The electric vehicle charger has been affixed with a label stating "Ventilation Not required" as required.



23 - Equipment/Deviations: 2017 National Electrical Code

625.17 Cords and Cables.

(A) Power-Supply Cord. The cable for cord-connected equipment shall comply with all of the following:

(1) Be any of the types specified in 625.17(B) or hard service cord, junior hard service cord, or portable power cable types in accordance with Table 400.4. Hard service cord junior hard service cord, or portable power cable types shall be listed, as applicable, for exposure to oil and damp and wet locations.

(2) Have an ampacity as specified in Table 400.5(A)(1) or, for 8 AWG and larger, in the 60°C columns of Table 400.5(A)(2).

Non-conformance – The output EV cable for the connection of the electric vehicle to the charger station is a marked 35mm² which is equivalent to 2 AWG. This cable is not properly sized for the output of the charging station gun which is 120 A (100kW, @480Vac, 3 phase, 4 wire plus ground, 60 Hz). The current cable is 4W + Gnd (4 current carrying conductors). Table 400.5(A)(2) in the 2017 National Electrical Code states that a 2 AWG cord with 3 current carrying conductors is suitable for 112 A.

However according to Article 400.5(A) of the National Electrical Code, since there are 4 current carrying conductors (neutral) an Adjustment Factor of 80% shall be applied to the 112A which equates to 112A x 80% = 90 ampacity.

The cable shall be replaced with a properly sized cable that has an ampacity of 120A with the properly adjustment factors applied.

Corrective Action – The 2 AWG cable has been found acceptable using Table 400.5(A)(2) by determining and assuring that the termination at both ends of the cable are rated for 90 °C conductors and the output cable has a Listed temperature rating of 105 °C.

In view of this Table 400.5(A)(2) for 2 AWG cord column F, has an ampacity of 152 Amps. With 4 current carrying conductors in the cable, 80% of 152 Amps = 121.6 Amps. The marked and measured load is 120 A (verified during testing) does not exceed the allowable ampacity of the cable with the adjustment factor.

24 - Equipment/Deviations: 2017 National Electrical Code

625.18 Interlock. Electric vehicle supply equipment shall be provided with an interlock that de-energizes the electric vehicle connector whenever the electrical connector is uncoupled from the electric vehicle. An interlock shall not be required for portable cord-and-plug-connected electric vehicle supply equipment intended for connection to receptacle outlets rated at 125 volts, single phase, 15 and 20 amperes. An interlock shall not be required for dc supplies less than 60 volts dc.

Non-conformance – It cannot be determined if Charging Station is provided with an interlock that de-energizes the electric vehicle connector whenever the electrical connector is uncoupled from the electric vehicle.

Corrective Action - Objective evidence has been supplied by circuit analysis of the function of the electrical safety circuits and a video from the local factory in Lancaster, CA. Prior to the test, a circuit analyses has been conducted and a test plan was developed to assure the de-energizing of the cable conductor upon the uncoupling of the vehicle connector.

Note that the Top Pick Handler by Taylor Machine Works, Inc, model ZLC-976 and the on board charger is not included in the Final Evaluation of the electric vehicle charger. However the charger is looking for specific signals in order to safely energize and de-energize the electric vehicle charger.

Circuit analysis and test results are acceptable and the compliance with this requirement is confirmed compliant.

25 - Equipment/Deviations: 2017 National Electrical Code

625.19 Automatic De-Energization of Cable. The electric vehicle supply equipment or the cable-connector combination of the equipment shall be provided with an automatic means to

de-energize the cable conductors and electric vehicle connector upon exposure to strain that could result in either cable rupture or separation of the cable from the electric connector and exposure of live parts. Automatic means to de-energize the cable conductors and electric vehicle connector shall not be required for portable electric vehicle supply equipment constructed in accordance with 625.44(A)

Non-conformance – It cannot be determined if the if the Charging Station is provided with an automatic means to de-energize the cable conductor or the electric vehicle connector upon exposure to strain that could result in the cable rupture or separation of the cable from the electrical connector.

Corrective Action - Objective evidence has been supplied by circuit analysis of the function of the electrical safety circuits and a video from the local factory in Lancaster, CA. Prior to the test a circuit analyses has been conducted and a test plan was developed to assure the de-energizing of the cable conductor upon strain to the cable.

Note that the Top Pick Handler by Taylor Machine Works, Inc, model ZLC-976 and the on board charger is not included in the Final Evaluation of the electric vehicle charger. However the charger is looking for specific signals in order to safely energize and de-energize the electric vehicle charger.

Circuit analysis and test results are acceptable and the compliance with this requirement is confirmed compliant.

26 - Equipment/Deviations: 2017 National Electrical Code

625.43 Disconnecting Means. For equipment rated more than 60 amperes or more than 150 volts to ground, the disconnecting means shall be provided and installed in a readily accessible location. The disconnecting means shall be lockable open in accordance with 110.25.

Non-conformance – The Charging Station may be provided with 400 A service and it cannot be confirmed that the disconnect means is in readily accessible and has an integral lockable method.

Corrective Action – the verification of the correct size and location of the disconnecting means is under direct supervision and enforcement of the Local Authority Having Jurisdiction.

27 - Equipment/Deviations: 2017 National Electrical Code

625.46 Loss of Primary Source. Means shall be provided such that, upon loss of voltage from the utility or other electrical system(s), energy cannot be back fed through the electric vehicle and the supply equipment to the premises wiring system unless permitted by 625.48.

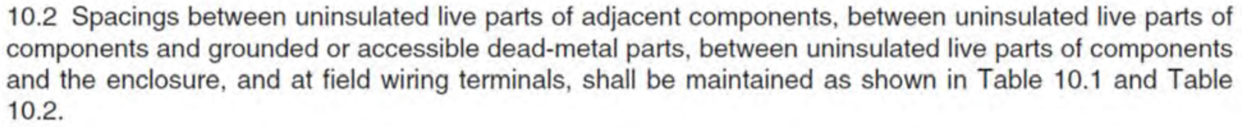
Non-conformance – It cannot be determined if the Charging Station is provided with a means to prevent the energy being back-fed to the utility or other electrical systems through the electric vehicle and the Charging Station.

Note that the Charging Station is not an Interactive System.

Corrective Action – Objective evidence has been supplied to support the circuit analysis to assure that upon loss of voltage from the utility. The electric vehicle cannot back feed the back to the utility.

This has been confirmed the operation of the electric vehicle charger.

28 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels



10.2 Spacings between uninsulated live parts of adjacent components, between uninsulated live parts of components and grounded or accessible dead-metal parts, between uninsulated live parts of components and the enclosure, and at field wiring terminals, shall be maintained as shown in Table 10.1 and Table 10.2.

Non-conformance – The spacing between the uninsulated vertical feeder busabars of opposite polarity (Phase A, B and C) are spaced 5/8 in apart rather than a minimum of 1 inch as per table 10.2 for the Feeder circuit.

Note that the feeder circuit is defined as the "The conductors and circuitry on the supply side of the last branch-circuit overcurrent device prior to the load".

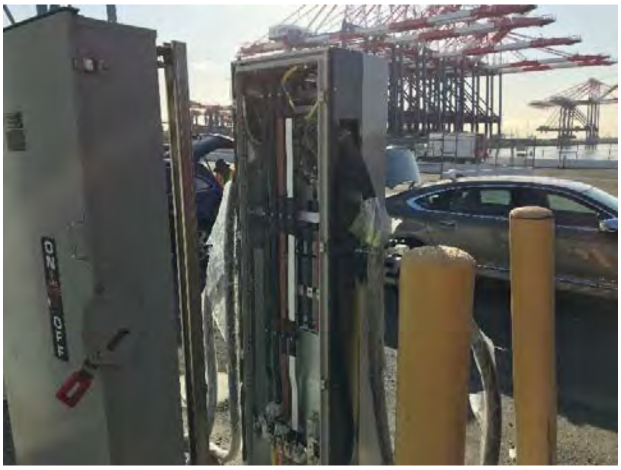
See Table 10.1 at the end of this Report.

Corrective Action – Additional UL Recognized Component shrink tube rated 600 V 125 °C has been added to the uninsulated bus bars where the uninsulated busbars do not meet the minimum spacings between the live uninsulated bas bars. The addition of the shrink tube eliminates any requirements for spacings and can be treated as an insulated conductor. The UL Recognized Component certification is attached to the end of this report for review.

Note that the capsrew that is securing the busbars are greater than 1 inch apart.

Additional Note – the electrical contractor did not want the sleeving on the (incoming) feeder circuit at the time of installation. However, specific instructions were added adjacent to the feeder supply connection. The instructions stated "Warning – Feeder supply connections must have UL Listed heat shrink tubing applied to lug and uninsulated bus bar, Heat shrink tubing rated 600V, 110 °C".

The shrink tubing was applied and the Authority Having Jurisdiction must assure that the shrink tube is properly applied to the feeder circuit conductors, terminal lugs and uninsulated bus bars.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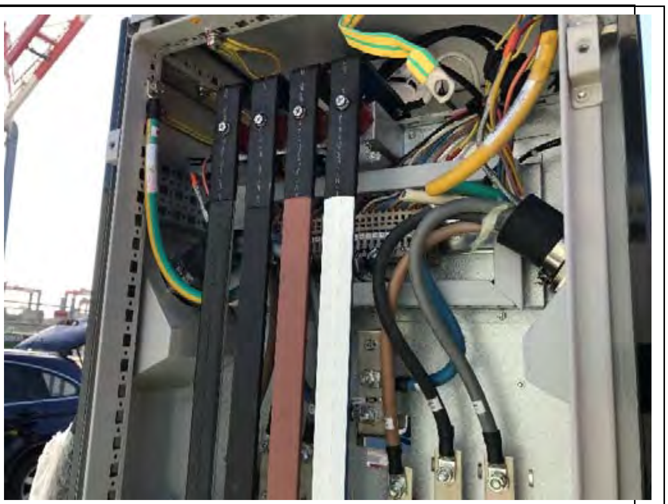
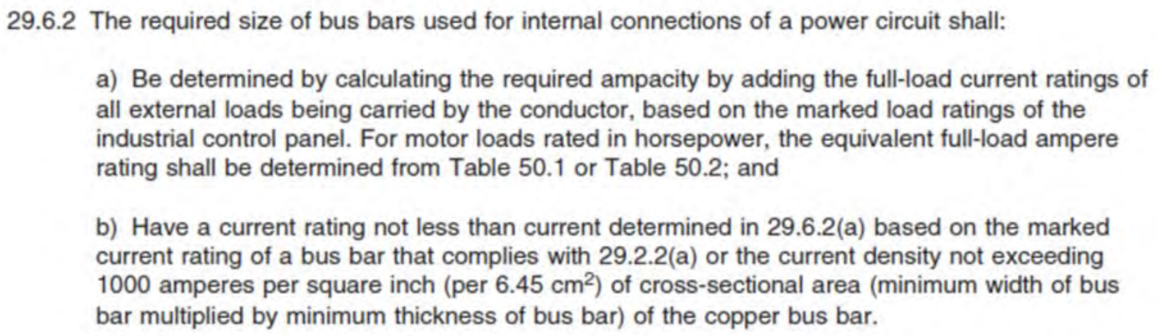
OFF




Warning–Feeder supply connection
Heat shrink tubing rated 600 V, 110C


uninsulated bus bar
3 Tubes
Heat Shrink Tubing
3M

29 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels



29.6.2 The required size of bus bars used for internal connections of a power circuit shall:

a) Be determined by calculating the required ampacity by adding the full-load current ratings of all external loads being carried by the conductor, based on the marked load ratings of the industrial control panel. For motor loads rated in horsepower, the equivalent full-load ampere rating shall be determined from Table 50.1 or Table 50.2; and

b) Have a current rating not less than current determined in 29.6.2(a) based on the marked current rating of a bus bar that complies with 29.2.2(a) or the current density not exceeding 1000 amperes per square inch (per 6.45 cm^2) of cross-sectional area (minimum width of bus bar multiplied by minimum thickness of bus bar) of the copper bus bar.

Non-conformance – during the initial review of the busbar current density cannot be determined if the bus bars exceed a 1000 A/in^2. Preliminary review indicates that the busbar current density are approximately:

1083.6 A/in^2 at the feeder vertical busbars in the line side of the main 400 A circuit breaker.

1176.5 A/in^2 at the horizontal busbar from the load side of the main circuit breaker to the line side of the branch circuit breakers.

1283 A/in^2 at the busbar output of the main 400 A circuit breaker to the horiszontal bus bar.

Either objective evidence shall be provided to prove that the busar current density does not exceed the 1000 A/in^2 or a temperature test must be conducted under full load.

However, please note, the temperature test cannot be conducted in the field due to safety issues during the test.

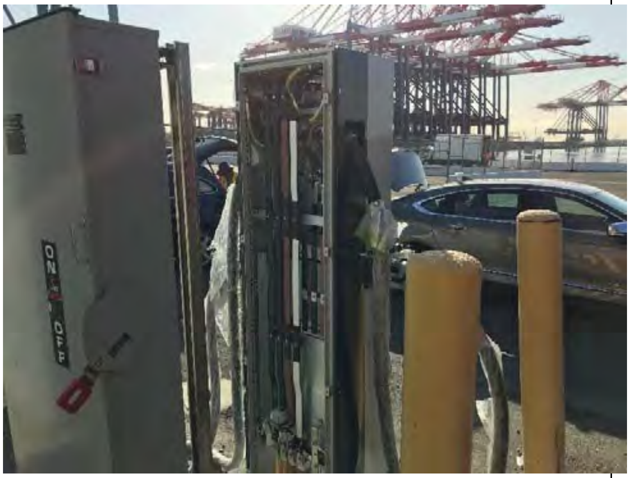
Corrective Action - After a careful review and correct measurement of the busbars in questions the busbar current density are 1032 A/in^2 at the feeder vertical busbars to the line side of the main circuit breaker and the bus bars from the output from the 400 A main circuit breaker to the horizontal bus bars.

Utilizing ANSI/UL 508A Standard for Industrial Control Panels and ANSI/UL 891 Standard for Safety Switchboards the cross section of the bus bars cannot reduced more than 5% due to rounding , shaping and dimensional tolerances. The 5% would equate to a 1032 A/in^2 bus bar current density.

After careful analysis and measurements, the feeder vertical busbars on the load side of the 400 from the horizontal bus bar to the vertical bus bars have a current density of 967.7 A/in^2.

In conclusion, the bus bar that were in question are at maximum capacity and do not require a temperature test.

Reference Standard – ANSI/UL 891 Standard for Safety Switchboards Section 8.8.1.6 Ampacity



30 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels

30.3 Location

30.3.1 A disconnecting means shall be provided for each incoming supply circuit.

Exception: A disconnecting means is not required when the industrial control panel is marked in accordance with 60.1.

30.3.2 The disconnecting means shall open each ungrounded conductor of the supply circuit.

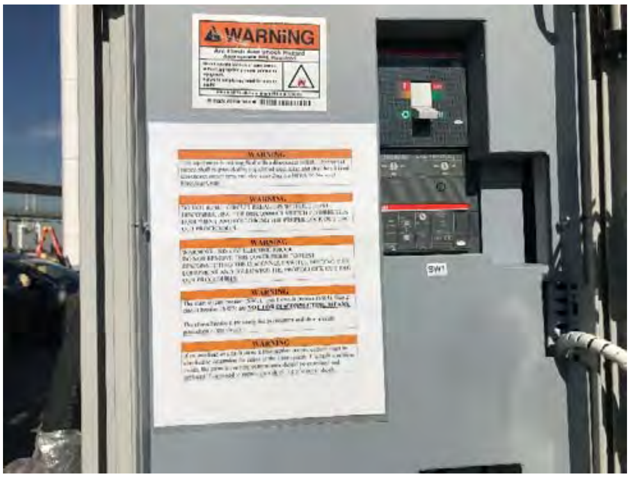
Non-Conformance – The electric vehicle charger is supplied with a main 400 A UL Listed circuit breaker however the circuit breaker is not able to be locked in the open (off) position. In view of this the main 400 A UL Listed circuit breaker cannot act as the disconnecting means.

Corrective Action - the vehicle charger/industrial control panel is supplied with a deadfront for the sole purpose of protection of accessing live parts with the door open.

The main circuit breaker and branch circuit breakers (for charging guns) are for the sole purpose of providing overcurrent and short circuit protection only not for disconnecting means.

The proper marking was provided on the deadfront stating that the industrial control panel is not provided with a main disconnect and the main disconnect shall be provided by others. In addition, the marking indicated that the Listed disconnect switch shall be supplied by a qualified electrician.

Note that the local AHJ (Authorities Having Jurisdiction) will be required to assure that the electric vehicle charger is supplied with the properly size and type of disconnect switch in accordance with the National Electrical Code.

31 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels

31 Branch Circuit Protection

31.1 Component requirements

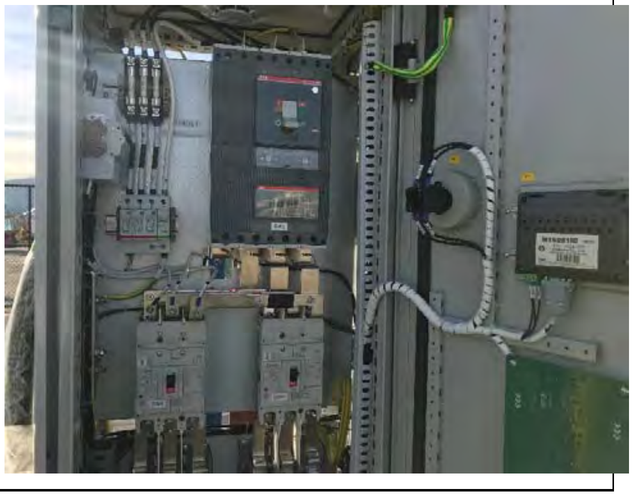
31.1.1 An inverse-time or instantaneous-trip circuit breaker shall comply with the requirements in the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489. An instantaneous-trip circuit breaker, in combination with the motor controller and motor overload device, shall additionally comply with the requirements for combination motor controllers in the Standard for Industrial Control Equipment, UL 508.

31.1.2 A branch circuit fuse shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, and the applicable parts of the UL 248 series. A branch circuit fuse intended to be located in a direct-current circuit shall be marked with a dc voltage rating. A special purpose fuse that meets the applicable performance requirements of the UL 248 series of standards for a branch circuit fuse are able to be used as branch circuit protection based on the specified fuse class.

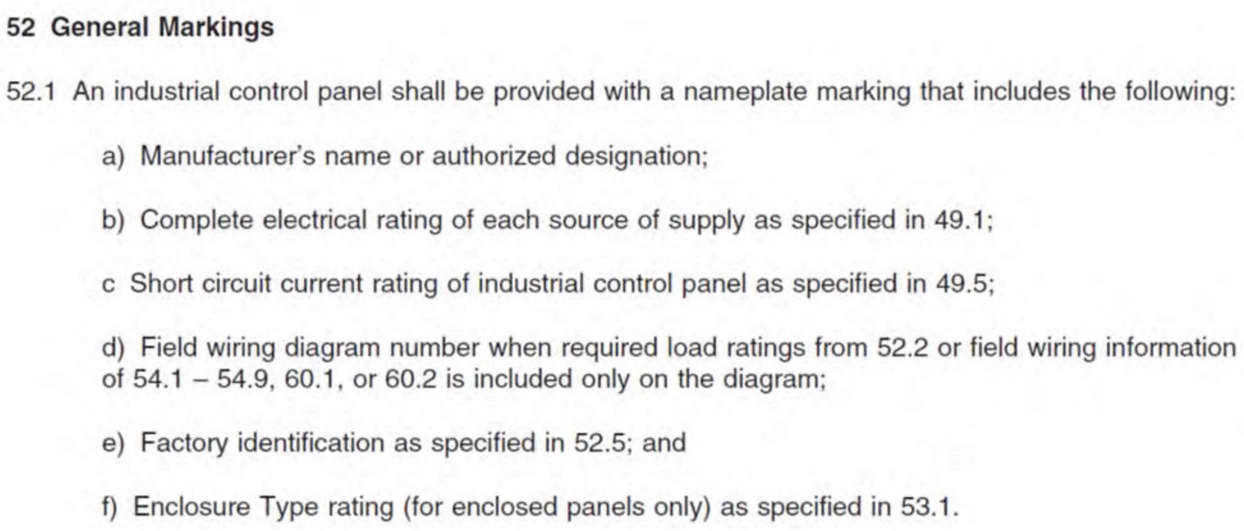
31.1.3 A semiconductor fuse that complies with the Standard for Low-Voltage Fuses – Part 13: Semiconductor Fuses, UL 248-13 is able to be used for branch circuit protection of a motor circuit containing a variable speed drive whose installation instructions recommend its use.

Non-conformance – The main 400 ampere circuit breaker and the two 250 ampere branch circuit breaker protecting the two charging gun circuits are not a NRTL (Nationally Recognized Testing Laboratory) Listed circuit breaker to ANSI/UL 489 Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures as required.

Corrective Actions – The non-Listed 400 ampere and 250 ampere rated circuit breakers have been replaced with UL Listed 400 A manufactured by ABB and a 250 A circuit breakers manufactured by Mitsubishi as required,

32 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels



52 General Markings

52.1 An industrial control panel shall be provided with a nameplate marking that includes the following:

a) Manufacturer’s name or authorized designation;

b) Complete electrical rating of each source of supply as specified in 49.1;

c Short circuit current rating of industrial control panel as specified in 49.5;

d) Field wiring diagram number when required load ratings from 52.2 or field wiring information of 54.1 – 54.9, 60.1, or 60.2 is included only on the diagram;

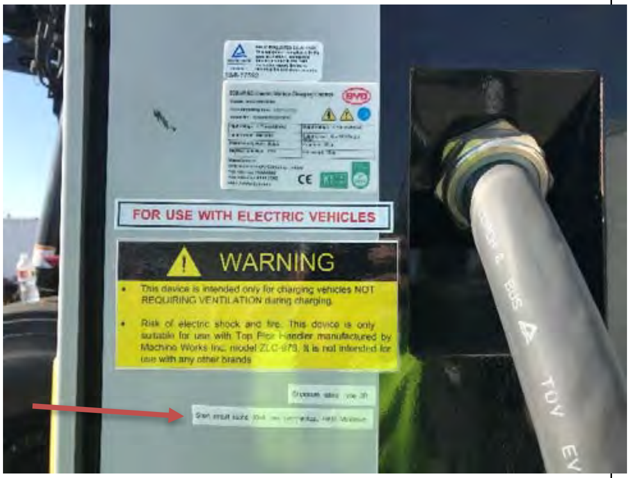
e) Factory identification as specified in 52.5; and

f) Enclosure Type rating (for enclosed panels only) as specified in 53.1.

Non-conformance – The industrial control panel/vehicle charger is not marked with the calculated short circuit current ratings as defined and calculated in Supplement SB – Short Circuit Current Ratings for Industrial Control Panel

Corrective Actions – The manufacturer has assessed the construction/design of the electrical circuits and power circuit components as required by the Supplment SB – Short Circuit Current Ratings for the industrial Control Panels in ANSI/UL 508A Standard for Industrial Control Panels.

After review of the power circuit and power circuit components It has been determined that the industrial control panel/vehicle charger has a short circuit current rating of a maximum of 10,000 A @ maximum 480 Vac RMS.



33 – Equipment/Deviation: ANSI/UL 508A Standard for Industrial Control Panels

56.1 A branch circuit fuseholder that accepts a fuse having a rating larger than the maximum specified rating and all control circuit fuseholders shall be marked with the voltage and current rating of the replacement fuse.

Non-conformance – the fuse holders can accept a fuse having a rating larger than the maximum rating of the control circuit and is missing the fuse replacement marking showing the voltage and current rating of the replacement fuse.

Corrective Action – There was a fuse replacement chart affixed to the front door indicating the fuse replacement marking indicating the voltage and current rating of the replacement fuse as required.

Terms and conditions of acceptability for the equipment inspected:

1. The Top Pick Handler manufactured by Taylor Machine Works, Inc, model ZLC-976 and all required safety requirements of the truck are not part of the scope of this project
2. The onboard charger on the Top Pick Handler manufactured by Taylor Machine Works, Inc, model ZLC-976 is not included in the scope of this project.
3. The type, size and location of the disconnecting means ahead of the vehicle charger shall comply with the National Electrical Code, which is enforceable by the Local Authorities Having Jurisdiction.

4. **Additional Note –** the electrical contractor did not want the sleeving on the (incoming) feeder circuit at the time of installation. However, specific instructions were added adjacent to the feeder supply connection. The instructions stated “Warning – Feeder supply connections must have UL Listed heat shrink tubing applied to lug and uninsulated bus bar, Heat shrink tubing rated 600V, 110 °C”.

   The shrink tubing must be applied at the connection of the feeder circuit and the Authority Having Jurisdiction must assure that the shrink tube is properly applied to the feeder circuit conductors, terminal lugs and uninsulated bus bars. See Item 28 above for additional details.

Non-standard Inspection procedure used (if applicable):N/A

List of Critical and non-Recognized or un-Listed Components for Review

Component	Manufacturer	Model	Mark(s) of conformity
Main circuit breaker	ABB	SACE T5N 400	UL, CSA
Branch circuit breaker	Mitsubishi	NF250-HVU	cULus
Surge protective device	CITEL	DS40G-600, DS40-480	cURus
Surge protective device branch circuit protection	Cooper Bussmann	Class G	UL Listed
Main contactor	LS	GMC 180	cULus
Enclosure	BYD Motors Inc	Double ended door 500 mm x 400 mm x 2000mm	Previously Tested see Note 1 below
Current transformer	Carlo Gavazzi	CTD-2X.200.5A.XXX	cURus
24 Vdc power supply	Carlo Gavazzi	SPD242403	cULus
EV Cable	CHANGZHOU MARINE CABLE CO LTD	EV, VW-1, 105 °C, 2 AWG, 600 V	TUVus
Vehicle Coupler	BYD Motors Inc	KD2	cTUVus
Power Analyzer	SOCOMEC	DIRIS A10	cULus
Controller board	BYD	PCB-JLK-QDB-SQ	URus
Shrink Tube (used on bus bars)	E203950	VW-1, 125°C	cURus
Shrink Tube (used on bus bars)	E203950	RSFR-H	cURus
Main copper tin plated busbar (vertical bus bars, contactor and circuit breaker connector bus bar)	Various	Bus bar density ≤ 1000 A/in²	None – evaluated by construction. Bus bar cross sectional area/ampacity load less than or equal to 1000 A/in²

Other components are Listed or approved for the application

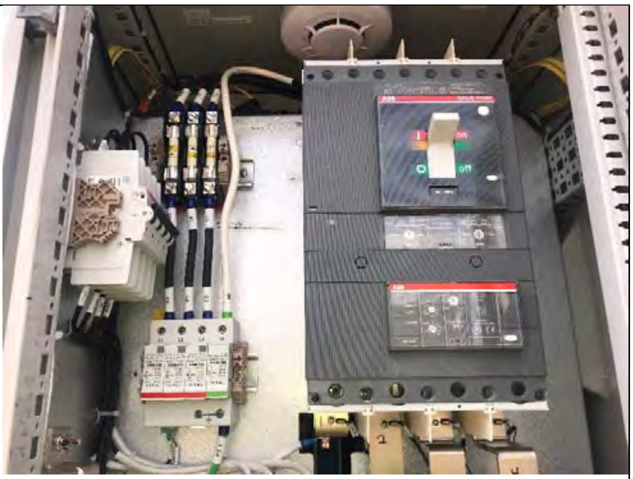
*EIA – Evaluated in Application (See also Notes Section on page 10)

Note: Critical Components shall be Listed or Recognized, (example: Breakers, Fuses, motors etc.)

Note 1 - – the identical enclosure has been tested under Project No 163103, Report No 31874271.001, June 24, 2019.

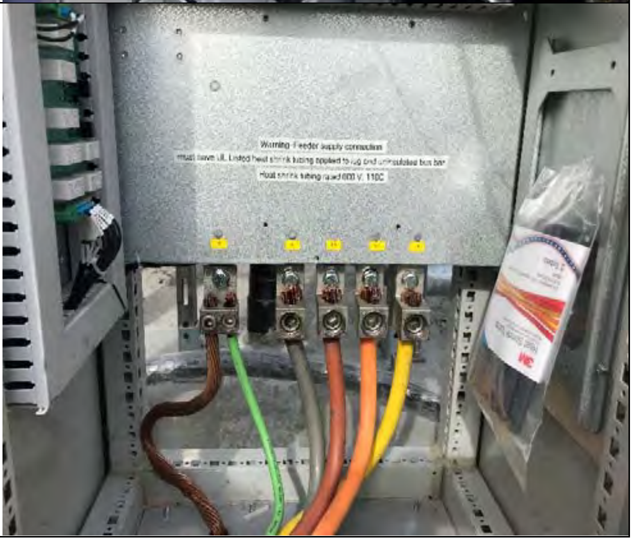
Photo(s)


BYD
BYD Coach & Bus
KDZ Vehicle Connector
Rating: 480V ~ 120A
type 35
TÜV Rheinland of North America
US




MEC
LS
MEC
LS


U5


Warning- Feeder supply connection
must have UL Listed heat shrink tubing applied to lug and uninsulated bus bar
Heat shrink tubing rated 600 V. 110C
3M

Reference only
1

Reference only 2

2-6-12

TAYLOR MACHINE WORKS, INC.
LOUISVILLE, MISSISSIPPI, U.S.A.

MODEL: [illegible] TYPE: E SERIAL NO: [illegible] YEAR: 2010

BASIC MODEL CAPACITY 95000 LBS. @ 48 " LOAD CENTER

SAFE WORKING CAPACITY WITH EQUIPPED OPTIONS:

[illegible] LBS. @ 97 " LOAD CENTER -OR-

[illegible] LBS. @ 106 " CTR. LOAD TO CTR. DRIVE AXLE UP TO [illegible] " LIFT HEIGHT

SAFE CAPACITY WITH MAST VERTICAL, LOADS LATERALLY CENTERED, EVENLY DISTRIBUTED AND EQUIPPED AS SHOWN
DO NOT OVERLOAD. CAPACITY IS GREATLY REDUCED WHEN MAST IS TILTED FORWARD.

TOTAL VEHICLE WEIGHT [illegible] LBS. (±5%) STEER AXLE WEIGHT 58000 LBS. (±5%)

BATTERY TYPE E BATTERY MODEL [illegible] NOMINAL VOLTAGE [illegible] V

MAXIMUM AMPERE-HOUR CAPACITY [illegible] AH @ 6 HOURS

MIN. WEIGHT OF BATTERIES [illegible] LBS. MAX. WEIGHT OF BATTERIES [illegible] LBS.

TOTAL VEHICLE WEIGHT (WITHOUT BATTERIES) [illegible] LBS. (±5%)

TIRE SPECIFICATIONS

AXLE	SIZE	PLY RATING	PRESSURE
DRIVE	[illegible]	[illegible]	145
STEER	1800X25	40	145

WHEEL LUG NUT TORQUE PROCEDURE

WHEEL AND MOUNTS REQUIRE RUN-IN PERIOD ON A NEW VEHICLE AND AFTER EACH TIRE CHANGE. TORQUE BEFORE VEHICLE IS PUT IN SERVICE AND EACH 10 HOURS UNTIL WHEELS ARE SEATED. CARE SHOULD BE TAKEN TO KEEP GREASE AND OTHER FOREIGN MATERIAL FROM RIM SEATING SURFACES.

⚠ CAUTION: DO NOT OVERTORQUE.

AXLE	STUD SIZE	WRENCH SIZE	TORQUE-FT. LBS.
DRIVE	M 18 - 2.0	1 1/16	275
STEER	3/4 - 10 NC	1 1/16	150

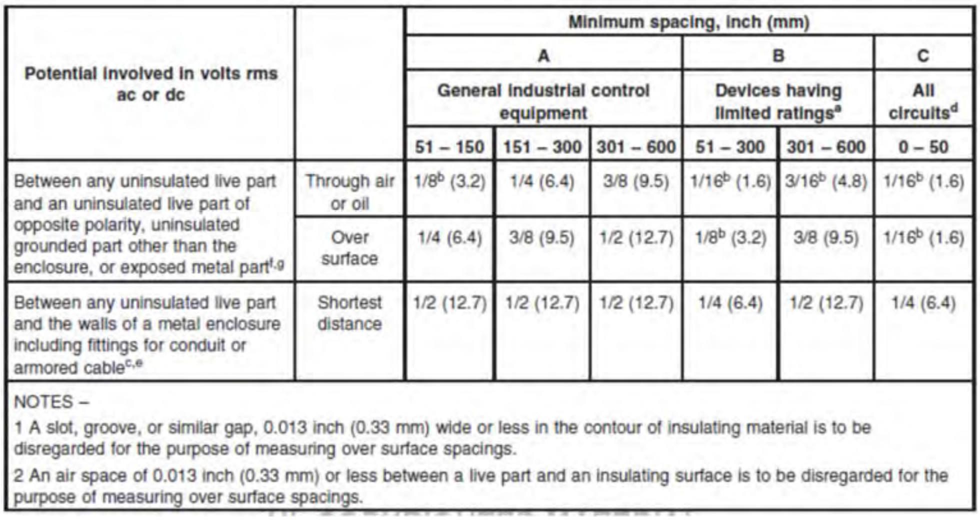
⚠ DANGER: — FIRST STEP IN TIRE DEMOUNTING OPERATIONS. ALWAYS REMOVE THE VALVE CORE AND EXHAUST ALL AIR FROM A SINGLE TIRE AND FROM BOTH TIRES OF A DUAL ASSEMBLY PRIOR TO REMOVING ANY RIM COMPONENTS OR ANY WHEEL COMPONENTS SUCH AS NUTS AND RIM CLAMPS. TO ENSURE THAT THE VALVE STEM IS NOT DAMAGED, RUN A PIECE OF WIRE THROUGH THE STEM TO MAKE SURE IT IS NOT PLUGGED AND ALL THE AIR IS EXHAUSTED.

PATENTS

Reference only 3

1 Table 10.1 and Table 10.2 from ANSI/UL 508A Standard for Industrial Control Panels.

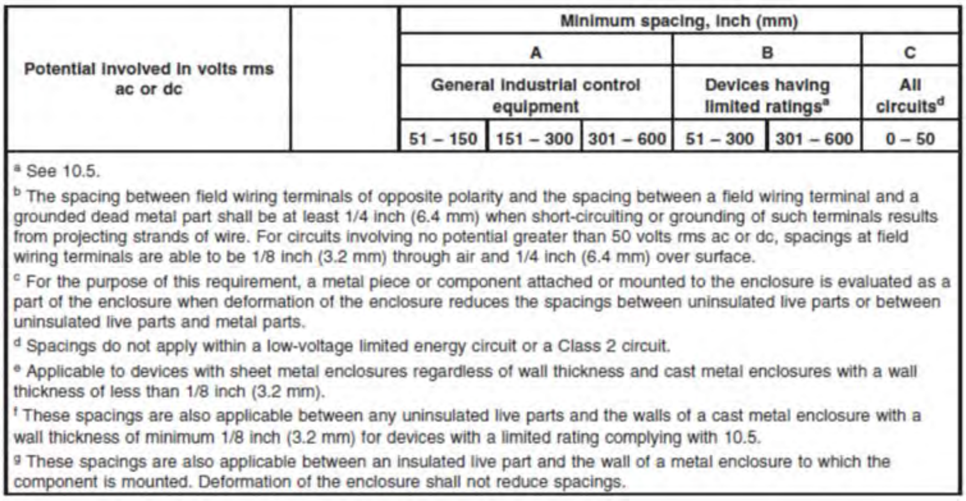
Table 10.1
Minimum required spacings in branch and control circuits



Potential involved in volts rms ac or dc		Minimum spacing, inch (mm)					
		A			B		C
		General industrial control equipment			Devices having limited ratings[a]		All circuits[d]
		51 – 150	151 – 300	301 – 600	51 – 300	301 – 600	0 – 50
Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part[f,g]	Through air or oil	1/8[b] (3.2)	1/4 (6.4)	3/8 (9.5)	1/16[b] (1.6)	3/16[b] (4.8)	1/16[b] (1.6)
	Over surface	1/4 (6.4)	3/8 (9.5)	1/2 (12.7)	1/8[b] (3.2)	3/8 (9.5)	1/16[b] (1.6)
Between any uninsulated live part and the walls of a metal enclosure including fittings for conduit or armored cable[c,e]	Shortest distance	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	1/4 (6.4)	1/2 (12.7)	1/4 (6.4)

NOTES –
1 A slot, groove, or similar gap, 0.013 inch (0.33 mm) wide or less in the contour of insulating material is to be disregarded for the purpose of measuring over surface spacings.
2 An air space of 0.013 inch (0.33 mm) or less between a live part and an insulating surface is to be disregarded for the purpose of measuring over surface spacings.

Table 10.1 Continued



Potential involved in volts rms ac or dc		Minimum spacing, inch (mm)					
		A			B		C
		General industrial control equipment			Devices having limited ratings[a]		All circuits[d]
		51 – 150	151 – 300	301 – 600	51 – 300	301 – 600	0 – 50

[a] See 10.5.

[b] The spacing between field wiring terminals of opposite polarity and the spacing between a field wiring terminal and a grounded dead metal part shall be at least 1/4 inch (6.4 mm) when short-circuiting or grounding of such terminals results from projecting strands of wire. For circuits involving no potential greater than 50 volts rms ac or dc, spacings at field wiring terminals are able to be 1/8 inch (3.2 mm) through air and 1/4 inch (6.4 mm) over surface.

[c] For the purpose of this requirement, a metal piece or component attached or mounted to the enclosure is evaluated as a part of the enclosure when deformation of the enclosure reduces the spacings between uninsulated live parts or between uninsulated live parts and metal parts.

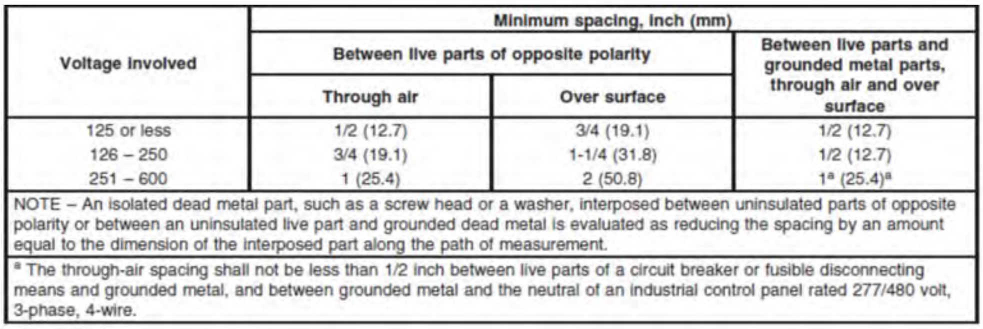
[d] Spacings do not apply within a low-voltage limited energy circuit or a Class 2 circuit.

[e] Applicable to devices with sheet metal enclosures regardless of wall thickness and cast metal enclosures with a wall thickness of less than 1/8 inch (3.2 mm).

[f] These spacings are also applicable between any uninsulated live parts and the walls of a cast metal enclosure with a wall thickness of minimum 1/8 inch (3.2 mm) for devices with a limited rating complying with 10.5.

[g] These spacings are also applicable between an insulated live part and the wall of a metal enclosure to which the component is mounted. Deformation of the enclosure shall not reduce spacings.

Table 10.2
Spacings in feeder circuit



Voltage involved	Minimum spacing, inch (mm)		
	Between live parts of opposite polarity		Between live parts and grounded metal parts, through air and over surface
	Through air	Over surface	
125 or less	1/2 (12.7)	3/4 (19.1)	1/2 (12.7)
126 – 250	3/4 (19.1)	1-1/4 (31.8)	1/2 (12.7)
251 – 600	1 (25.4)	2 (50.8)	1[a] (25.4)[a]

NOTE – An isolated dead metal part, such as a screw head or a washer, interposed between uninsulated parts of opposite polarity or between an uninsulated live part and grounded dead metal is evaluated as reducing the spacing by an amount equal to the dimension of the interposed part along the path of measurement.

[a] The through-air spacing shall not be less than 1/2 inch between live parts of a circuit breaker or fusible disconnecting means and grounded metal, and between grounded metal and the neutral of an industrial control panel rated 277/480 volt, 3-phase, 4-wire.

2 EV Cable TUV Certification to ANSI/UL 62

Certificate No. TU 50422964 - Certipedia Page 1 of 2

Back

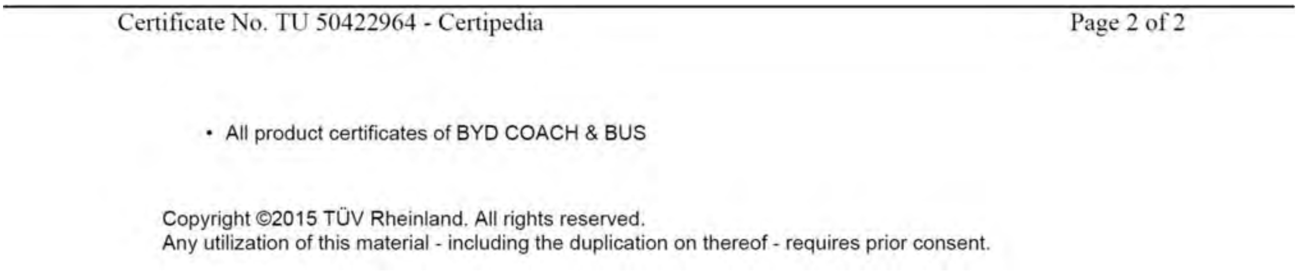
Certificate No. TU 50422964

Certificate Holder:	**BYD COACH & BUS** 46147 7th Street West, 93534 Lancaster, CA United States
Certificate Number:	TU 50422964
Order Number:	164129185
Certified Product:	EV-Cables (Cables for Electric Vehicle Conductive Charging System) Model Designation: EV 35mm^2(2AWG)/5C + (1mm^2(18AWG)/2C)P + 1mm^2(18AWG)/9C BYD (logo)
Fulfilled Standards:	UL 62:2018 The standard(s) listed here reflect the status at the time of the release of this certificate.
Date of Issue:	January 18, 2019
Certificate Type:	TUV Rheinland US Mark **USA standard conformity certificate** The TU Certificate is based on a valid, applicable U.S. national standard in combination with all the related services such as regular factory inspections. The TUV Rheinland U.S. test mark is proof of compliance with U.S. national standards. It shows the buyer, customer, local authority having jurisdiction or consumer that a device has been successfully tested and certified by an impartial and independent testing laboratory. The principle of integrating regular spot checks into an approval, assures both the client and the buyer of continued compliance. This system guarantees the quality of the test-mark and therefore represents a credible marketing tool.

Further Information

- Request more information on BYD COACH & BUS

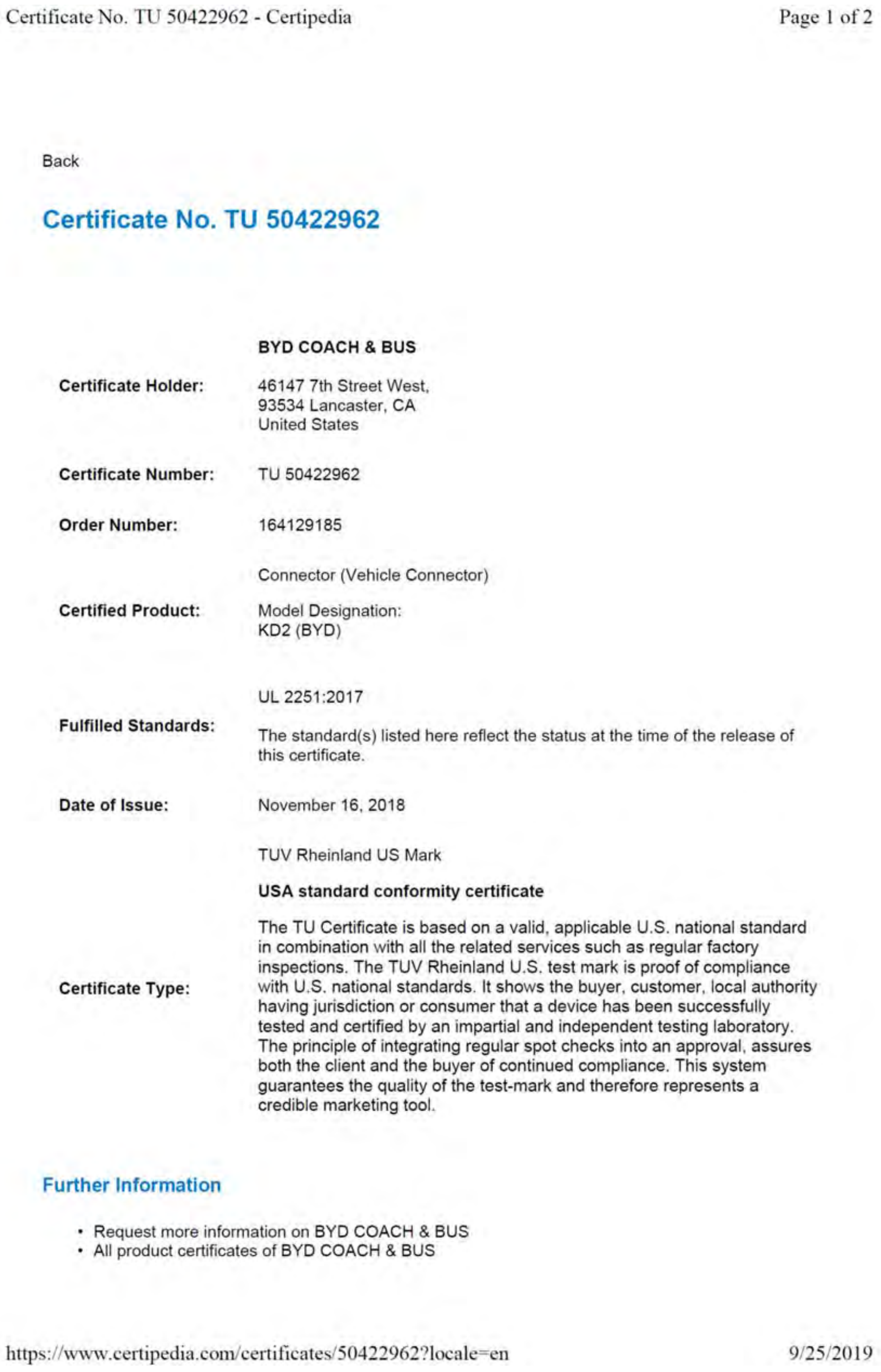
https://www.certipedia.com/certificates/50422964?locale=en 9/25/2019



Certificate No. TU 50422964 - Certipedia Page 2 of 2

- All product certificates of BYD COACH & BUS

3 Vehicle Coupler TUV Certifcation



Certificate No. TU 50422962 - Certipedia Page 1 of 2

Back

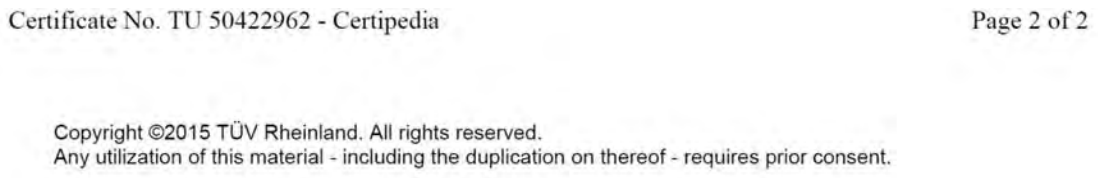
Certificate No. TU 50422962

Certificate Holder:	**BYD COACH & BUS** 46147 7th Street West, 93534 Lancaster, CA United States
Certificate Number:	TU 50422962
Order Number:	164129185
Certified Product:	Connector (Vehicle Connector) Model Designation: KD2 (BYD)
Fulfilled Standards:	UL 2251:2017 The standard(s) listed here reflect the status at the time of the release of this certificate.
Date of Issue:	November 16, 2018
Certificate Type:	TUV Rheinland US Mark **USA standard conformity certificate** The TU Certificate is based on a valid, applicable U.S. national standard in combination with all the related services such as regular factory inspections. The TUV Rheinland U.S. test mark is proof of compliance with U.S. national standards. It shows the buyer, customer, local authority having jurisdiction or consumer that a device has been successfully tested and certified by an impartial and independent testing laboratory. The principle of integrating regular spot checks into an approval, assures both the client and the buyer of continued compliance. This system guarantees the quality of the test-mark and therefore represents a credible marketing tool.

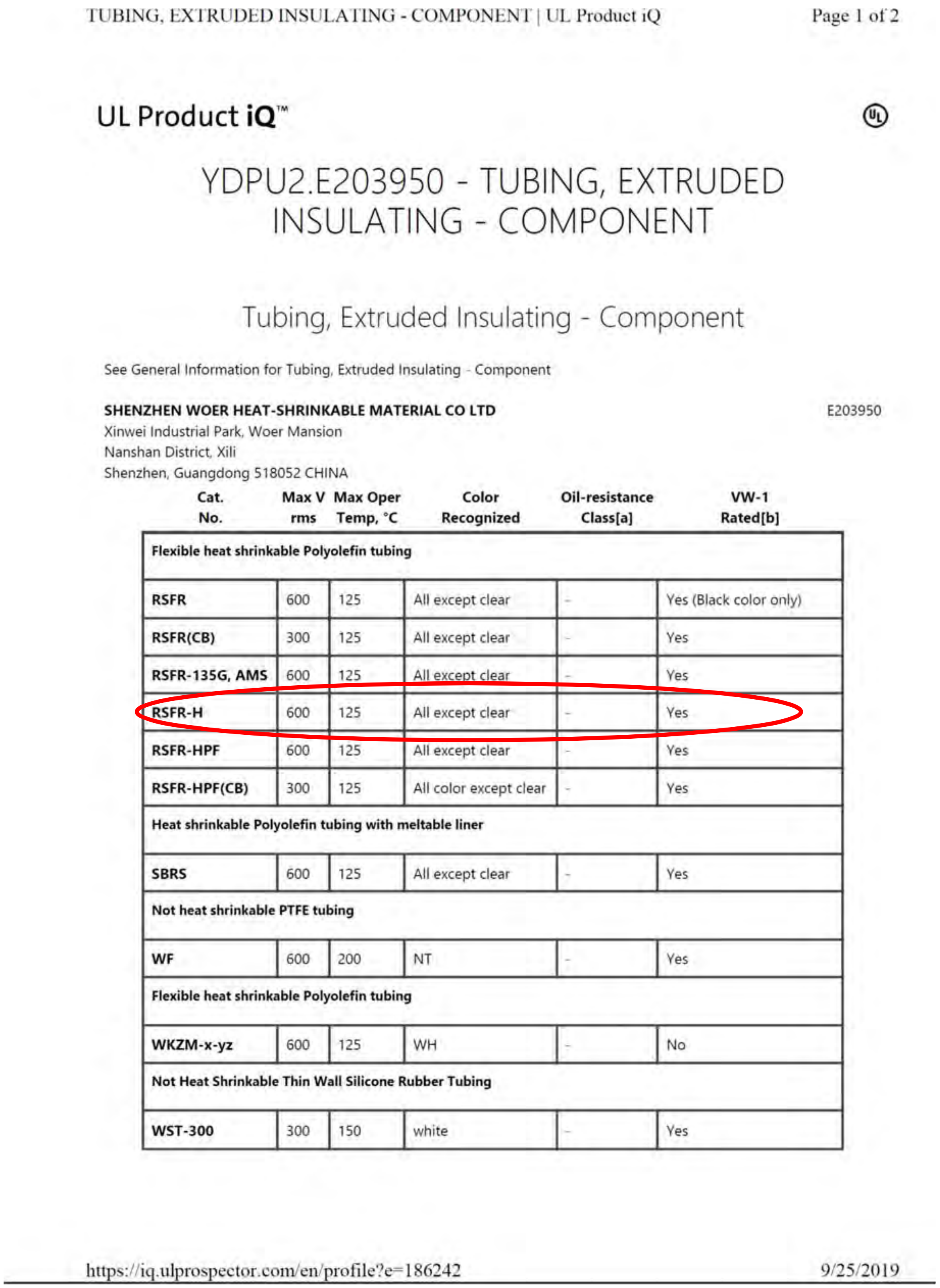
Further Information

- Request more information on BYD COACH & BUS
- All product certificates of BYD COACH & BUS

https://www.certipedia.com/certificates/50422962?locale=en 9/25/2019



4 UL Recognized Component heat shrink tubing Certification



TUBING, EXTRUDED INSULATING - COMPONENT | UL Product iQ Page 1 of 2

UL Product iQ™

YDPU2.E203950 - TUBING, EXTRUDED INSULATING - COMPONENT

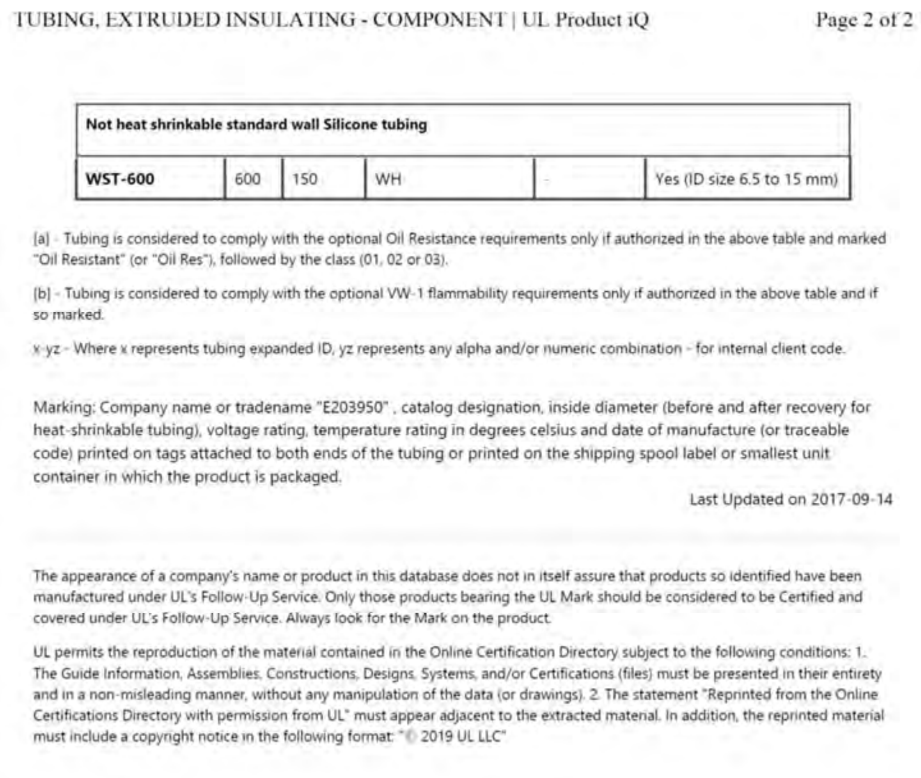
Tubing, Extruded Insulating - Component

See General Information for Tubing, Extruded Insulating - Component

SHENZHEN WOER HEAT-SHRINKABLE MATERIAL CO LTD E203950
Xinwei Industrial Park, Woer Mansion
Nanshan District, Xili
Shenzhen, Guangdong 518052 CHINA

Cat. No.	Max V rms	Max Oper Temp, °C	Color Recognized	Oil-resistance Class[a]	VW-1 Rated[b]
Flexible heat shrinkable Polyolefin tubing					
RSFR	600	125	All except clear	-	Yes (Black color only)
RSFR(CB)	300	125	All except clear	-	Yes
RSFR-135G, AMS	600	125	All except clear	-	Yes
RSFR-H	600	125	All except clear	-	Yes
RSFR-HPF	600	125	All except clear	-	Yes
RSFR-HPF(CB)	300	125	All color except clear	-	Yes
Heat shrinkable Polyolefin tubing with meltable liner					
SBRS	600	125	All except clear	-	Yes
Not heat shrinkable PTFE tubing					
WF	600	200	NT	-	Yes
Flexible heat shrinkable Polyolefin tubing					
WKZM-x-yz	600	125	WH	-	No
Not Heat Shrinkable Thin Wall Silicone Rubber Tubing					
WST-300	300	150	white	-	Yes

https://iq.ulprospector.com/en/profile?e=186242 9/25/2019



Not heat shrinkable standard wall Silicone tubing					
WST-600	600	150	WH	-	Yes (ID size 6.5 to 15 mm)

[a] - Tubing is considered to comply with the optional Oil Resistance requirements only if authorized in the above table and marked "Oil Resistant" (or "Oil Res"), followed by the class (01, 02 or 03).

[b] - Tubing is considered to comply with the optional VW-1 flammability requirements only if authorized in the above table and if so marked.

x-yz - Where x represents tubing expanded ID, yz represents any alpha and/or numeric combination - for internal client code.

Marking: Company name or tradename "E203950" , catalog designation, inside diameter (before and after recovery for heat-shrinkable tubing), voltage rating, temperature rating in degrees celsius and date of manufacture (or traceable code) printed on tags attached to both ends of the tubing or printed on the shipping spool label or smallest unit container in which the product is packaged.

Last Updated on 2017-09-14

End of Report

TÜVRheinland®

Precisely Right.

FIELD EVALUATED EQUIPMENT
This equipment complies with the specific ANSI/UL standard(s) for safety noted in the Field Evaluation report, limited to electrical fire and shock hazards.

TUVR-37592

200kW AC Electric Vehicle Charging Cabinet

BYD

Model : EVA200KS/01

Manufacturing date : 2017-11-01

Serial No : 010449DVHA0100007

Input Voltage : 3-Phase 480VAC	Output Voltage : 3-Phase 480VAC
Input Current : Max.240A	Output Current : Max.120A/Output Circuit
Rated output power : 200kW	Frequency : 60Hz
Degree of protection : IP54	Total weight:155kg

Manufacturer:
BYD Auto Industry Company Limited
Tel:+86-755-23860806
Fax:+86-755-8993 7043
Http: //www.byd.com

May 14, 2019

Transportation Power Inc
2415 Autopark Way
Escondido, CA 92029

Attention: James Burns

UL Order Number: 12616183

Subject: Field Evaluation of Industrial Control Panel

Dear Mr. Burns:

UL has completed a Field Evaluation of the above subject equipment. Please find attached one electronic copy of the final report(s) for this project. With the issuing of this report, we are closing this project and notifying our accounting department to invoice you for any outstanding charges. This report should be reviewed to verify that the information provided is complete and correct, and to determine whether further action may be required by the AHJ for final approval of the installation.

If you have any questions, or if we can be of service in future projects please do not hesitate to call anytime.

Kind regards,

Cathy Sledjeski
Project Handler II
Field Engineering Services

Direct Line: 813-253-9489
Email: Cathy.Sledjeski@ul.com

CC: Mr. Stanley Ingram - Sr. Electrical Inspector,
City of Long Beach

Field Evaluation Services
Final Report

For

Industrial Control Panel

Requested by:

Transportation Power Inc
2415 Autopark Way
Escondido, CA 92029

UL Order Number - 12616183

Installation Site and Authority Having Jurisdiction:

Port of Long Beach Container Terminals, 350 Pier D Avenue West
Long Beach, CA 90802
City of Long Beach, Long Beach, CA 90802

Report by: Charles Hansford
Charles Hansford

Reviewed by:
Walt Stoddard
Staff Engineer

UL LLC
333 Pfingsten Road, Northbrook, IL 60062-2096 USA
T: 847.272.8800 / F: 847.272.8129 / W: UL.com

Report Date: May 6, 2019

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1 Executive Summary

Federal OSHA requirements mandate that all electrical equipment in the workplace be "certified" or subjected to a complete and thorough evaluation before use (29 CFR 1910.303 and 1910.399). Many state, county and city electrical jurisdictions have similar requirements. A UL Field Evaluation is an accepted approach to meet this requirement; UL conducts an unbiased, independent assessment of products at a specific location to essential requirements of applicable product safety standard(s). UL's engineering assessment informs regulating authorities who make product and related installation approval decisions.

Please note that the regulating authority for the final installation site provides final approval of this equipment and the installation.

This project's purpose was to evaluate a product that was not Listed or otherwise certified by a testing laboratory recognized by the authority having jurisdiction. Products undergoing this evaluation process do not acquire a UL Listing, UL Recognition, or UL Classification. UL has not established factory Follow-Up Services to determine the conformance of any subsequently produced, relocated, or otherwise altered product(s) or system(s).

Installation model codes are referenced in this document where necessary to ensure the product can be properly installed according to the code (e.g. National Electrical Code, NFPA 70).

At the request of James Burns of Transportation Power Inc, a Field Evaluation project was initiated A Final evaluation was completed at:

- Port of Long Beach Container Terminals, 350 Pier D Avenue West, Long Beach, CA

Based on the inspection, testing, and evaluation completed, UL considers the product to be suitable for application of the Field Evaluation Product Mark and for use in accordance with any conditions of acceptability stated in this report.

2 Conditions of Acceptability

Except where otherwise stated in the product description and evaluation sections of this report, this evaluation and the application of the Field Evaluated Product Mark is subject to the following Conditions of Acceptability.

2.1 Except for like-for-like component replacement in the event of component failure, no change or addition to the product or system shall be made that would alter its construction, operation, function, layout, source of supply, physical location or operating environment. If such changes or additions to the product occur, the Field Evaluated Product Mark shall be considered invalid, and a separate evaluation shall be required to determine compliance with applicable product safety standards under the changed conditions.

2.2 The completed evaluation and application of the UL Field Evaluated Product Mark by UL does not assume liability on the part of UL and does not relieve the manufacturer, installer, user, or other relevant parties of their responsibilities. The product evaluation is based on adherence to sound engineering practices, and compliance with the applicable product safety standards and installation code.

2.3 This evaluation considered the risks associated with electric shock, fire, and casualty hazards as specified in the evaluation section of the report only. No other hazards were evaluated during this evaluation.

2.4 Unless otherwise stated in the product description, this product was evaluated for installation in an indoor, dry, normal environment only. The product was not evaluated for installation in any hazardous classified location as defined in the latest edition National Electrical Code as adopted by the National Fire Protection Association. The product was not evaluated for installation in an environment subject to rainfall, water spray, steam, or exposure to any corrosive chemicals that deteriorate the enclosure or components.

2.5 The UL Field Evaluated Product Mark shall not be considered as equivalent to the UL Listing Mark, UL Recognized Component Mark, or UL Classified Product Mark. The UL Field Evaluated Product Mark indicates compliance with the applicable parts of the Standards referenced in Section 3 at the time the Mark was applied and considering only the final installation site. The applicable parts included in the evaluation are the construction review, markings, and those testing protocols that are non-destructive.

3 Referenced Standards

- UL 508A, Standard For Industrial Control Panels, 3rd Edition, Revised 07/03/2018
- NFPA 70, National Electrical Code - 2017, 1st Edition

4 Product Description

Equipment Name: Industrial Control Panel

Description: Equipment is an Industrial Control Panel used to distribute power to an Electric Vehicle. The Equipment Under Test (EUT) does not control or have any charging capacity. The EUT consists of a UL Listed Circuit Breaker, a UL Listed Contactor, 24 VDC Power Supply. The System is installed outdoors.

Manufacturer: Transport Power Inc.

Model Number: TP-EVSE-100

Serial Number: TP-EVSE-100-001

4.1 Nameplate Data

Electrical Ratings

Volts	208 Vac
Amps	195 A
Phase	3
Wire	3
Frequency	60 Hz
Short Circuit Current	18k Amps
Enclosure Type	4

4.2 Field Evaluation Label

UL Engineers have determined that the subject product complied with the Standards referenced in Section 3 and the following UL Field Evaluated Product marks were applied.

- FE-467786 Date Applied: 05/01/2019

5 Evaluation Discrepancies

This section details the non-compliant findings of the preliminary evaluation. Unless corrective actions are described, a final evaluation is necessary to complete all remaining tests and verify that changes have rendered the equipment compliant.

No Discrepancies Found

6 Evaluation Details

The following specific areas were evaluated using the methods described. All items comply with the applicable parts of standard(s) referenced in Section 3.0, unless stated otherwise in Section 5.0 of this report. Additional characteristics and features unique to the product were further addressed as deemed necessary considering the final installation site, or as required by the applicable product safety standard(s).

6.1 Critical Components

Method: The following critical components were inspected for evidence of Listing or Recognition according to UL policies:

- Circuit Breakers / Fuses	- Enclosures
- Power Disconnecting Devices	- Receptacles
- Transformers and Power Supplies	- Wire and Cables

Results: The critical components are Listed or Recognized by a testing laboratory acceptable to UL according to UL policies.

6.2 Drawings and Instructions

Method: The information necessary for safe installation, operation, and maintenance of the equipment is reviewed for completeness and accuracy. The review may include drawings, diagrams, charts, and/or tables based upon the complexity of the equipment and the service environment.

Results: User and maintenance manuals, electrical/mechanical schematics, bills of materials, parts lists, and/or programming instructions are provided as appropriate.

6.3 Environmental Rating

Method: The design, assembly, and installation of the equipment are examined for suitability with the environment, electrical supply, and operating conditions of the installation site.

Results: The general operating conditions are acceptable for the design and use of the equipment as required by the standards referenced in Section 3.0.

6.4 Grounding and Bonding

Method: All accessible metal parts are verified (visually and/or by test) to be bonded together and to be connected to the supply equipment grounding conductor. Where applicable, a bonding continuity test is conducted and the results recorded.

Results: The product is grounded and bonded according to the applicable standards referenced in Section 3.0 and Article 250 of the NEC. The product has an identified terminal to connect the supply equipment grounding conductor or a suitable cord with an integral equipment grounding conductor.

6.5 Guarding of Live Parts

Method: The product is visually inspected to ensure that all components were housed in a suitable enclosure and made effectively inaccessible to unauthorized persons. An articulated finger probe is used to measure access where necessary. Vent openings are verified to not align with potential discharge paths of gases expelled from circuit breakers when clearing fault conditions.

Results: Enclosures prevent contact with moving parts, electrically energized parts, and hot parts. Enclosures provide an acceptable degree of protection for internal components (according to the product's installation environment). All electrically live parts external to the enclosure are guarded as required by the applicable standards. No electrically hazardous energized parts are accessible from the exterior of the ultimate enclosure as required by Section 110.27 of the NEC.

6.6 Markings

Method: The product nameplate is inspected for all required information. The content, placement, and format of hazard-warning labels, fuse replacement markings, environmental limitations, and installation type markings are also verified.

Results: The product bears the required markings according to the applicable standards. Additional markings are identified for the installation site, as the working environment requires.

6.6.1 Unit Nameplate

The product bears a permanent nameplate, suitable for the intended installation environment and with all the applicable information. The nameplate is visible or accessible after installation or located according to the provisions in the referenced standard.

6.6.2 Hazard Warning Labels

Applicable hazard warning markings that identify known hazards are located on or within the product.

6.6.3 Fuse Replacement

Fuse replacement markings are provided and installed at all fuse locations or on a permanent chart suitable for the intended environment.

6.7 Means of Disconnect

Method: Disconnecting means shall be located within sight and readily accessible from the equipment. The disconnecting means shall be permitted to be installed on or within equipment but shall not be located on panels that are designed to allow access to the equipment or to obscure the equipment nameplate(s). The disconnecting means shall open all ungrounded supply conductors and shall be designed so that no pole can be operated independently. The device shall be designed so that it cannot be closed automatically.

Results: The disconnecting means is within sight, readily accessible, and is installed and operates as required.

6.8 Mounting of Components

Method: Components that support live parts and uninsulated current carrying parts are secured to prevent them from turning or shifting in position if such motion may result in a reduction of spacings below the minimum acceptable values. Friction between surfaces is not acceptable as a means of preventing shifting or turning of a live part.

Result: Components are mounted such that they are fixed in place and protected from a reduction in electrical spacings and strain on wiring terminations.

6.9 Overcurrent Protection

Method: The product is inspected to ensure that proper overcurrent protection exists for internal conductors and components. Overcurrent devices are inspected for proper ratings, including voltage, ampere, and interrupting ratings, suitability as branch circuit protection (where required), and Listing.

Results: Details as follows:

6.9.1 Conductors

Factory and field installed internal conductors have proper overcurrent protection.

6.9.2 Supply

The product has properly rated main overcurrent protection. Internal overcurrent protection is properly rated for the intended application. All devices designed to open under fault conditions have proper short circuit current interrupting ratings.

6.9.3 Components

Components such as transformers, heater elements, and motors have overcurrent protection of the correct ratings and proper type.

6.10 Suitability for Installation

Method: The product is inspected to ensure suitability for installation according to the NEC as specified in the referenced standards. This inspection determined whether correct working space and clearances existed, noted proper wire bending space for all field wiring, observed provisions for mounting, and assured that areas for conduit entries, as applicable, were in place.

Results: Details as follows:

6.10.1 Clearance and Working Space

The product is or can be installed with acceptable access, clearances, working spaces, and distances from combustibles.

6.10.2 Wire Bending & Gutter Space

Wire bending space for all field wiring exists according to the NEC.

6.11 Wiring and Wiring Methods

Method: All conductors were inspected for Listing or Recognition by a Nationally Recognized Testing Laboratory according to UL policies. The conductors were examined for proper ratings (voltage, ampacity, temperature, flexibility, flame, and environmental ratings) as required for the application. The wiring methods were verified to comply with the applicable standards and provide proper physical protection, including strain relief, where applicable. The wiring terminations were inspected for correct application, number of conductors according to their Listing, and correct ampacity based on temperature ratings.

Results: Details as follows:

6.11.1 Wire Terminations

All wire terminations are suitable for the number and size of conductors installed.

6.11.2 Conduit Connections

All conduits, gutters, and wireways are properly supported and sized for the number and size of conductors.

6.11.3 Supply Connections

The supply connection points have proper terminals and identification provided.

6.11.4 Strain Relief

External conductors, cable assemblies entering enclosures, and internal conductors are secured to prevent strain from being transmitted to terminations.

6.11.5 Separation of Circuits

Unless provided with insulation rated for the highest voltage involved, low voltage and line voltage circuit wires within enclosures are segregated or separated by barriers. The product wiring for low voltage and line voltage circuits outside enclosures is installed in separate raceways or wireways.

6.11.6 Wiring Methods

Internal wiring methods are in compliance with the requirements of the applicable standard. All wiring is routed, secured, and protected from moving parts, external heat sources, and sharp edges.

7 Test Results

The following tests verified that the product operates within normally expected parameters. Unless stated otherwise in Section 5.0, all the following items comply with the applicable part(s) of the referenced standard(s). Field evaluation test methods follow the applicable standards as closely as practical, considering the limits of a non-laboratory field setting and the need for the equipment to perform its function following the test.

- Bonding Resistance Test

8 Test Equipment

All test equipment used to evaluate product(s) covered by this report, which may have an effect on test results, was calibrated and traceable to the National Institute of Standards and Technology (NIST) or other national metrology institution and managed according to ISO/IEC 17025, *General Requirements for the Competence of Calibration and Testing Laboratories.*

9 Photographs

Photo 1 Panel Overall View

Photo 2 Panel Internal View

Photo 3 Panel Nameplate

Photo 4 Power Receptacle

Photo 5 Panel Disconnect

Photo 6 Panel back view

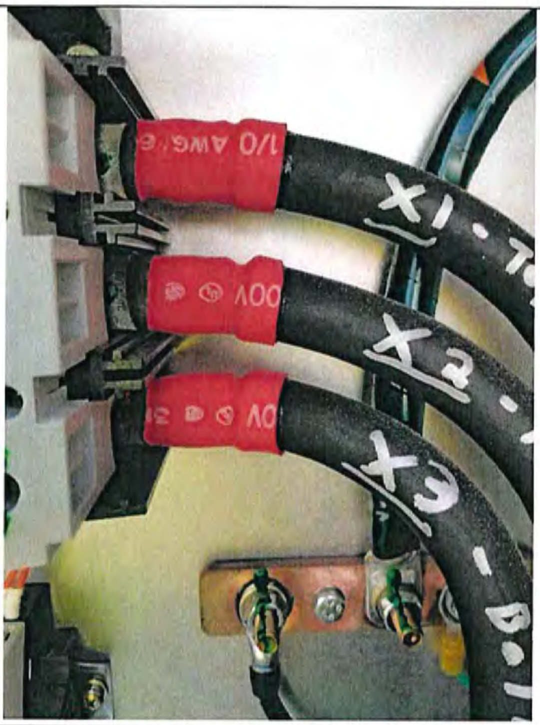


Photo 7 Receptacle ground conductor with green tape.

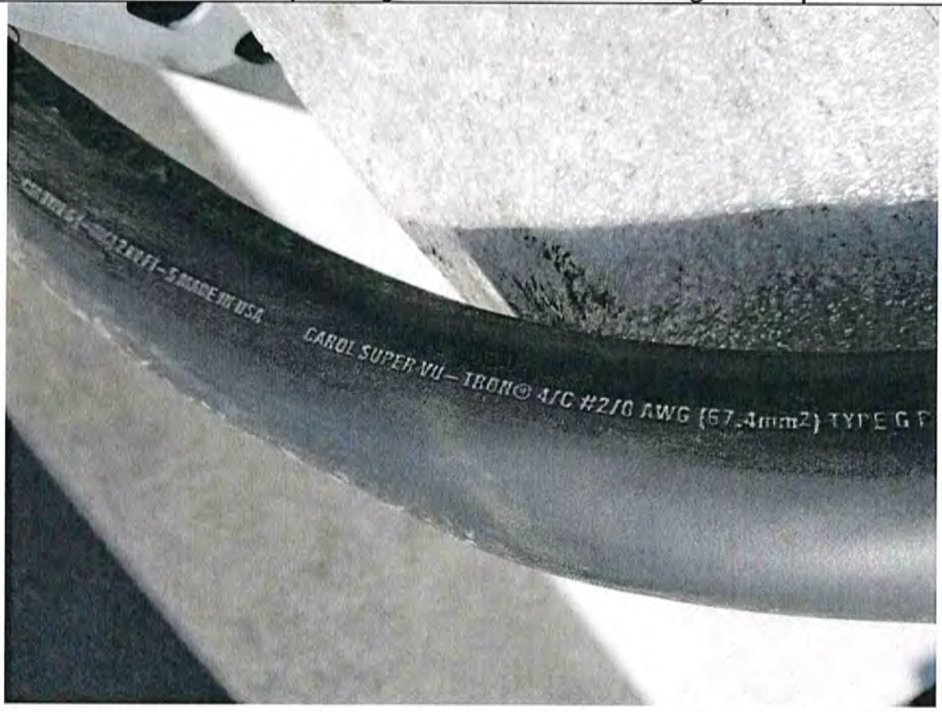


Photo 8 Conductor size 2/0 AWG, rated 90 degrees C

UL
EVALUATED
UL LLC © 2014

No. FE 467786

This product has been evaluated in accordance with the procedures and limitations specified in the issued report

Contact UL 1.877.854.3577
field@ul.com

ENCLOSURE TYPE 4

MANUFACTURER:
MODEL: TP
VOLTAGE
NO.

LINE SET TICKET
YARD TRACTOR

UNIT EFFECTIVE NUMBER: 351488

SOLD TO: CARGOTEC FINLAND OY, TEPR PRIN

ORDER NO: Z41023 S70010582

CUSTOMER: LBCT DEMO

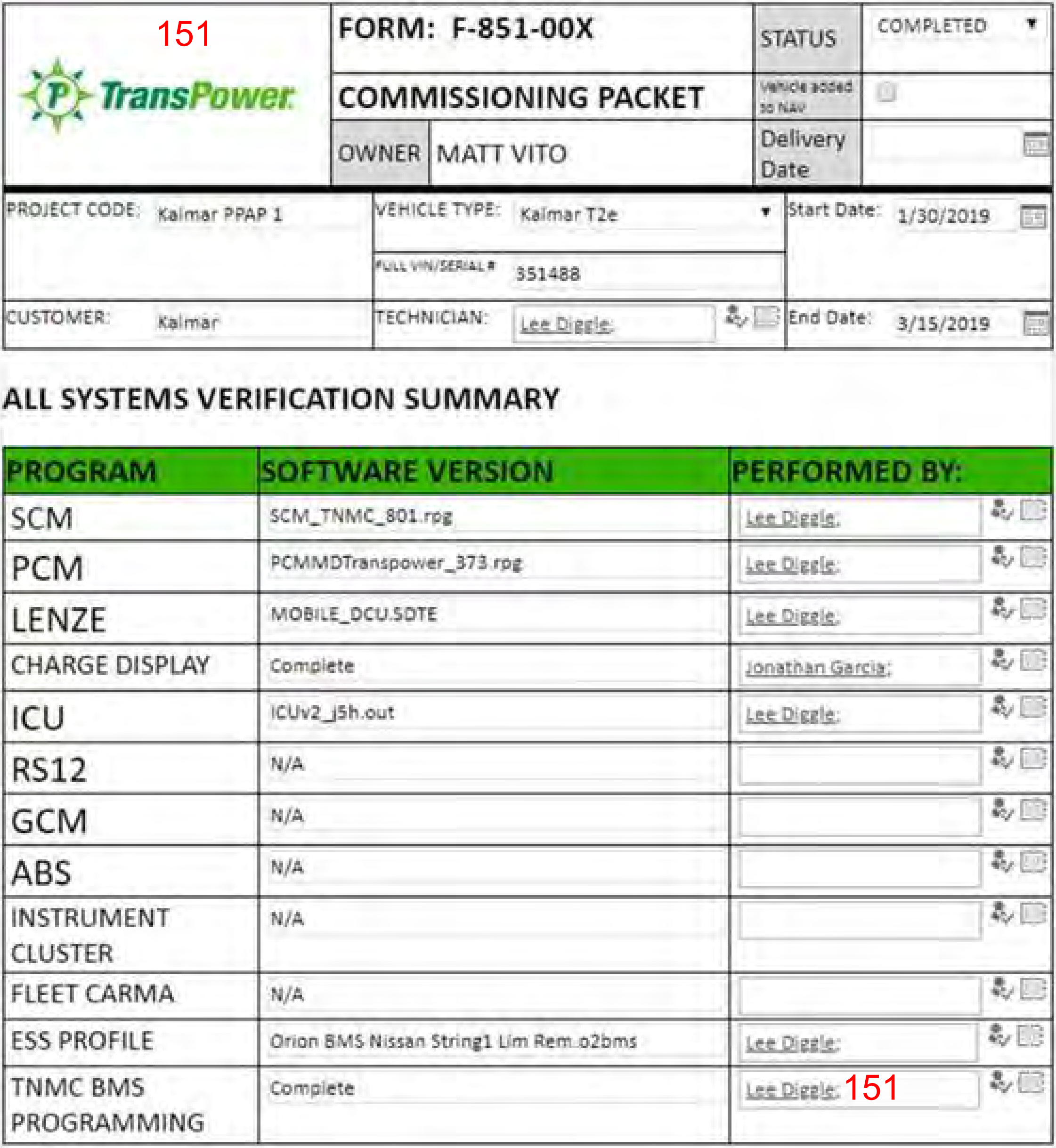
UNIT EFFECTIVE: (RANGE) 351488

MODEL: OTTAWA T2E 4x2 126 WB

COMPONENTS	MAKE	MODEL	PART NO	SERIAL NO	VERSION
TRANSPOWER KITS:					
PCAS:	TRANSPOWER		CTT00021813	19010049	
SCM	TRANSPOWER			SN00120	
PCM	TRANSPOWER			18120046	
MDS	TRANSPOWER	MDS-160	CTT00009381	SN00118	
				SERIAL NO	
ESS-A	TRANSPOWER	44kWh	CTT00021810	18120030	
ESS-B	TRANSPOWER	44kWh	CTT00021810	18120031	
ESS-C	TRANSPOWER	44kWh	CTT00021810	18120026	
ESS-D	TRANSPOWER	44kWh	CTT00021810	18120028	
ESS-E	TRANSPOWER	44kWh	CTT00021810	18120029	
OTHER:				SERIAL NO	
HYD VALVE	PRINCE		90016497		
FRONT AXLE	MERITOR	FG941	CTT00008805	01282051	
REAR AXLE	MERITOR	MOR32	90037225	01262702	
FIFTH WHEEL	HOLLAND	FW35 TT	TTFW0269		
LIFT CYLINDER	PRECISION	5"	CTT00001645		
TIRES:					
FRONT	MICHELIN X TERM T	280/75R22.5	TTWT0019		
FRONT	" "	"	"		
REAR	" "	"	"		
REAR	" "	"	"		
REAR	" "	"	"		
REAR	" "	"	"		
PAINT SPECS:					
CAB	STANDARD	WHITE			
CHASSIS	STANDARD	BLACK			
WHEELS	STANDARD	WHITE			

REVISIONS:

DATE PREPARED: 3/15/2019



TransPower

FORM: F-851-00X		STATUS	COMPLETED ▾
COMMISSIONING PACKET		Vehicle added to NAV	☐
OWNER	MATT VITO	Delivery Date	

PROJECT CODE: Kalmar PPAP 1

VEHICLE TYPE: Kalmar T2e ▾

FULL VIN/SERIAL # 351488

Start Date: 1/30/2019

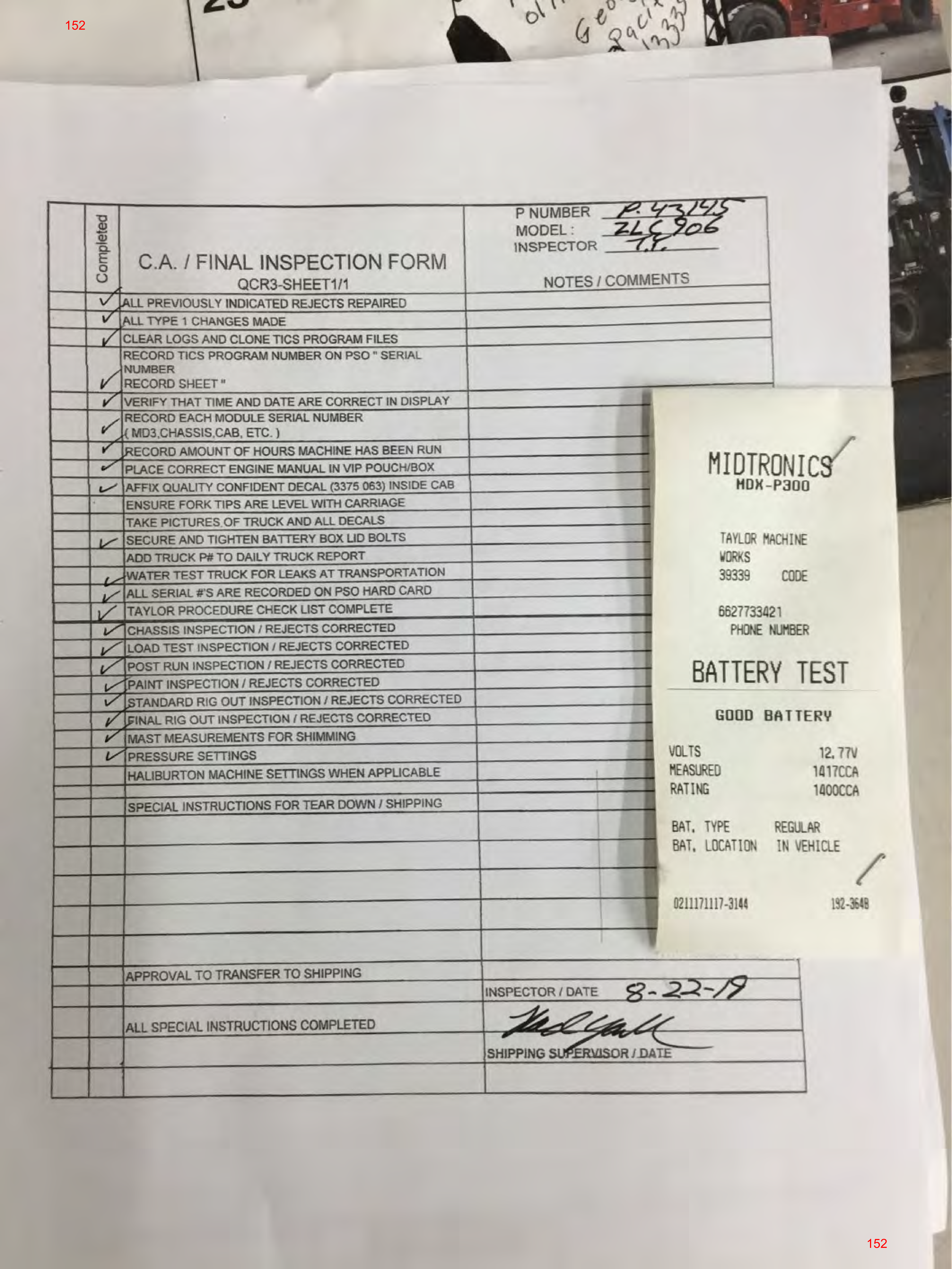
CUSTOMER: Kalmar

TECHNICIAN: Lee Diggle;

End Date: 3/15/2019

ALL SYSTEMS VERIFICATION SUMMARY

PROGRAM	SOFTWARE VERSION	PERFORMED BY:
SCM	SCM_TNMC_801.rpg	Lee Diggle;
PCM	PCMMDTranspower_373.rpg	Lee Diggle;
LENZE	MOBILE_DCU.SDTE	Lee Diggle;
CHARGE DISPLAY	Complete	Jonathan Garcia;
ICU	ICUv2_j5h.out	Lee Diggle;
RS12	N/A	
GCM	N/A	
ABS	N/A	
INSTRUMENT CLUSTER	N/A	
FLEET CARMA	N/A	
ESS PROFILE	Orion BMS Nissan String1 Lim Rem.o2bms	Lee Diggle;
TNMC BMS PROGRAMMING	Complete	Lee Diggle;



C.A. / FINAL INSPECTION FORM

QCR3-SHEET1/1

P NUMBER P. 43145
MODEL : ZLC 906
INSPECTOR T.T.

Completed		NOTES / COMMENTS
✓	ALL PREVIOUSLY INDICATED REJECTS REPAIRED	
✓	ALL TYPE 1 CHANGES MADE	
✓	CLEAR LOGS AND CLONE TICS PROGRAM FILES	
✓	RECORD TICS PROGRAM NUMBER ON PSO " SERIAL NUMBER RECORD SHEET "	
✓	VERIFY THAT TIME AND DATE ARE CORRECT IN DISPLAY	
✓	RECORD EACH MODULE SERIAL NUMBER (MD3,CHASSIS,CAB, ETC.)	
✓	RECORD AMOUNT OF HOURS MACHINE HAS BEEN RUN	
✓	PLACE CORRECT ENGINE MANUAL IN VIP POUCH/BOX	
✓	AFFIX QUALITY CONFIDENT DECAL (3375 063) INSIDE CAB	
	ENSURE FORK TIPS ARE LEVEL WITH CARRIAGE	
	TAKE PICTURES OF TRUCK AND ALL DECALS	
✓	SECURE AND TIGHTEN BATTERY BOX LID BOLTS	
	ADD TRUCK P# TO DAILY TRUCK REPORT	
✓	WATER TEST TRUCK FOR LEAKS AT TRANSPORTATION	
✓	ALL SERIAL #'S ARE RECORDED ON PSO HARD CARD	
✓	TAYLOR PROCEDURE CHECK LIST COMPLETE	
✓	CHASSIS INSPECTION / REJECTS CORRECTED	
✓	LOAD TEST INSPECTION / REJECTS CORRECTED	
✓	POST RUN INSPECTION / REJECTS CORRECTED	
✓	PAINT INSPECTION / REJECTS CORRECTED	
✓	STANDARD RIG OUT INSPECTION / REJECTS CORRECTED	
✓	FINAL RIG OUT INSPECTION / REJECTS CORRECTED	
✓	MAST MEASUREMENTS FOR SHIMMING	
✓	PRESSURE SETTINGS	
	HALIBURTON MACHINE SETTINGS WHEN APPLICABLE	
	SPECIAL INSTRUCTIONS FOR TEAR DOWN / SHIPPING	
	APPROVAL TO TRANSFER TO SHIPPING	
		INSPECTOR / DATE 8-22-19
	ALL SPECIAL INSTRUCTIONS COMPLETED	
		SHIPPING SUPERVISOR / DATE

MIDTRONICS
MDX-P300

TAYLOR MACHINE
WORKS
39339 CODE

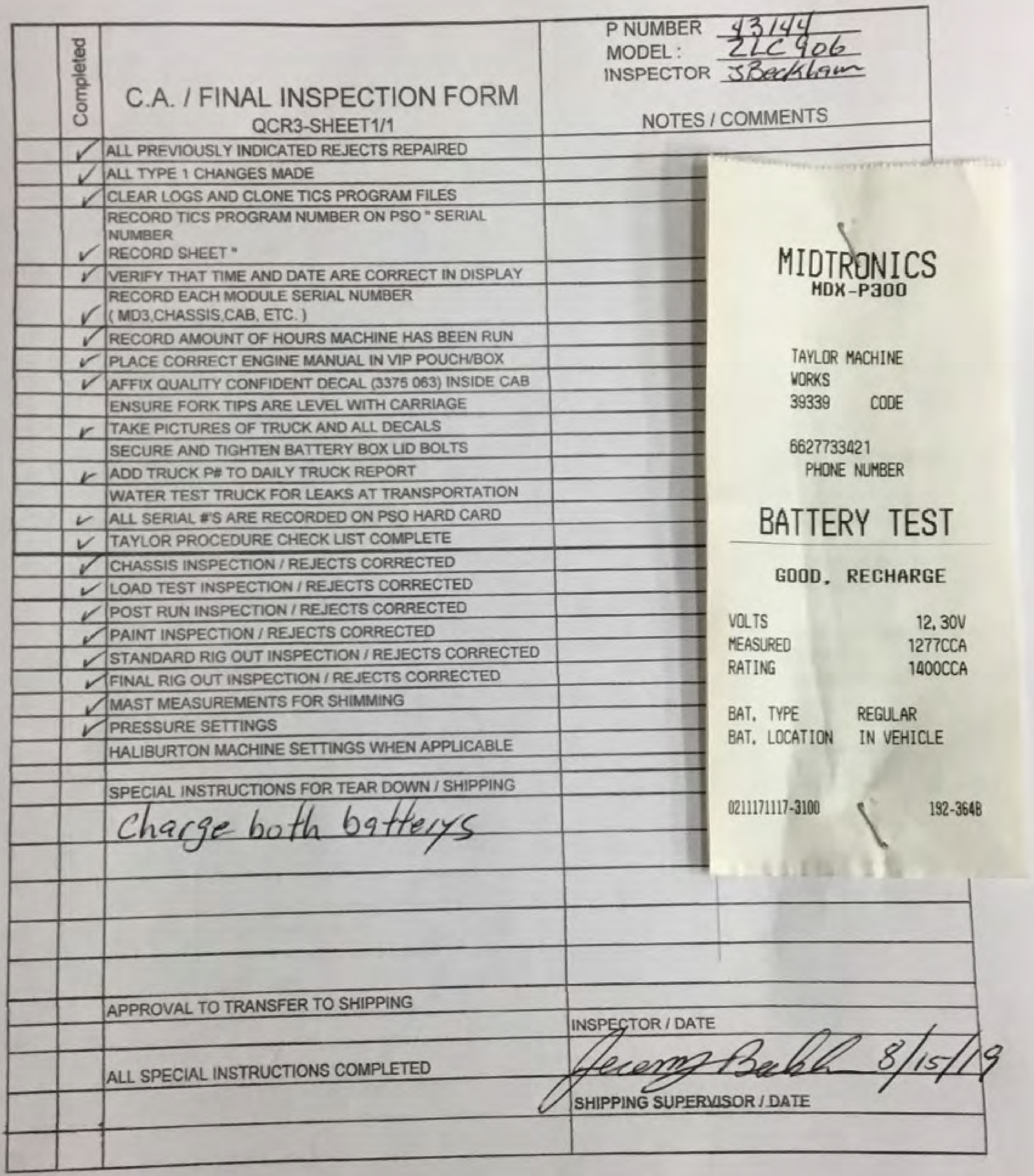
6627733421
PHONE NUMBER

BATTERY TEST

GOOD BATTERY

VOLTS	12.77V
MEASURED	1417CCA
RATING	1400CCA
BAT. TYPE	REGULAR
BAT. LOCATION	IN VEHICLE

0211171117-3144 192-364B



C.A. / FINAL INSPECTION FORM

QCR3-SHEET1/1

P NUMBER 43144
MODEL: 2LC906
INSPECTOR JBeckham

Completed		NOTES / COMMENTS
✓	ALL PREVIOUSLY INDICATED REJECTS REPAIRED	
✓	ALL TYPE 1 CHANGES MADE	
✓	CLEAR LOGS AND CLONE TICS PROGRAM FILES	
✓	RECORD TICS PROGRAM NUMBER ON PSO " SERIAL NUMBER RECORD SHEET "	
✓	VERIFY THAT TIME AND DATE ARE CORRECT IN DISPLAY	
✓	RECORD EACH MODULE SERIAL NUMBER (MD3,CHASSIS,CAB, ETC.)	
✓	RECORD AMOUNT OF HOURS MACHINE HAS BEEN RUN	
✓	PLACE CORRECT ENGINE MANUAL IN VIP POUCH/BOX	
✓	AFFIX QUALITY CONFIDENT DECAL (3375 063) INSIDE CAB	
	ENSURE FORK TIPS ARE LEVEL WITH CARRIAGE	
✓	TAKE PICTURES OF TRUCK AND ALL DECALS	
	SECURE AND TIGHTEN BATTERY BOX LID BOLTS	
✓	ADD TRUCK P# TO DAILY TRUCK REPORT	
	WATER TEST TRUCK FOR LEAKS AT TRANSPORTATION	
✓	ALL SERIAL #'S ARE RECORDED ON PSO HARD CARD	
✓	TAYLOR PROCEDURE CHECK LIST COMPLETE	
✓	CHASSIS INSPECTION / REJECTS CORRECTED	
✓	LOAD TEST INSPECTION / REJECTS CORRECTED	
✓	POST RUN INSPECTION / REJECTS CORRECTED	
✓	PAINT INSPECTION / REJECTS CORRECTED	
✓	STANDARD RIG OUT INSPECTION / REJECTS CORRECTED	
✓	FINAL RIG OUT INSPECTION / REJECTS CORRECTED	
✓	MAST MEASUREMENTS FOR SHIMMING	
✓	PRESSURE SETTINGS	
	HALIBURTON MACHINE SETTINGS WHEN APPLICABLE	

SPECIAL INSTRUCTIONS FOR TEAR DOWN / SHIPPING

Charge both batterys

APPROVAL TO TRANSFER TO SHIPPING — INSPECTOR / DATE Jeremy Babb 8/15/19

ALL SPECIAL INSTRUCTIONS COMPLETED — SHIPPING SUPERVISOR / DATE

MIDTRONICS
MDX-P300

TAYLOR MACHINE
WORKS
39339 CODE

6627733421
PHONE NUMBER

BATTERY TEST

GOOD, RECHARGE

VOLTS	12.30V
MEASURED	1277CCA
RATING	1400CCA
BAT. TYPE	REGULAR
BAT. LOCATION	IN VEHICLE

0211171117-3100 192-364B


TAYLOR
www.taylorbigred.com
Build Your Dreams
WARNING


LIVE CIRCUIT
CHARGE / ENABLE
WARNING
ON
ENCLOSURE TYPE 4
DO NOT DISCONNECT UNDER LOAD
3φ 208v
SION
SWL
04
05
HEVI-DUTY
EMERSON
GENERAL PURPOSE TRANSFORMER
E2H75S
75 KVA
3 PHASE
60 HERTZ
480D
208Y/120
DOE 2016 EFFICIENCY COMPLIANT
DE-ENERGIZE TRANSFORMER BEFORE REMOVING COVER
HEVI-DUTY


MATCH COLORS & SYMBOLS WHEN CHARGING
FLOATING SYSTEM
WARNING
Automated equipment area DO NOT ENTER
VI-DUTY


DANGER
HIGH VOLTAGE
MATCH COLORS & SYMBOLS WHEN CHARGING
FLOATING SYSTEM
WARNING
Automated equipment area
DO NOT ENTER
HEVI-DUTY
LIFT


UNISTRUT
E·T·N
DIL M250
OFF
X1 - Top
X2 - Mid
X3 - Bottom
CLASS T, 300V, 6A FUSE ONLY
ENCLOSURE TYPE 4
SERIAL NO.
TP-EVSE-200-
Marechal


TAYLOR
www.taylorbigred
TAYLOR
EVSE # 2
Build Your Dreams
WARNING
TRITON


WHEN TRAVELING WITH CONTAINER TILT MAST BACK-MAINTAIN LINE OF SIGHT
CAUTION DO NOT PARK SPREADER OVER CAB
80368
DANGER STAY CLEAR
CAUTION-MUST DEFLATE TIRES BEFORE REMOVAL
ZLC906
ZERO EMISSIONS
68
DANGER DO NOT APPROACH THIS MACHINE ON FOOT WHILE IN USE
OOCL
SSATerminals

比亚迪汽车
BYD AUTO

User Manual
BYD AC Charging Box

Dedicated Service Commitment from BYD Auto

Dear valuable customers:

Because of your attention, part of our service is above the industry standard, also because of your suggestion, we continue to provide better service. To give you an excellent service, we promise:

I. We will keep smiling and passion at any time.

II. We will provide you with a safe, beautiful AC charging box.

III. We will provide original pure accessories when maintenance, do not mix the false with the genuine and mix the old with new.

IV. We will respond actively in a timely manner in the case of any doubt or requirement.

V. Your comments on our service quality are highly appreciated. We would record your complaint in detail, if any and try to solve it as soon as possible.

Version Date: 201503

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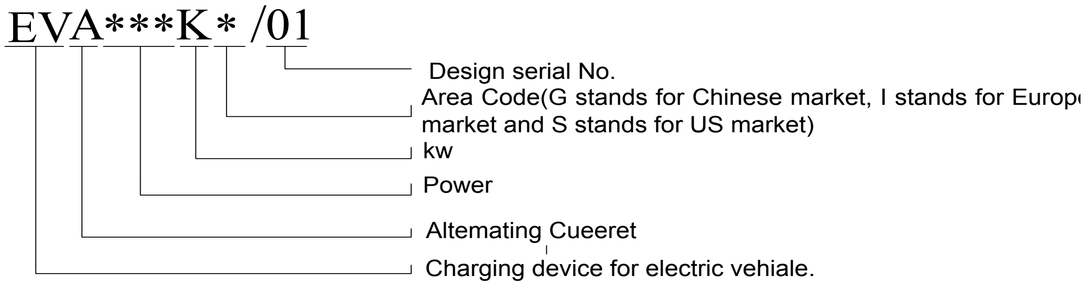
Foreword

Thank you for choosing BYD AC charging box (hereinafter referred to as the charging box). For better use and maintenance of the charging box, please read and keep this user manual carefully.

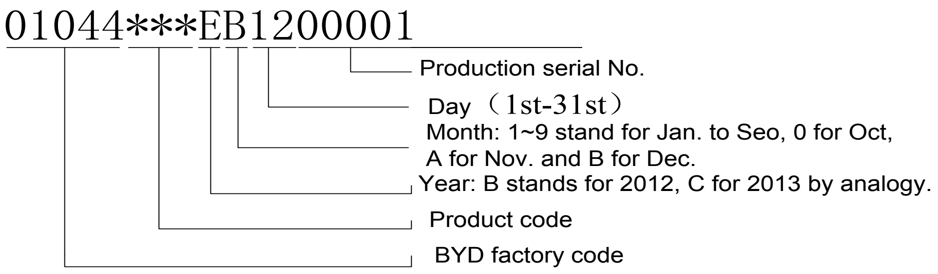
The charging box is designed to charge BYD electric vehicle, which may be installed in a garage or on a parking lot. As the charging box contains a number of high voltage lines, low voltage lines and complicated electronic components, please do not disassemble or refit these lines and components, or any fault caused thereby would not be covered by warranty provided by BYD, and any personal injury incurred not be of our liability.

This User Manual is provided ONLY to help you use this product properly, and shall not be construed as any specification of the product configuration. For the product configuration, please refer to the contract (if any) related to this product or contact your distributor. The illustrations provided in this Manual are for reference only. Actual product may differ in appearance.

Model:



Serial No:



BYD Auto Industry Company Limited reserves the right to modify technical property and content in the user manual without restraint and prior notice.

For better service, please provide accurate contact method. In case of any change, please contact BYD authorized service station to update it in the system.

Please keep informed of related national laws and regulations as well as your local policies. Thank you again for choosing our charging box, and you are welcomed to give us your comments and suggestions.

I. Instruction

1.1 Appearance

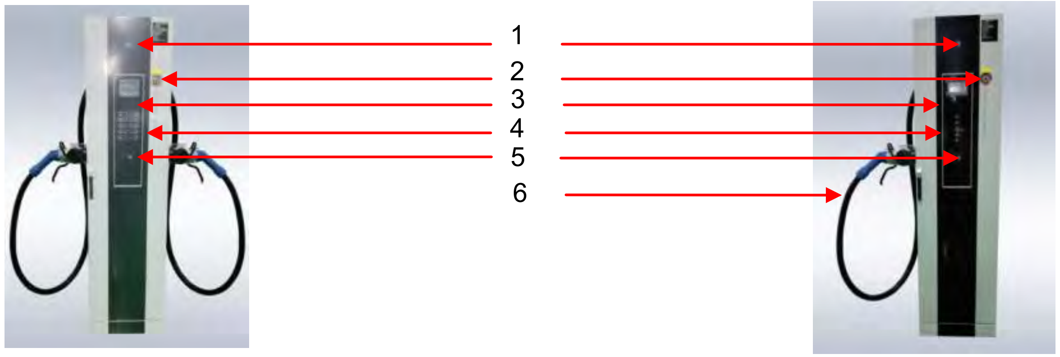


Fig. 1.1 Diagram of AC Charging Box Appearance

1. Emergency stop: In case of emergency, press the button to cut off input power supply and stop the AC charging box from operating. For power restart, please turn the switch clockwise until it pops up.
2. Surveillance camera: AC charging box comes with surveillance cameras, which can take real-time photos of the vehicles and any moving objects within the scope of the parking of the vehicle.(16G or 32G high speed micro mini SD card, which is not provided);
3. Touch screen: An interface of operation and display, you can observe the real-time charging status and operate the AC charging box according to the tips. (Refer to instruction of use for specific operation process)
4. LED indicator: Indicates five kinds of status, including power supply, connection, charging, complete and fault, as shown in Fig. 1.2.
5. RFID Area: The Radio Frequency Identification area. Swipe your card at the RFID area according to the prompting on the touch screen.
6. Charging connector: A device connecting an AC charging box and an electric vehicle (Refer to instruction of use for specific operation process), The EVA100K AC charging box is equipped with single charging connector, while the EVA200 AC charging box is equipped with double charging connectors.

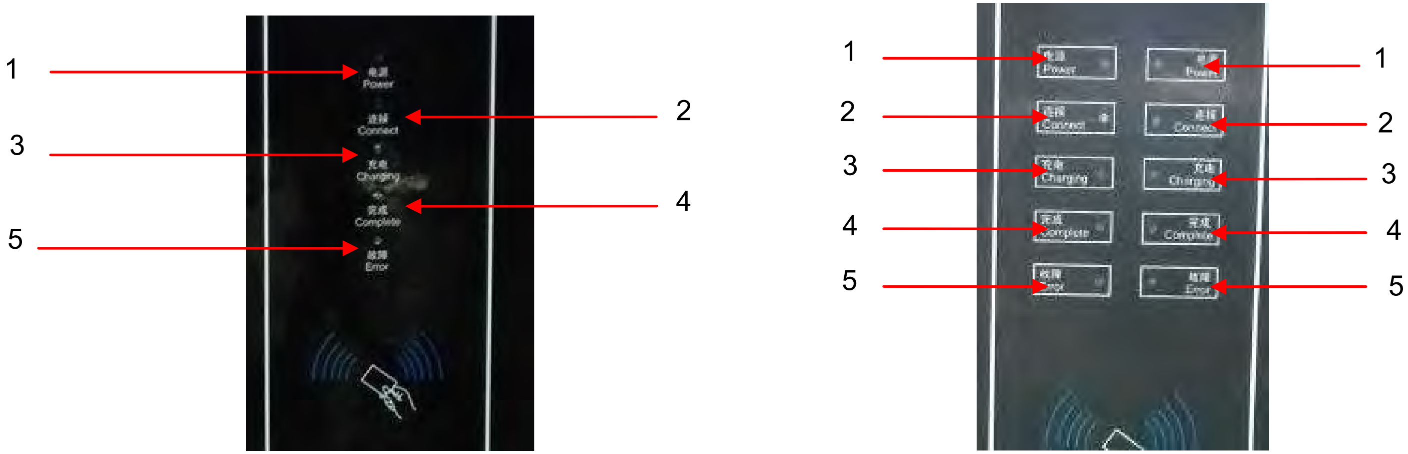


Fig. 1.2 Diagram of AC Charging Box LED indicator

Table 1.1 LED indicator status

Serial No.	Mark	Operating status
1	power	On
2	connect	Blinking
3	charging	Blinking
4	complete	Blinking
5	error	Blinking

1.2 Technical index

Model		EVA050KS/01	EVA100KI/01	EVA100KS/01	EVA100KS/02	EVA200KI/01	EVA200KS/01
ELECTRICS	Rated input voltage	AC208V (three phase)	AC380V/400V/415V (three phase)	AC480V (three phase)	AC208V (three phase)	AC380V/400V/415V (three phase)	AC480V (three phase)
	operating voltage range	AC189V-228V	AC342V-440V	AC432V-528V	AC189V-228V	AC342V-440V	AC432V-528V
	Input current	≤150A	≤150A/144A/139A	≤120A	≤300A	≤300A/288A/278A	≤280A
	Input Power	≤50KW	≤100KW	≤100KW	≤100KW	≤200KW	≤200KW
	Operating frequency	60Hz	50Hz/60Hz	60Hz	60Hz	50Hz/60Hz	60Hz
	Output Voltage	AC189V-228V (three phase)	AC342V-440V (three phase)	AC432V-528V (three phase)	AC189V-228V (three phase)	AC342V-440V (three phase)	AC432V-528V (three phase)
	Output Current	≤150A	≤150A/144A/139A	≤120A	≤150A/Charging connector	≤150A/144A/139A / Charging connector	≤120A/ Charging connector
	Output power	≤50KW	≤100KW	≤100KW	≤50KW/ Charging connector	≤100KW/ Charging connector	≤100KW/ Charging connector
	Output interface standard	IEC62196 (BYD charging connector)	IEC62196(BYD charging connector)	IEC62196 (BYD charging connector)	IEC62196 (BYD charging connector)	IEC62196 (BYD charging connector)	IEC62196 (BYD charging connector)
PHSICS	product size (mm)	500*400*2000 (Length* Width* Height (mm))					
	Net weight	130kg			180kg		
	Number of charging connectors	1			2		

	Length of charging cable	3m					
SAFETY	Protection function	short circuit protection /over-temperature protection /surge protection					
	Certification	DEKRA	CQC/ DEKRA	DEKRA	DEKRA	CQC/ DEKRA	DEKRA
	IP degree for enclosure	IP54					
OTHERS	Noise	≤60dB					
	Cooling method	Natural cooling					
	Operation temperature	-25℃～+40℃					
	Storage temperature	-30℃～+60℃					
	Environment humidity	5～95% non-condensing					
	Display method	Touch screen, LED lights					
	Documents and manuals	User manual					
	Transportation requirements	Avoid water, bumping, upside-down and handle with care					

1.3 Notes on symbols

DANGER!

The symbol indicates that improper operation might endanger user’s safety or cause severe damage to the product. Please read and observe notes on the symbol carefully.

WARNING!

The symbol indicates that improper operation might endanger user’s safety or cause major damage to the product. Please read and observe notes on the symbol carefully.

ATTENTION!

The symbol indicates that improper operation might endanger user’s safety or cause certain damage to the product.

NOTICE!

The symbol indicates that improper operation might endanger user’s safety or cause certain damage to the product.

1.4 Transportation

- Transportation equipment used must withstand the weight of the charging box.
- During transportation, please place the charging box in the direction indicated by the mark. Do not incline or invert it.

DANGER!
Improper handing during transportation may cause damage to the charging box!

Please consider barycentre or centre of gravity of a Charging Box and transport it in a correct way to avoid, damage or injury to pedestrians.

II. Installation Instruction

2.1 About Safety

- In this section, general installation specifications are provided, which must be complied with during the whole installation.
- The section is prepared for product installer and covers installation procedure and installation notes of the product.
- Please read the section carefully before installing and observe notes in the section during installation. Damage caused by improper operation or not following the instruction shall not be the liability of BYD.
- It is assumed that installers are fully aware of electric installation and corresponding regulations
- Please read all safety notes. All operation of the charging box must be performed in strict compliance with the safety notes.

⚠ DANGER!
Improper operation may causes electric shocks!

Incompliance with correct procedure might cause electric shock. Incompliance with the guide, operation instruction and safety notes might cause electric shock and severe injury.

NOTICE!
Warning signs must always be visible.

- ▲ Warning signs must always be visible. In cans of damage, please replace them immediately.
- ▲ Please keep documents near the Charging Box within the reach of service and maintenance personnel and take care of it property.

2.2 Requirements of installation

2.2.1 Environment and conditions for installation of the charging box

Table 2.1 Environment and conditions for installation of the charging box

Installation environment	**Indoor/Outdoor**
Atmosphere pressure	80kPa～110kPa
Air flow speed	7,000m^3/h
Maximum altitude	≤ 2,000
Wall surface gradient	≤5°
Minimum installation distance from the Charging box to around	See Figure 2.1
Concrete requirement for wall surface and foundation	Strength grade of concrete should be above C30#
Requirement for foundation	Installed in high position, the foundation should be concrete
Load bearing for unit area (when it is required to mount bracket)	≧2000kg/m2

For safe operation of charging box, the installation site must meet the following conditions:

- The charging box shall not be installed in places where severe vibration or explosive exists, such as inflammable gases, vapor or dust.
- When charging box is installed in high temperature, cold or high humidity areas, please take corresponding measures, to ensure the running environment of the system to meet the requirements.
- The charging box shall not be installed in places which are low-lying or easily waterlogged.
- With good ventilation.
- The installation location shall ensure convenience to observe indicators and operate.
- The installation place shall be clean.
- The Charging box is not allowed spraying water, spraying water fiercely, short time immersion and continuous immersion in water.
- The position of charging box and it's operation area shall place the safety warning signs, or to take corresponding protective measures;
- The distance from charging box to rear wall or other projects and the distance between charging box to front electric vehicle should be greater than or equal to 600mm, for the other installation distance please see Fig. 2.1 below.

Fig. 2.1 Diagram of minimum installing distance

- The charging box should be equipped with a waterproof shed (shown in Figure 2.2) which is capable of blocking the charging port of the vehicle, in case the charging gun gets wet in the rain leading to injuring people by electric leakage and electric shock during charging.

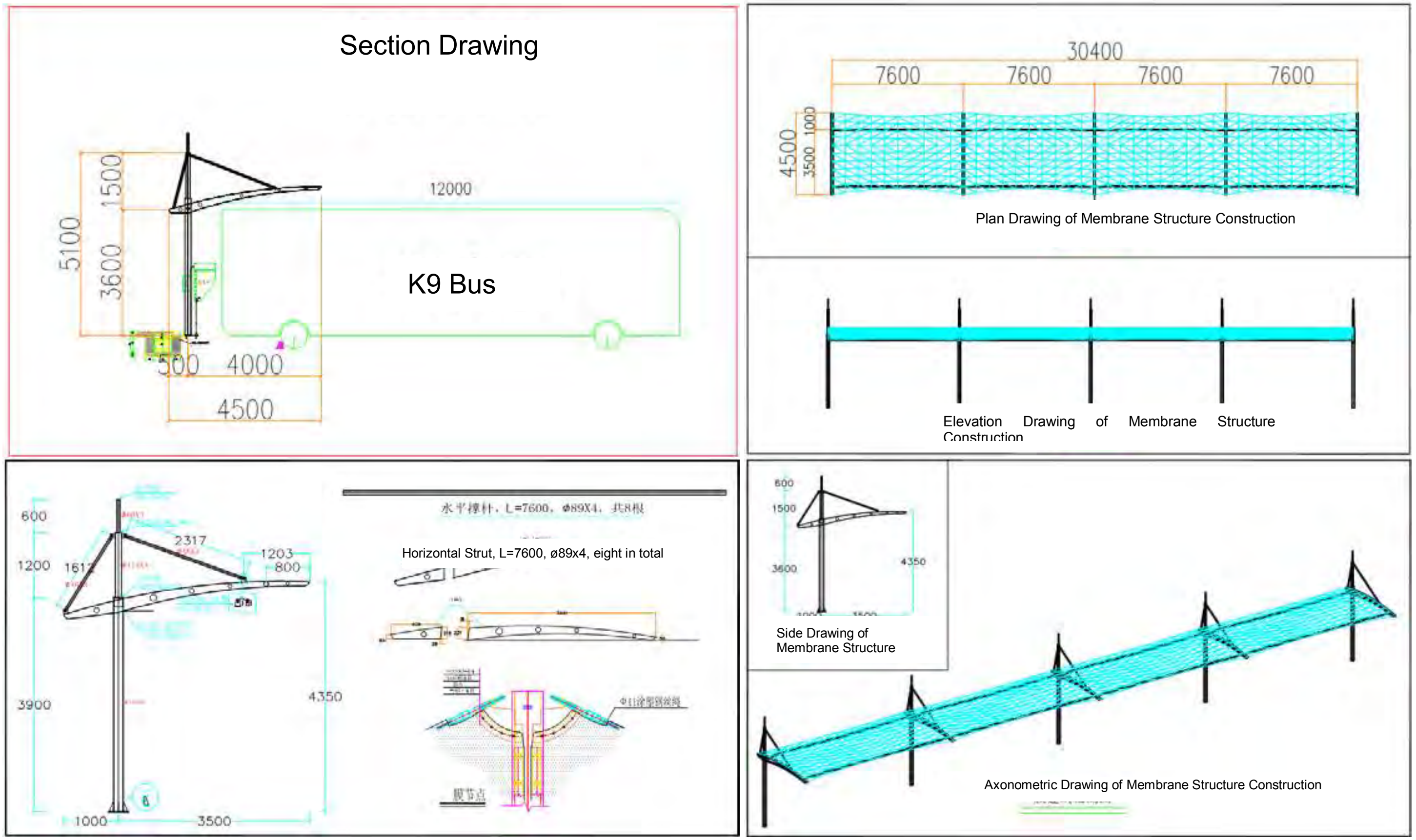


Fig. 2.2 Reference case of the waterproof shed of the AC charing box

Note:
The solution of the waterproof shed is a case of our company and just a reference for installation. The actual design of waterproof shed should be taken according to several factors, such as the amount of charging boxes, the design of the parking space and site environment.

2.2.2 Requirements of installing cables

1) The charging box with three-phase input voltage, shall apply Three-phase Five-Wire System (TN-S) to its supply power; for the charging box with single-phase input voltage, the supply power shall be connected to L, N, and PE (in case of US single-phase 240 V, to L1, L2 and PE respectively). Cable color shall comply with the requirements of local standards.
2) The independent distribution loop should be provide to charging box, and can't be shared with other electrical products. It is recommend to install circuit breaker in front of charging box, including EVA050KS/01, EVA100KS/01, EVA100KI/01. The rated current of recommended circuit breaker is 200A (ambient temperature exceeding 40℃ should consider reducing the amount of compensation), while EVA100KS/02, EVA200KS/01, EVA200KI/01, the rated current of recommended circuit breaker r is 400A (ambient temperature exceeding 40℃ should consider reducing the amount of compensation).
3) The input cable of the charging box shall be copper strand and the terminals shall be crimped as is required.
4) To meet the requirements of protection class, the input cable of charging box should be equipped with external pressure cable fixing.

Table 2.2 List of Requirements of installing cables

Type	Requirement of cable conductor	Remark
EVA100KS/01	≥150A	1. For cable type selection, refer to Schedule 2. Choosing the external-oppression type cable fixing according to the actual diameter of the cable selection, and take the cable capacity margin into consideration.
EVA050KS/01, EVA100KI/01	≥150A	
EVA200KS/01	≥300A	
EVA100KS/02, EVA200KI/01	≥300A	

Note: The terminal in this specification is recommended to use galvanized copper ears

WARNING!

▲ During installation, do not after any part in the Charging Box except the connection terminal.
▲ Please ensure reliable input earthing to avoid electric shock.
▲ It is required that the torque is 29~30N.m when connection the power input cable to the terminal of the charging Box.

2.3 Unpacking

- Before unpacking, please make sure the box placed in the direction indicated by the sign.
- Handle with care while unpacking
- Check the nameplate of product, to identify the correct product.
- Check the inside and outside of the charging box in case of been damaged in transportation
- Please confirm all materials in the packing box (refer to Attachment 1).

WARNING!

Please check the BOM in the packing box on the spot. In case of absence of certain parts, please contact your dealer immediately and do not install the Charging Box.

2.4 Figure of involved component installing position

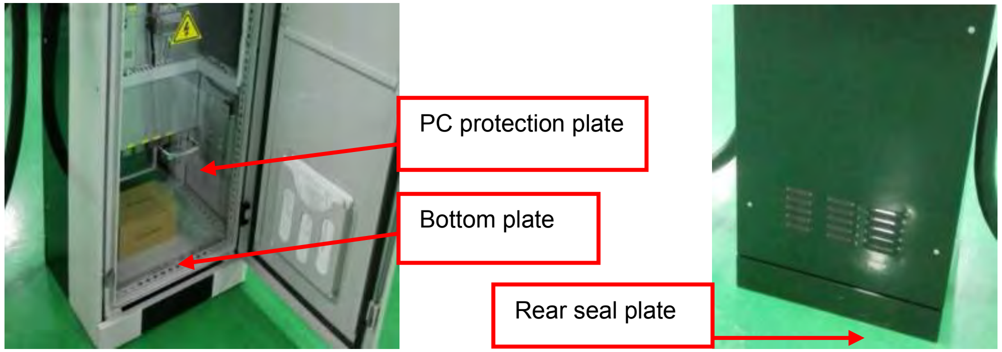


Fig. 2.3 Figure of involved component installing position

2.5 Installation method

Please prepare the tools following before installing:

Table 2.3 Installation tools list

NO.	Description	NO.	Description
1	Monkey spanner	5	Wire stripping pliers
2	Sockets wrenches	6	Iron hammer
3	churn drill φ16	7	Cross-type screwdriver
4	Hydraulic crimping pliers		

⚠ DANAGER!

Installation by non-professionals may cause danger!

Only trained and licensed electricians are allowed to install a Charging Box.

2.5.1 Charging box installing steps

- Step 1: Put the box body near the preinstallation site, open the front door and remove the transparent protective PC plate and the base plate, as shown in Figure 2.4.
- Step 2: Remove the rear closure plate of the box body by the socket wrench and expose mounting holes fully, as shown in Figure 2.5.
- Step 3: On the preinstallation site, make four mounting holes of M14 with a depth of 130mm by the impact drill, according to the size of Figure 2.6.
- Step 4: Move the box onto the preinstallation site and align mounting holes of U-steel on the base of the box body with drilling holes on the cement ground.
- Step 5: Pass through mounting holes of U-steel with four expansion bolts of M14*150 and hammer expansion bolts into drilling holes
- Step 6: Lock tight expansion bolts with nuts (require installing flat washers and spring washers) and set the proper torque (the torque value is 51~61.8 N*m), according to Figure 2.7.
- Step 7: Install the transparent protective cover of the base of the charging gun by the cross-type screwdriver and cross-type flat head screws of M4*8 (skip the step if installed)

Fig. 2.4 Removal of the PC plate and the base plate

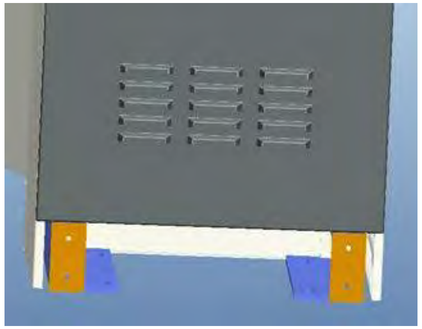


Fig. 2.5 Removal of the rear closure plate

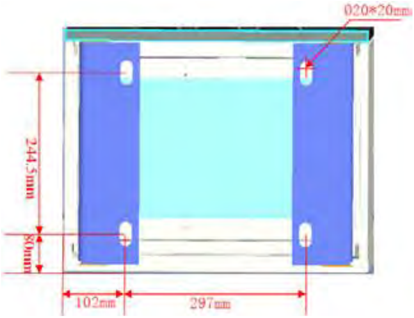


Fig. 2.6 Punching on the ground

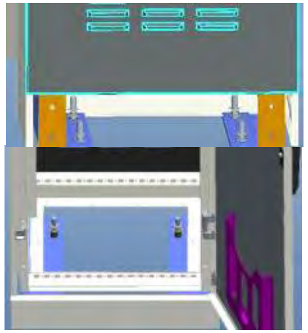


Fig. 2.7 Fixation of bolts

2.5.2 Cable installation steps

- Step 1: Lay the cables on the position which is suitable for connecting (such as the back or bottom of the box), reserve the sufficient length of cables so as to bring them easily to the interior of the box body for connecting, and do not press and link the terminals.
- Step 2: Punch on the rear closure plate and the base plate of the box body according to the holes' dimensions required of the actual external-oppression type cables selected (one hole for each cable, five holes totally), as shown in Fig. 2.8.
- Step 3: Fix the external-oppression type cables onto the rear closure plate and the base plate of the box body with the matching nuts (torsional forces shall meet requirements of the external-oppression type cables selected), as shown in Fig. 2.9.

- Step 4: Install the rear closure plate of the box body onto the original position and fix tightly nuts (the torsional force required is 1.5N), as shown in Fig. 2.10.

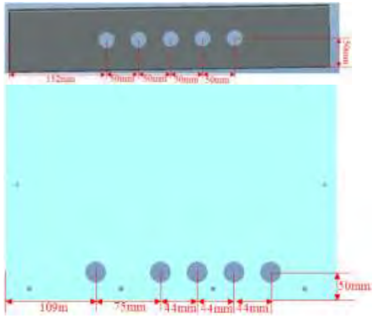


Fig. 2.8 Punching on the rear closure plate and base plate

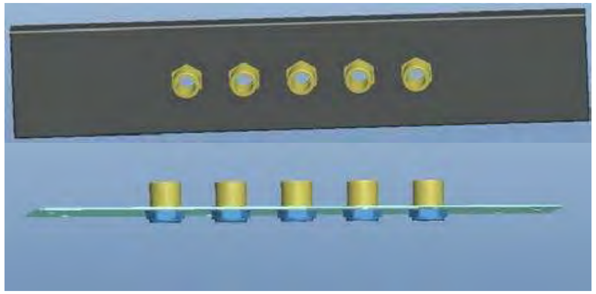


Fig. 2.9 Fixation of the joints of external-oppression type cables

Fig. 2.10 Fixation of the joints of external-oppression type cables

- Step 5: Penetrate the cables into the body of joints of the external-oppression type cables through the oppression ends of joints, clamping rings and clamping claws in sequence, and fix the base plate onto the box body, as shown in Fig. 2.11 and Fig. 2.12.

Fig. 2.11 Penetration cables into the rear closure plate

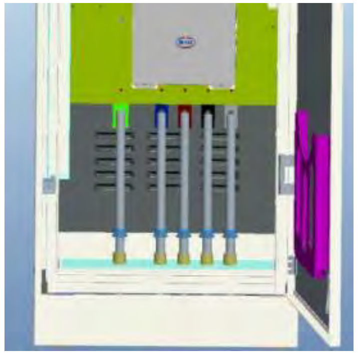


Fig. 2.12 Penetration cables into the rear closure plate

- Step 6: Press and link the terminals on each cable, as shown in Fig. 2.13.

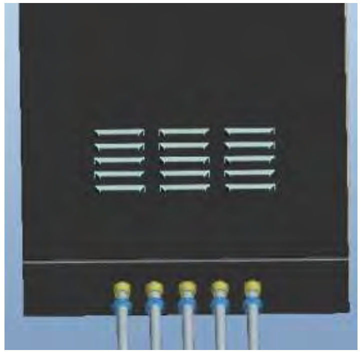


Fig. 2.13 Pressing and linking of terminals

- Step 7: Insert the cables into the copper bar of the box body according to A phase (L1) / B phase (L2) / C phase (L3), fix tightly with bolts of M10 (torque 29 to 30N.m) and keep the cables and phases linked correctly, as shown in Fig. 2.14.
- Step 8: Fasten all oppression ends of joints of the external-oppression cables (use methods and torsional forces shall meet requirements of the external-oppression type cables selected), as shown in Fig. 2.15.
- Step 9: Install the front protective PC plate of the box body onto original position after completing all above steps, as shown in Fig. 2.16.

Fig. 2.14 Fixation of terminals of the cables

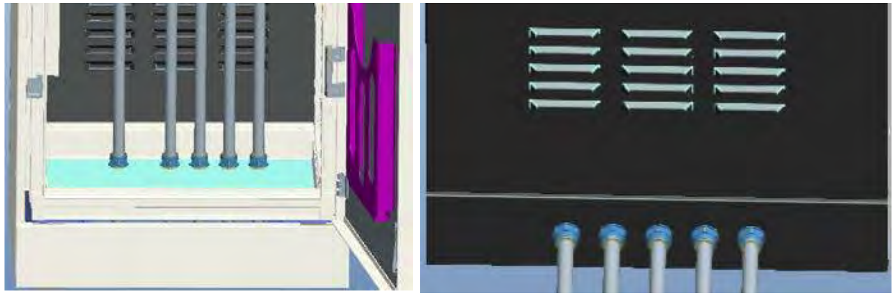


Fig. 2.15 Fastening of oppression ends of the external-oppression type cables

Fig. 2.16 Installation of the protective PC plate

WARNING !

- ▲ The input wire hamess of the Charging Box must be connected correctly. The phase sequence should be in compliance with that marked on the input line of the Charging Box.
- ▲ To avoid any over-heating, burning accidents and other phenomena due to poor contact, the cable and wire hamess connection should be firm and reliable, also the screw should be fight.
- ▲ Notice its I-direction when install the residual current circuit breaker.

2.6 Installation examination

When examining installation connection, all electric connection on site must be examined to ensure correct and firm connection.

1) Cable diameter in compliance with the requirements.
2) Ensure the reliable connection of the terminal.
3) Ensure torque at connection in compliance with the requirements.
4) The nylon cable gland of the control box Input& Output cable should be lock without leaking.
5) After installation, the test insulation resistance value of input cable to ground (L1 to PE, L2 to PE, L3 to PE, N to PE) should be ≧30MΩ (Test voltage is DC,500V, testing time is1minute)
6) Correct phase sequence connection.

WARNING！
Missing some inspection items may cause danger!

After installation completed, make sure that the above item acceptance have been finished before being energized.

III. Charging Operation

DANGER!

Improper operation may cause danger!

- ▲ Please operate the Charging Box only when it in compliance with normal and safe operation.
- ▲ Keep the Charging Box out of the reach of children.
- ▲ Charging Box should be installed away from the fireworks, dust and corrosive environments.
- ▲ As the Charging Box outputs high voltage, please pay attention to human safety when using it.
- ▲ A Charging Box with faulty has a risk of electric shock and even death. In case of emergency, please press the emergency stop switch immediately and disconnect the Charging Box and the grid, and then contact professional personal. Do not try to handle by yourself.
- ▲ Do not switch off the circuit-breaker or press the emergency stop switch during normal operation of the Charging Box.
- ▲ Remove the Charging Box is prohibited during use.

- **Step 1:** Park the electric vehicle at a designated place and power off the vehicle;
- **Step 2:** Open charging inlet door and examine the charging inlet to ensure that there is no dust, water or foreign objects at the charging inlet;
- **Step 3:** Take out the charging connector from the socket on the front side of the charging box (the charging connector is in compliance with Chinese standard, you need to hold the charging connector and lightly touch the switch button);
- **Step 4:** Connect the charging connector with the vehicle, as shown in Fig 3.1 and Fig 3.2. When the connecting is successful, the connect indicator will be lighted up;

  Note：The EVA200K charging box is equipped with double charging connectors. Please refer to the connecting method as shown in Fig3.2. The EVA100K charging box is equipped with single charging connector. Please refer to the connecting method as shown in Fig3.1.

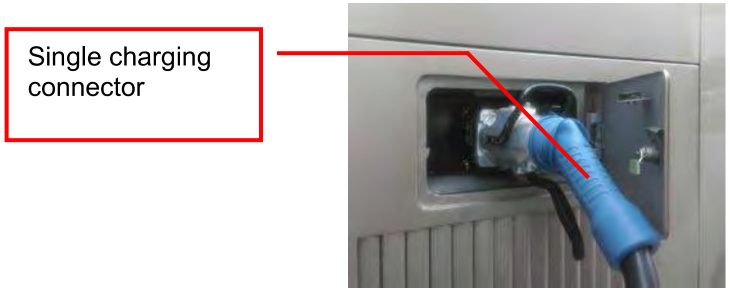


Fig. 3.1 Single charging connector

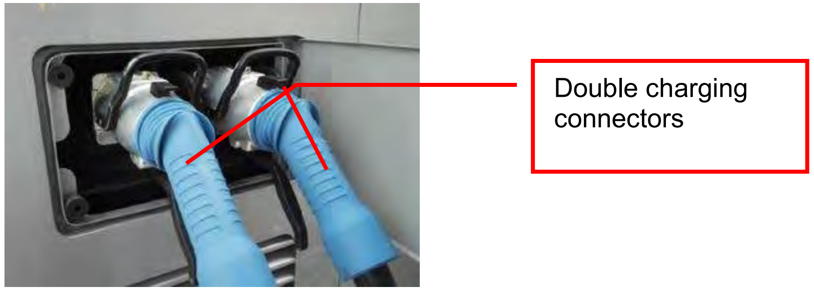
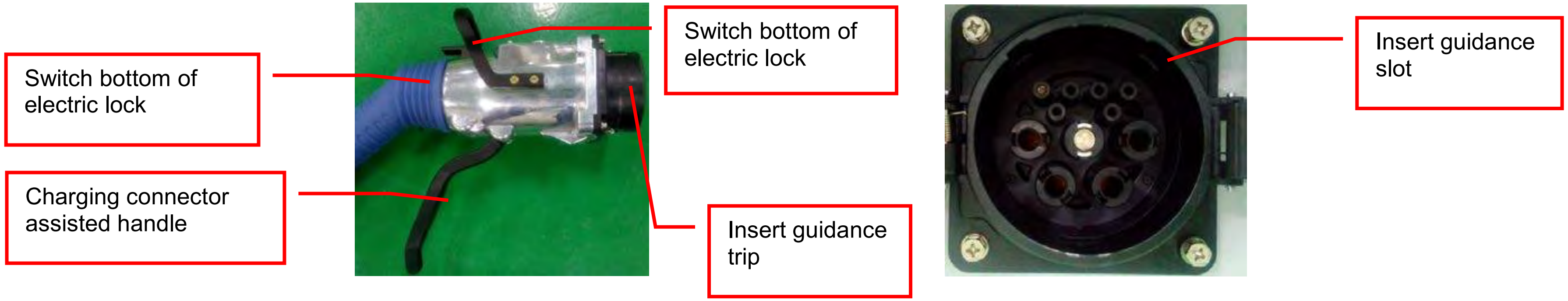


Fig. 3.2 Double charging connectors

- **Step 5**: Hold the charging connector, insert the front top of charging connector into the plug with the help of guidance slot, After confirm the charging connector is in the plug , a hand pull plug charging connector assisted handle, and confirm the charging gun well connected, the connection indicator (connect) light is on, charging connector as shown below:



- **Step 6:** Touch screen turns into the card swiping interface. In this interface you can use the "Language" button to select a desired language as shown in Figure 3.4.

  Note: The charging box has plan charging function (this can be set in the electric vehicle, which is an optional function) and button charging function (Charge the vehicle by controlling the charging box directly without charging card, which is an optional function), the swiping card screen is just as shown in Figure 3.4. If you have the above requirements, please contact BYD, the manufacturer.

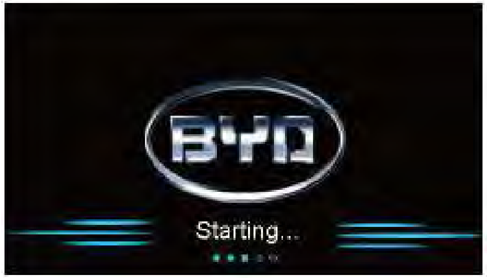
Please swipe the card

Fig 3.3 Prompt for card swiping

Please swipe the card

Fig 3.4 Card swiping screen (Start the button charging function)

- **Step 7**: Swipe the card, then the system will turn into the Start-up screen, as shown in Figure 3.5.



Starting...

Fig 3.5 Start-up screen

Charging volume: 130. 0 Kwh

SOC 40 %

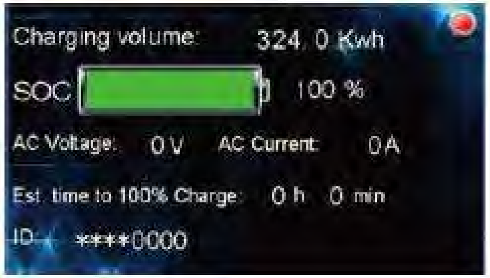
AC Voltage: 380 V AC Current: 50A

Est. time to 100% Charge: 2 h 10 min

ID: ****0000

Fig 3.6 Charging screen

- **Step 8**: After the above choice completed, the charging box begins to charge the electric vehicle. During charging, the charging progress bar of SOC and the charging indicator are blinking, as shown in Fig 3.6.



Charging volume: 324. 0 Kwh

SOC 100 %

AC Voltage: 0 V AC Current: 0 A

Est. time to 100% Charge: 0 h 0 min

ID: ****0000

Fig3.7 Charging completed screen

- **Step 9:** When charging is completed, the charging box stops charging automatically, and displays 100% of SOC as shown in Fig. 3.7, the complete indicator blinks.
- **Step 10:** Pull out the charging connector from the charging inlet (you need press the switch button on the head of the charging connector). Then touch screen returns the card swiping interface.
- **Step 11:** Put the charging connector back to the socket in the charging box. Close the charging inlet door of the electric vehicle and complete charging operation.
- During charging, to stop charging, please swipe the card again.
- The communication indicator on top right corner of the touch screen indicates the communication status between the charging box and the data center. If the charging box is equipped with a billing system and connected to the network, the green light indicates normal communication status and the red light indicates communication failure, as show in Fig. 3.9. If no network connection is available, the indicator will be red all the time.
- Any errors in the charging box, the touch screen displays a protection screen when the system protection is activated. For example, a

charging forbid screen is displayed when charging process is forbidden, as show in Fig. 3.9, and the error light blinks. Pull out and plug in the charging connector again to clear errors.

- When the service life of the charging connector expires, a red error indicator appears below the communication indicator and blinks, as show in Fig.3.10. Under this case, replacement of charging connector is necessary to ensure safety operations.

Fig. 3.8 Forbidding charging the car

Fig. 3.9 Red light blinking when the charging gun arrives its useful life

- The customer with senior administrator rights is capable to start up charging with the starting button and then click “Start Up Charging” or “Stop Charging” on the touch screen instead of swiping card and other operation is same with the above steps.

IV. Notes on maintenance

- To ensure normal life of the charging box and reduce operation risk, please conduct examination and maintenance at stated intervals.
- Examination and maintenance of equipment must be conducted by professional personnel with specialized tools.

4.1 Examination and maintenance

DANGER!
Improper operation may cause danger!

▲ Conduct regular examination to see whether the Charging Box is damaged. Operation of a damaged Charging Box might cause electric shock and severe injury.
▲ Ensure all external safety facilities are available at any time and conduct regular test to ensure correct operation.
▲ In case of earthing failure, please assume that the earthing cable carries voltage. Ensure that there is no high voltage in the system before examining and repairing the Charging Box.

The following table shows recommended items, content and cycle of examination and maintenance. Please follow steps in the Attachment 2 when conducting examination and maintenance.

- **Step 1:** Disconnect both of protection switches for power grid input and circuit breaker for protection against current leakage on AC charging box;
- **Step 2:** Remove PC protection plate of AC charging box;
- **Step 3:** Measure the voltage between phases in input cables of AC charging box with multimeter and ensure that the voltage is 0 and power grid has been disconnected;
- **Step 4:** Tighten bolts in Table 4.1 in sequence with torque spanner and ensure that torques meet requirements;
- **Step 5:** Examine input cables, cable contactor and charging connector states and ensure that examination items meet requirements;
- **Step 6:** Examine the interior and clean;
- **Step 7:** Close circuit breaker for protection against current leakage on AC charging box;
- **Step 8:** Close protection switch for power grid input and start AC charging box;
- **Step 9:** After starting AC charging box completely, confirm that functions of circuit breaker, contactor and AC charging box are normal;
- **Step 10:** After confirming functions, disconnect both of protection switch for power grid input and circuit breaker for protection against current leakage on AC charging box and install PC protection plate;
- **Step 11:** Close both of protection switch for power grid input and circuit breaker for protection against current leakage on AC charging box and complete the examination and maintenance after confirm that AC charging box starts properly.

DANGER!
Improper operation may cause danger!

Power-on test and contact with power-on conductor might cause severe accident such as burn or electric shock. Examination and maintenance should not be conducted until the equipment is completely powered off.

4.1.1 200 kW ac charging box Examination and maintenance flow sheet

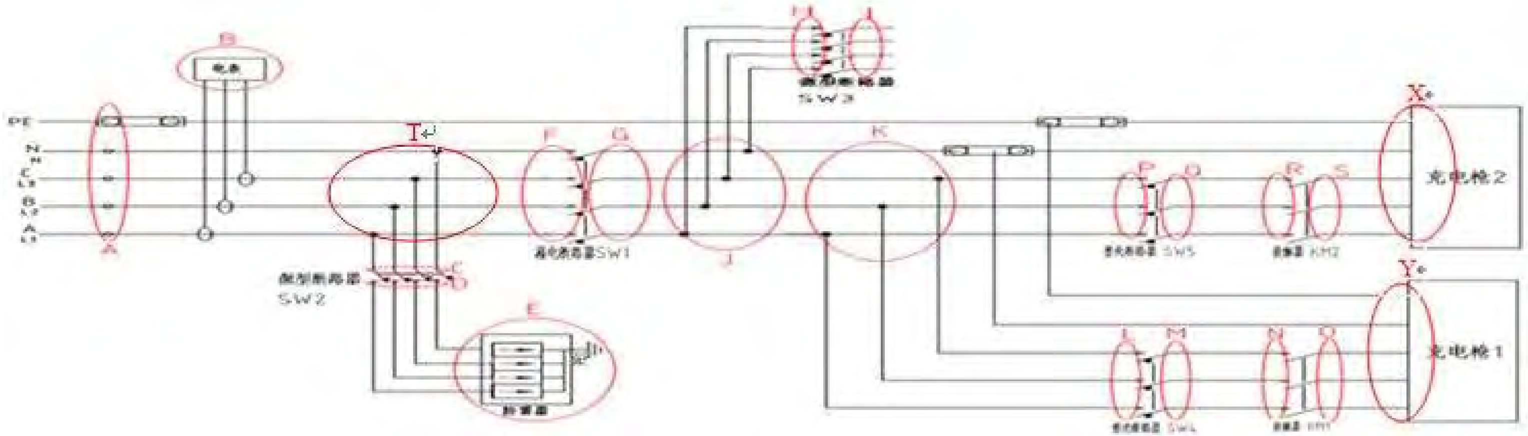


Fig 4.1 200 kW ac charging box Primary circuit schematics

Table 4.1 200 kW ac charging box Examination and maintenance flow sheet

No.	Items	Criteria for examination and maintenance	Test Data						Result	Remark
1	Appearance confirmation	Check and clean	1)Normal appearance 2)Clean surface							Power-off operation, be careful
2	The input cable with copper platoon join	Terminal torque requirements	L1	L2	L3	N	PE			

	points (Point A)	29.5±0.5N.m								
3	ammeter U1 cable terminal (Point B)	Terminal torque requirements 3.5±0.5N.m	L1	L2	L3	N	PE	Other (minimal)		
4	circuit breaker SW2 input cable with copper platoon connection point (Point T)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N				
5	circuit breaker SW2 input terminal (Point C)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N				
6	circuit breaker SW2 output terminal (Point D)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N				
7	Lightning protection device connection point (Point E)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N	PE			
8	Residual current circuit breaker SW1 input terminal (Point F)	Terminal torque requirements 14.5±0.5N.m	L1	L2	L3	N				
9	Residual current circuit breaker SW1 output terminal (Point G)	Terminal torque requirements 14.5±0.5N.m	L1	L2	L3	N				Power-off operation, be careful
10	circuit breaker SW3	Terminal torque	L1	L2	L3	N				

	input terminal (Point H)	requirements 9.5±0.5N.m							
11	circuit breaker SW3 output terminal (Point I)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N			
12	circuit breaker SW3 input cable with the main copper platoon connection point (Point J)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N			
13	Residual current circuit breaker output copper platoon and the horizontal platoon, horizontal platoon and molded case circuit breaker SW4 input copper platoon, horizontal platoon and molded case circuit breaker SW5 input copper platoon connection point (Point K)	Terminal torque Requirements 9.5±0.5N.m	L1	L2	L3			SW1 output to horizontal platoon	
			L1	L2	L3			horizontal platoon to SW4	
			L1	L2	L3			horizontal platoon to SW5	
14	Molded case circuit breaker SW4 input copper platoon connection point (Point L)	Terminal torque Requirements 14.5±0.5N.m	L1	L2	L3				

15	Molded case circuit breaker SW4 output copper platoon connection point (Point M)	Terminal torque Requirements 14.5±0.5N.m	L1	L2	L3					
										Power-off operation, be careful
16	Contactor KM1 input copper platoon join points (Point N)	Terminal torque Requirements 14.5±0.5N.m	L1	L2	L3					
17	Contactor KM1 output copper platoon join points (Point O)	Terminal torque Requirements 14.5± .5N.m	L1	L2	L3					
18	Charging connector 1 cables and copper platoon connection point (Point Y)	Terminal torque Requirements 14.5±0.5N.m	L1	L2	L3	N	PE			
19	Molded case circuit breaker SW5 input copper platoon connection point (Point P)	Terminal torque Requirements 10.5±0.5N.m	L1	L2	L3					
20	Molded case circuit breaker SW5 output copper platoon connection point (Point Q)	Terminal torque Requirements 10.5±0.5N.m	L1	L2	L3					
21	Contactor KM2 input copper platoon join points (Point R)	Terminal torque Requirements 11.5±0.5N.m	L1	L2	L3					
22	Contactor KM2 output copper platoon join	Terminal torque Requirements	L1	L2	L3					

	points (Point S)	11.5±0.5N.m								
23	Charging connector 2 cables and copper platoon connection point (Point X)	Terminal torque Requirements 14.5±0.5N.m	L1	L2	L3	N	PE			
24	Ac charging input cable and charging connector cable lock head	In a state of lock	1) Ensure the cable locking head screw is tightened. 2) Ensure there are no water flow into the lock head position							Power-off operation, be careful
25	charging connector	Charging connector is in good state	1) Check the appearance of the charging connector found no damage and no foreign objects in the charging inlet. 2) Charging connector terminal without indentation phenomenon.							
26	Interior cleaning and examination	Dry and clean interior	1) Use the air gun and brush to clean it. 2) Check if there are abnormal phenomena such as thermal deformation and burn marks.							
27	Circuit-breaker	Circuit-breaker function properly	1) When press the test button of RCCB it can be properly protected. 2) Circuit-breaker on-off is normal.							Power-on operation, be careful
28	Contactor	Contactor function properly	Test the voltage of the charging connector (L1-L1,L1-L3,L2-L3,L1-N,L2-N,L3-N) in the condition of the charging box is not activated ,the required voltage is less than 10 v.							
29	Function confirm	The charging box can charge normally.	Conduct charging validation after examination							

4.1.2 100 kW ac charging box Examination and maintenance flow sheet

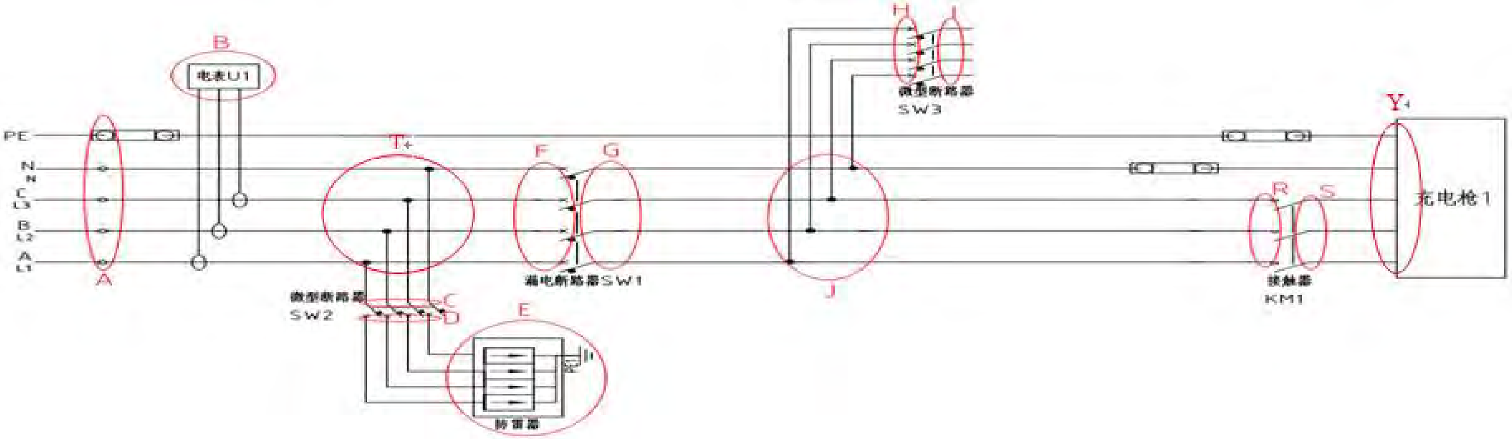


Figure 4.2 100 kW ac charging box Primary circuit schematics

Table 4.2 100 kW ac charging box Examination and maintenance flow sheet

No.	Items	Criteria for examination and maintenance	Test Data						Result	Remark
1	Appearance confirmation	Check and clean	1)Normal appearance 2)Clean surface							Power-off operation, be careful
2	The input cable with copper platoon join points (Point A)	Terminal torque requirements 29.5±0.5N.m	L1	L2	L3	N	PE			
3	Ammeter U1 cable terminal (Point B)	Terminal torque requirements 3.5±0.5N.m	L1	L2	L3	N	PE	Other(minimal)		

4	Circuit breaker SW2 input cable with copper platoon connection point (Point T)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N				
5	Circuit breaker SW2 input terminal (Point C)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N				
6	Circuit breaker SW2 output terminal (Point D)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N				
7	Lightning protection device connection point (Point E)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N	PE			
8	Residual current circuit breaker SW1 input terminal (Point F)	Terminal torque requirements 14.5±0.5N.m	L1	L2	L3	N				
9	Residual current circuit breaker SW1 output terminal (Point G)	Terminal torque requirements 14.5±0.5N.m	L1	L2	L3	N				Power-off operation, be careful
10	Circuit breaker SW3 input terminal (Point H)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N				
11	Circuit breaker SW3 output terminal (Point I)	Terminal torque requirements 9.5±0.5N.m	L1	L2	L3	N				
12	Circuit breaker SW3 input cable with the	Terminal torque requirements	L1	L2	L3	N				

	main copper platoon connection point (Point J)	9.5±0.5N.m								
13	Contactor KM1 input copper platoon join points (Point R)	Terminal torque Requirements 11.5±0.5N.m	L1	L2	L3					
14	Contactor KM1 output copper platoon join points (Point S)	Terminal torque Requirements 11.5±0.5N.m	L1	L2	L3					
15	Charging connector 1 cables and copper platoon connection point (Point Y)	Terminal torque Requirements 14.5±0.5N.m	L1	L2	L3	N	PE			
16	AC charging input cable and charging connector cable lock head	In a state of lock	1) Ensure the cable locking head screw is tightened. 2) Ensure there are no water flow into the lock head position							
17	Charging connector	Charging connector is in good state	1) Check the appearance of the charging connector found no damage and no foreign objects in the charging inlet. 2) Charging connector terminal without indentation phenomenon.							
18	Interior cleaning and examination	Dry and clean interior	1) Use the air gun and brush to clean it. 2) Check if there are abnormal phenomena such as thermal deformation and burn marks.							
19	Circuit-breaker	Circuit-breaker function properly	1) When press the test button of RCCB it can be properly protected. 2) Circuit-breaker on-off is normal.							Power-on operation, be careful

20	Contactor	Contactor function properly	Test the voltage of the charging connector (L1-L1,L1-L3,L2-L3,L1-N,L2-N,L3-N) in the condition of the charging box is not activated ,the required voltage is less than 10 v.		
21	Function confirm	The charging box can charge normally.	Conduct charging validation after examination		

⚠ ATTENTION!
Please wear necessary protective gear!

As mechanical burr will scratch skin, please take safety precautions.

4.2 Fault analysis and Troubleshooting

Table 4.2 Fault analysis and Troubleshooting

No.	Fault Description	Possible Causes	Solutions
1	The power light is off.	1. The power supply from the power grid is abnormal. 2. Circuit breaker SW1 and SW3 inside the charging box don't switch on. 3. Emergency stop switch doesn't reset.	1. Check if the power supply from the power grid is normal. 2. Close circuit break SW1 and SW3. 3. Turn the emergency stop switch in clockwise direction and ensure the switch is closed.
2	The connection light is off or blinking, after the charging gun is inserted into the electric car.	The charging gun is not inserted fully and terminals are in poor contact.	Pull out the charging gun and re-insert it into the car.
3	Card swiping doesn't work or the touch screen displays invalid card.	The card is demagnetized or invalid.	Retry after replacing with the valid card
4	The touch screen displays the fault code with '******00C'mafter swiping card.	1. The charging gun is not inserted fully and terminals are in poor contact. 2. The electric car is out of order.	1. Pull out the charging gun and re-insert it into the car. 2. Check the car.
5	The charging current appears as '0'after swiping card and starting charging.	1. Circuit breaker SW4 and SW5 inside the charging box don't switch on (only for the charging box with double guns). 2. The electric car is out of order.	1. Inspect and close circuit break SW4 and SW5 (only for the charging box with double guns). 2. Check the car.

⚠ WARNING！
Avoid any repair operations except faults in the above table!

If the fault is not solved by solution stated above, please stop operation immediately and contact repair personnet.

4.3 Warranty period

For a charging box that is damaged or cannot use due to quality problem within one year after shipment, our company will provide maintenance free of charge. Equipment damage caused by vandalism, force majeure or operation, installation and use not in compliance with the user manual is not covered by warranty. Non-professional personnel are prohibited from repairing the equipment. In case of any problem during use, please contact your retailer instead of trying to solve it by yourself.

Attachment 1 Packing List

No	Bill of Materials in packing box	EVA050KS/01	EVA100KS/01	EVA100KS/01	EVA100KS/02	EVA200KI/01	EVA200KS/01
1	AC Charging Box	1					
3	Quality Certificate	1					
4	User Manual	1					
5	SD Card	1					
6	Expansion Bolt_ M14*150	4					
8	Key for AC Charging Box	2					
9	Zip-lock Bag_100×150×0.05	1					
10	Zip-lock Bag _180×260×0.05mm	1					
11	Galvanized Hexagon Bolts _M10×25	6	6	6	6	6	6
12	Galvanized Spring Washer_Φ10	6	6	6	6	6	6
13	Galvanized Flat Washer_Φ10	12	12	12	12	12	12
14	Galvanized Nut_M10_8.8 level	6	6	6	6	6	6
15	Protection Cover of Charging Gun Base (not installed)	1	1	1	2	2	2
16	Cross-type flat headed bolt_M4*8	4	4	4	8	8	8

Attachment 2 Types Selection Table of Cables

No	Cross Sectional Area of Cables	Single-core Cables Standard Current-carrying Capacity (A)	Multi-core Cables Standard Current-carrying Capacity (A)	Remarks
1	35mm2	175	110	
2	50mm2	203	134	
3	70mm2	244	157	
4	95mm2	295	189	
5	120mm2	332	212	
6	150mm2	374	242	
7	185mm2	424	273	
8	240mm2	502	319	
9	300mm2	561	347	

Notes:

1. All productions in User Manual shall apply to three-phase-five-wire power grid system. Five cables are required for single-core cable and one five-core cable is required for multi-core cable.
2. The current-carrying capacity of cables in the table refers GB 50217-2007 *Code for design of cables of electric engineering*. Actual parameters of cables should be subject to the specification parameters provided by the manufacturer.
3. The current-carrying capacity of cables in the table refers the value of PVC insulated cables installed with directly-buried layout and operational ambient temperature is 25℃.If cables types, installation methods or ambient temperature change during actual use, the current-carrying capacity and correction factor shall be determined in accordance with factors such as actual cables types, layout methods and layout circumstances.

Attachment 3 Types Selection Table of Cable Sealing Ring and Nylon Cable Gland

Production Type Selection of Shanghai Wenyi Electrical Appliances							Production Type Selection of Shanghai Richeng Electronics			
Cable Sealing Ring			Nylon Cable Gland				Nylon Cable Gland			
Types	Applicable Outer Diameter for Cables (mm)	Sealing Plate Hole (mm)	Type	Applicable Outer Diameter for Cables (mm)	Sealing Plate Hole (mm)	Spanner Dimensions (mm)	Type	Applicable Outer Diameter for Cables (mm)	Sealing Plate Hole (mm)	Spanner Dimensions (mm)
RG-M20LB	20.5	8-13	HSK-EX-M32B-H	14-21	32	42	AG-25LB	13-18	25-25.4	33/33
RG-M25LB	25.5	11-17	HSK-EX-M32B	18-25	32	42	AG-32LB	16-21	32-32.4	39/36
RG-M32LB	32.5	15-20	HSK-EX-M42B	22-32	42	53	AG-40LB	22-32	40-40.4	50/54
RG-M40LB	40.5	19-28	HSK-EX-M50B	30-38	50	60	AG-50LB	32-38	50-50.4	63/61
RG-M50LB	50.5	27-35	HSK-EX-M60B	37-44	60	65	AG-63LB	37-44	63-63.4	75/65

Notes:
Cable sealing ring types and nylon cable gland types in the table are only recommended. The user can select the corresponding productions or equivalent with the same specifications of other brands according to the actual conditions and their specifications are subject to provider.

Statement

BYD AC charging box set stated above shall not be used until officially delivered by Party B (supplier) and officially accepted by Party A (user). Otherwise, Party B shall not be liable for any result thereby.

BYD Auto Industry Company Limited.
Address: No. 3009, BYD Road, Pingshan New District, Shenzhen, Guangdong Province, P.R. China.
Website: http://www.byd.com.cn
Tel: +86-0755-89888888

All information provided in this user manual are based on the latest data. BYD reserves the right to modify it without prior notice.
BYD reserves the right of final explanation.

Kalmar T2E
High Voltage System
Familiarization

Matt Vito, Harry Meyer
service@transpowerusa.com

29 April 2019

This presentation is to familiarize operators and maintenance personnel with the components and potential hazards of high voltage systems relating to the Kalmar T2e electric yard tractor.

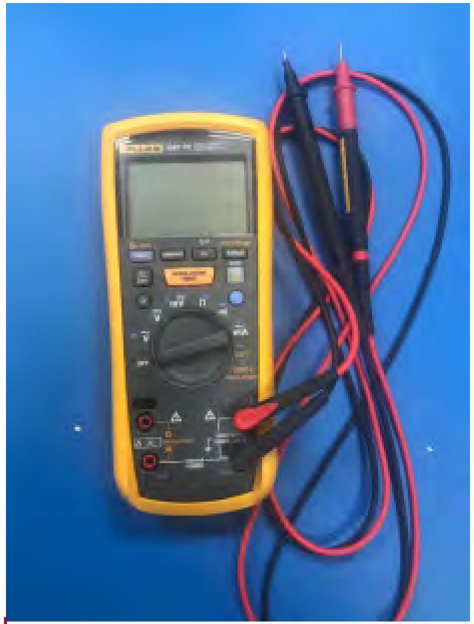
Only trained personnel may remove, replace, or repair high voltage components.

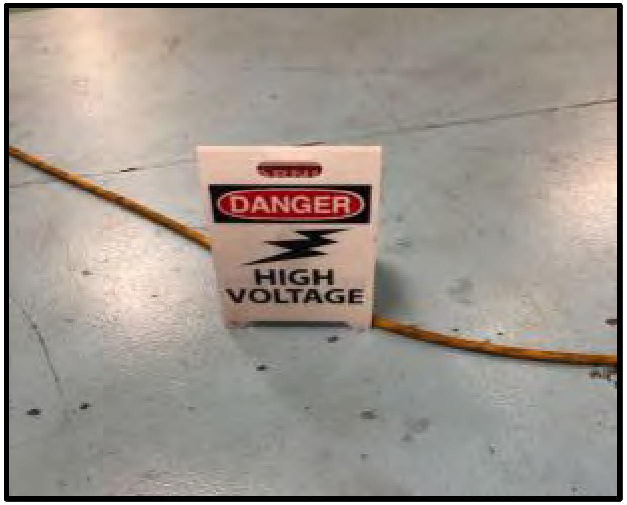
Any questions or concerns contact the TransPower Service department.

Introduction

- **An electric vehicle is any vehicle that uses an electric motor/s for propulsion**
- **Kalmar's T2e contains the following high voltage systems**
  - **Cables**
  - **Batteries**
  - **Motors**
  - **Invertor**
  - **Distribution Boxes**
  - **Accessories**

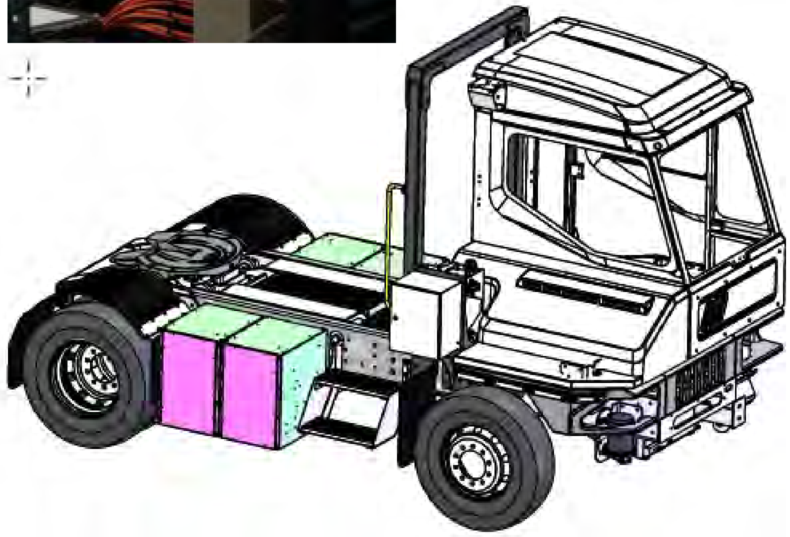
High Voltage Safety Tools





ESS (Electric Storage System)

- The ESS houses batteries and a controller to store and supply energy
- Each ESS contains 44kW of energy
- The T2e comes in options of 3,4, and 5 strings
- Never remove the cover
- Each ESS contains the following components
  - Batteries
  - Battery control module
  - Contactor
  - High voltage fusible link
- The grey 12 pin low voltage connector may be removed for troubleshooting and repair

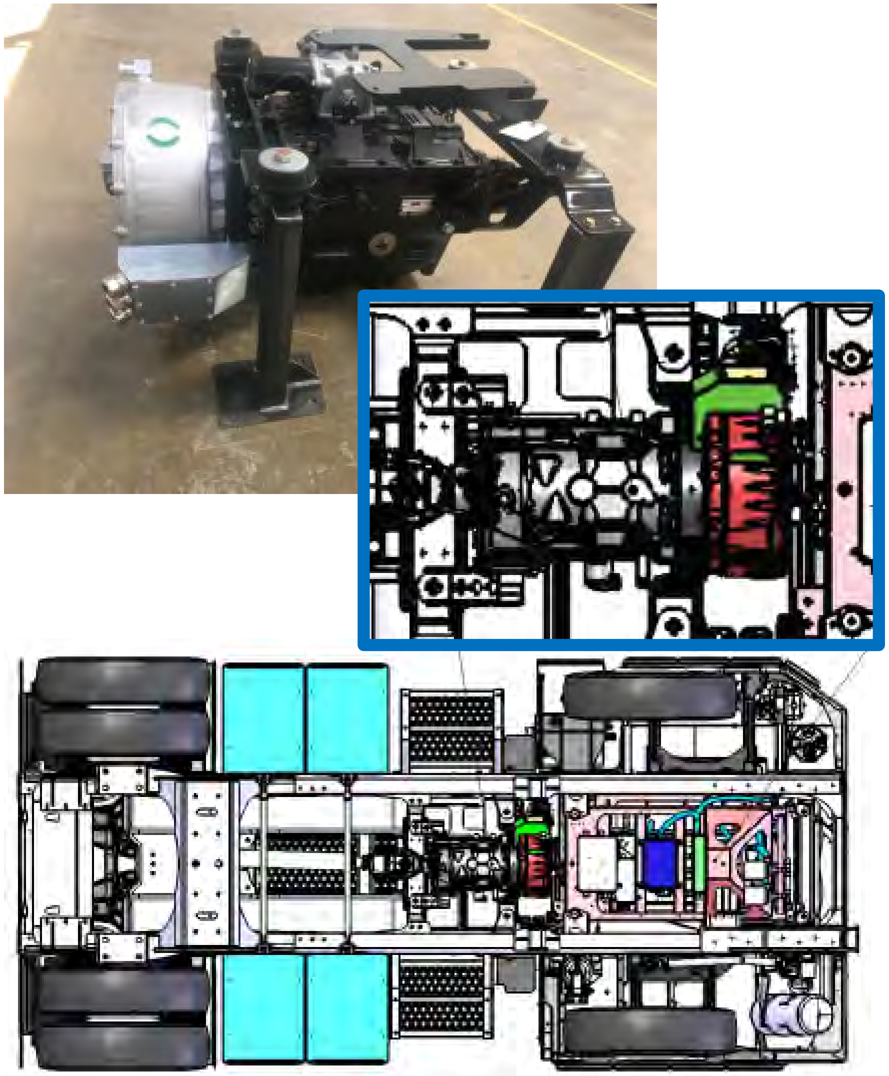


High Voltage Cables

- High voltage cables are identified by their orange color
- High voltage cables and components are capable of suppling 450 volts
- High voltage connectors are either directly lugged to the component or has a 2 stage lock release mechanism
- Never apply excessive force to disconnect a high voltage connecter
- For the T2e 12 volt & 24 volt systems are considered low voltage

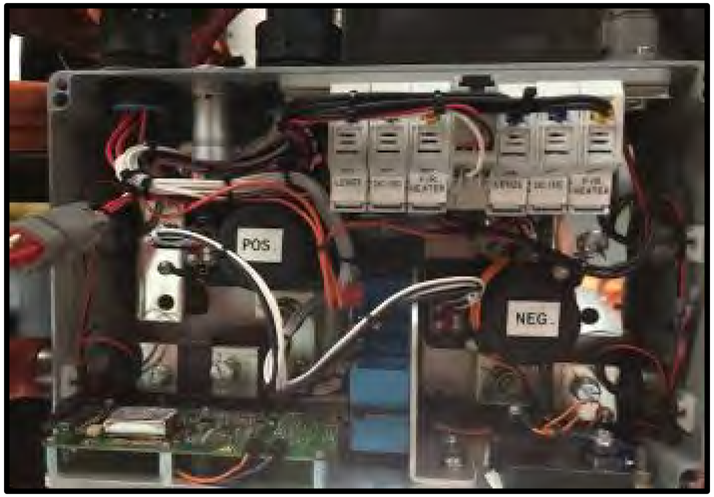
Motor

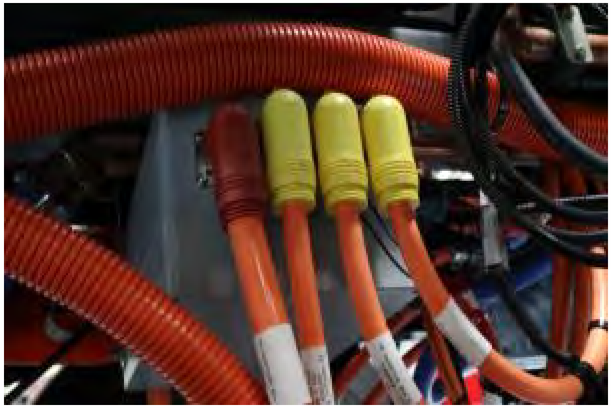
- The T2e uses a single motor that is directly attached to a Eaton 6 speed transmission
- The orange cables attached to the motor supplies 3 phase voltage from the ICU (Inverter Charger Unit) to turn the motors
- Untrained technicians should never remove the high voltage motor cover
- You may disconnect, troubleshoot, and repair the low voltage connection



HVDM (High Voltage Distribution Module)

- The HVDM is where all high voltage is distributed throughout the vehicle
- The following components are located inside the HVDM
  - Ground fault detector
  - High voltage fuses
  - Positive and negative contactors





HVJB (High Voltage Junction Box)

- The HVJB joins all batteries together using the ESS cables
- The HVJB then supplies the ESS voltage to the HVDM
- Never remove the HVJB cover or connector glands

Lenze DC to AC Inverter

- The Lenze takes ESS voltage from the HVDM and converts the energy from DC to AC
- The Lenze powers the hydraulic pump, air compressor, and air conditioning unit
- You may repair, troubleshoot, or replace the low voltage connector

Charge Box

- The charge box houses the high voltage connections and cables
- There is only voltage to/ from this box while charging
- Check voltage before attempting to repair
- You may repair, troubleshoot, or replace the low voltage connector

Bell DC to DC Converter

- The DC to DC convertor acts as an alternator
- It takes DC high voltage and converts it to 13.5 volts to charge and sustain the 12 volt battery
- You may diagnose the low voltage connectors and the supply cables to the batteries

Air Compressor Drive Motor

- The air compressor drive motor is controlled by the Lenze inverter
- There is only a single high voltage connection

Hydraulic Drive Motor

- The hydraulic drive motor is controlled by the Lenze inverter
- There is only a single high voltage connection
- The pump is a dual pump
  - Closest to the motor for the 5th wheel
  - Outer most is the power steering

ICU (Inverter Charger Unit)

- The ICU has 2 functions
  - Inverts DC voltage to AC voltage to drive the motor
  - Inverts AC voltage to DC voltage to supply energy to the batteries
  - Never remove the ICU cover
  - Only high voltage trained technicians may disconnect the orange high voltage connections
  - You may disconnect, troubleshoot, and repair the low voltage connection

ICU Inside

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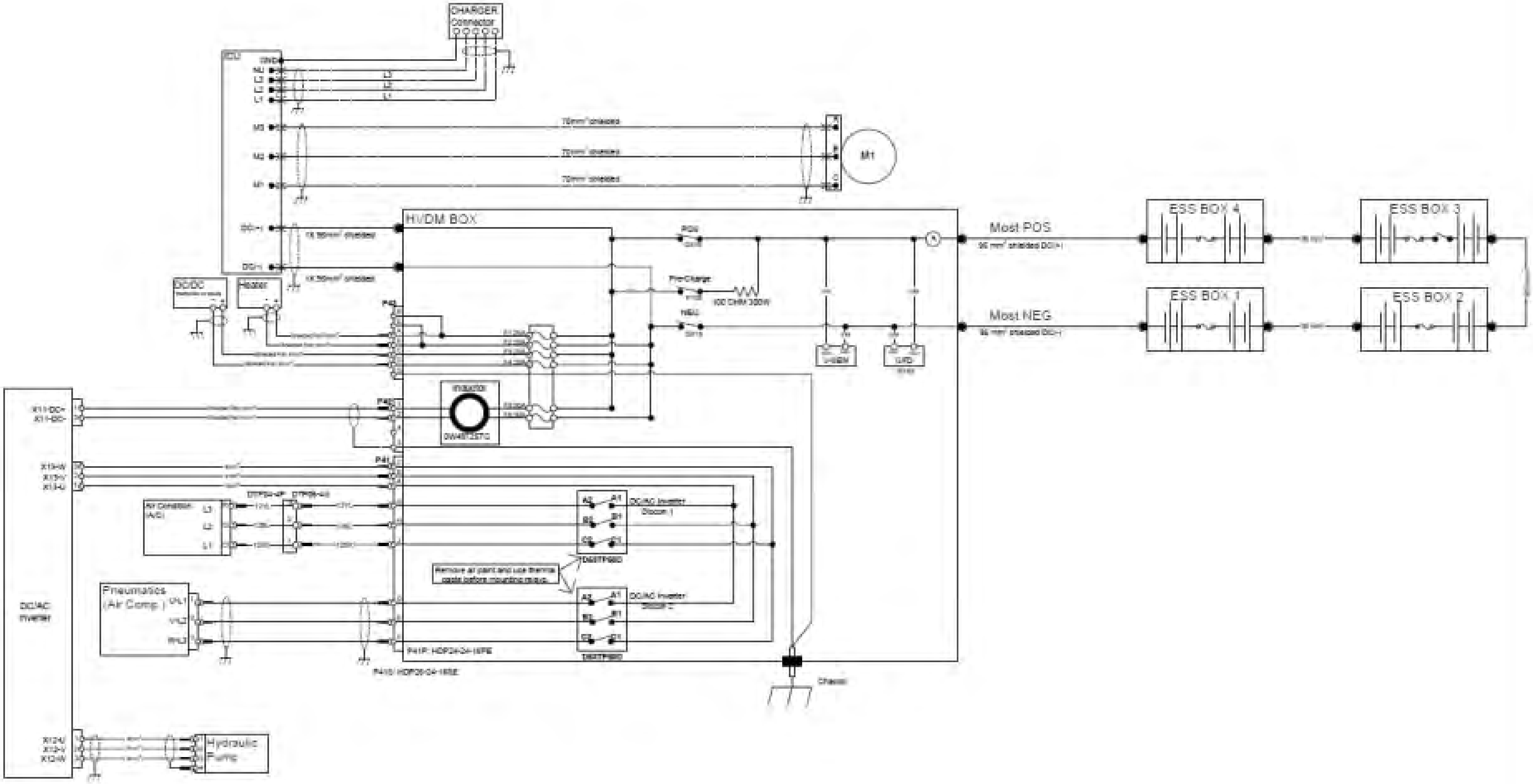
HV Electrical LFP



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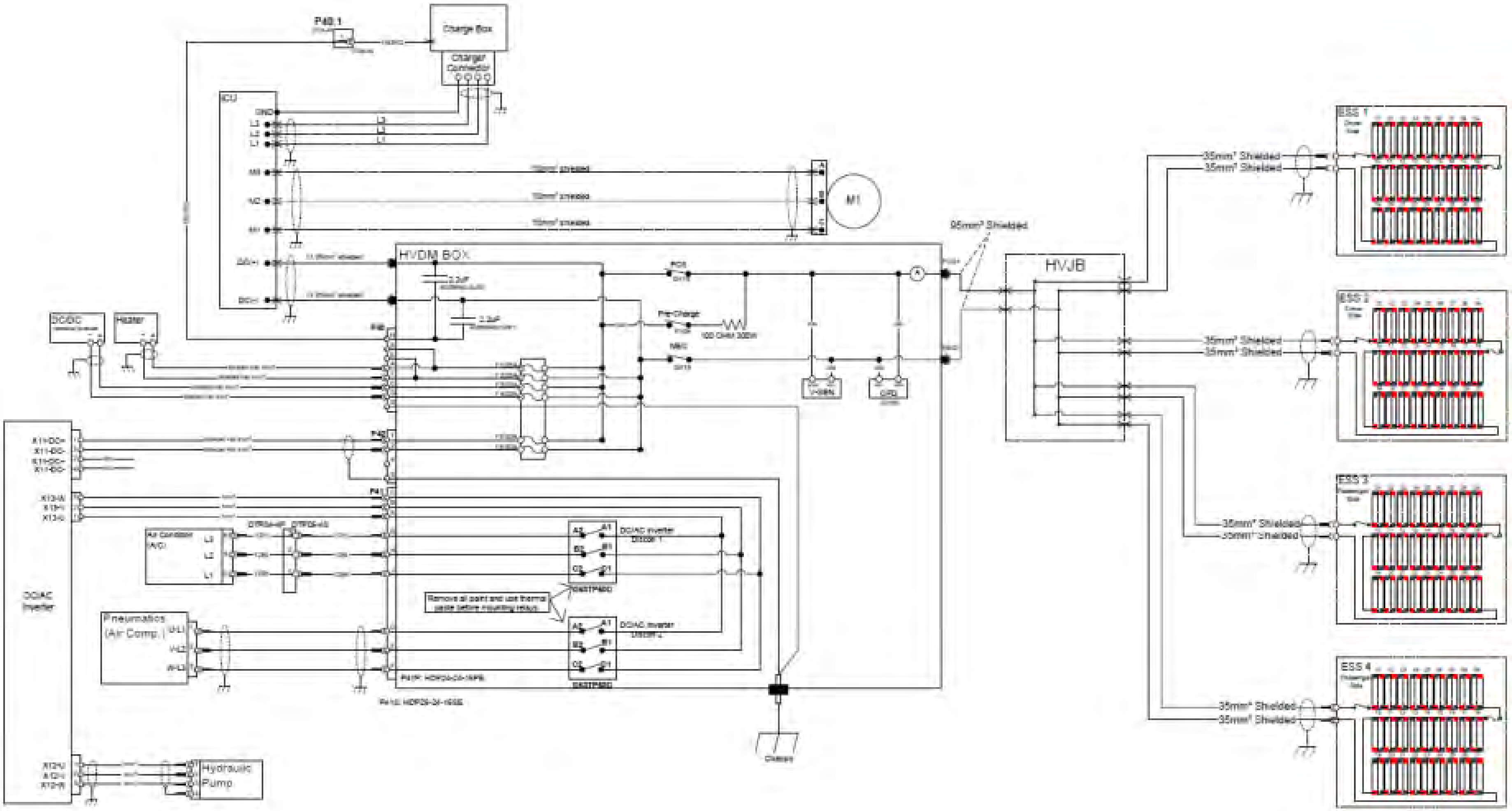
HV Electrical TNMC



TransPower BLUE HORIZON MERITOR

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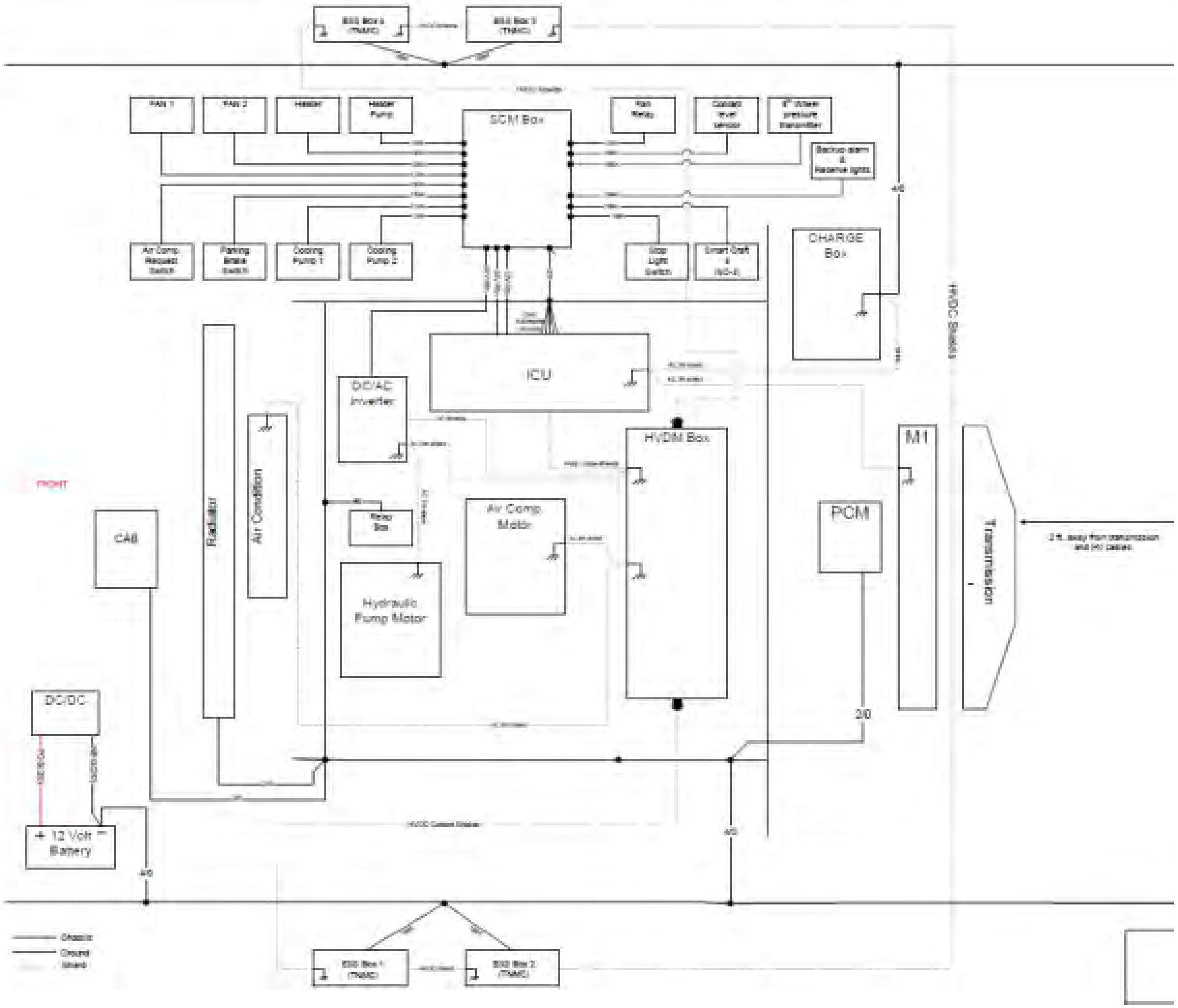
Grounding and Shielding



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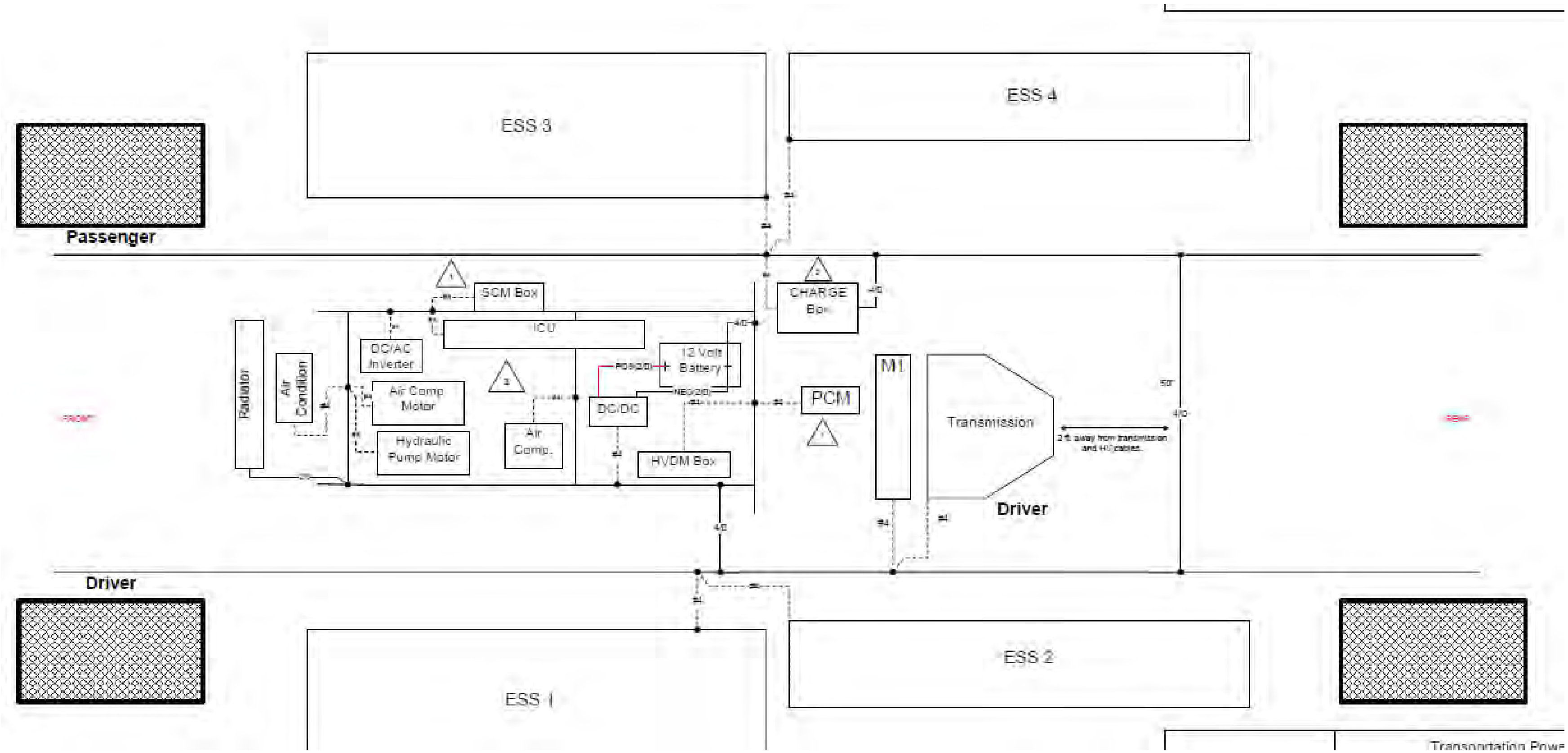
Bonding


ESS 3
ESS 4
Passenger
SCM Box
CHARGE Box
ICU
DC/AC Inverter
Radiator
Air Condition
Air Comp Motor
Hydraulic Pump Motor
Air Comp.
12 Volt Battery
POS(2/0)
NEG(2/0)
DC/DC
HVDM Box
PCM
M1
Transmission
2 ft. away from transmission and HV cables.
50"
4/0
#4
Driver
Driver
ESS 1
ESS 2
FRONT
REAR
Transportation Powe

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Climate Control

- The climate control consist of an electric air conditioning compressor (if applicable) and an electric heating unit.
  - Air conditioner compressor s located on the PCAS
    - Behind the ICU
    - Standard filter dryer unit
      - Located on the radiator assy
  - Electric heating unit
    - Provides defrost and cab heat
    - Stand alone unit
      - Has its own coolant system
      - HV heating element
      - LV control circuit
      - LV pump
    - Ties into the standard vehicle heater core

Air Conditioner

- The air conditioner is controlled by the Lenze
  - Shares the pneumatic side
- There is only a single high voltage connection

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Heater

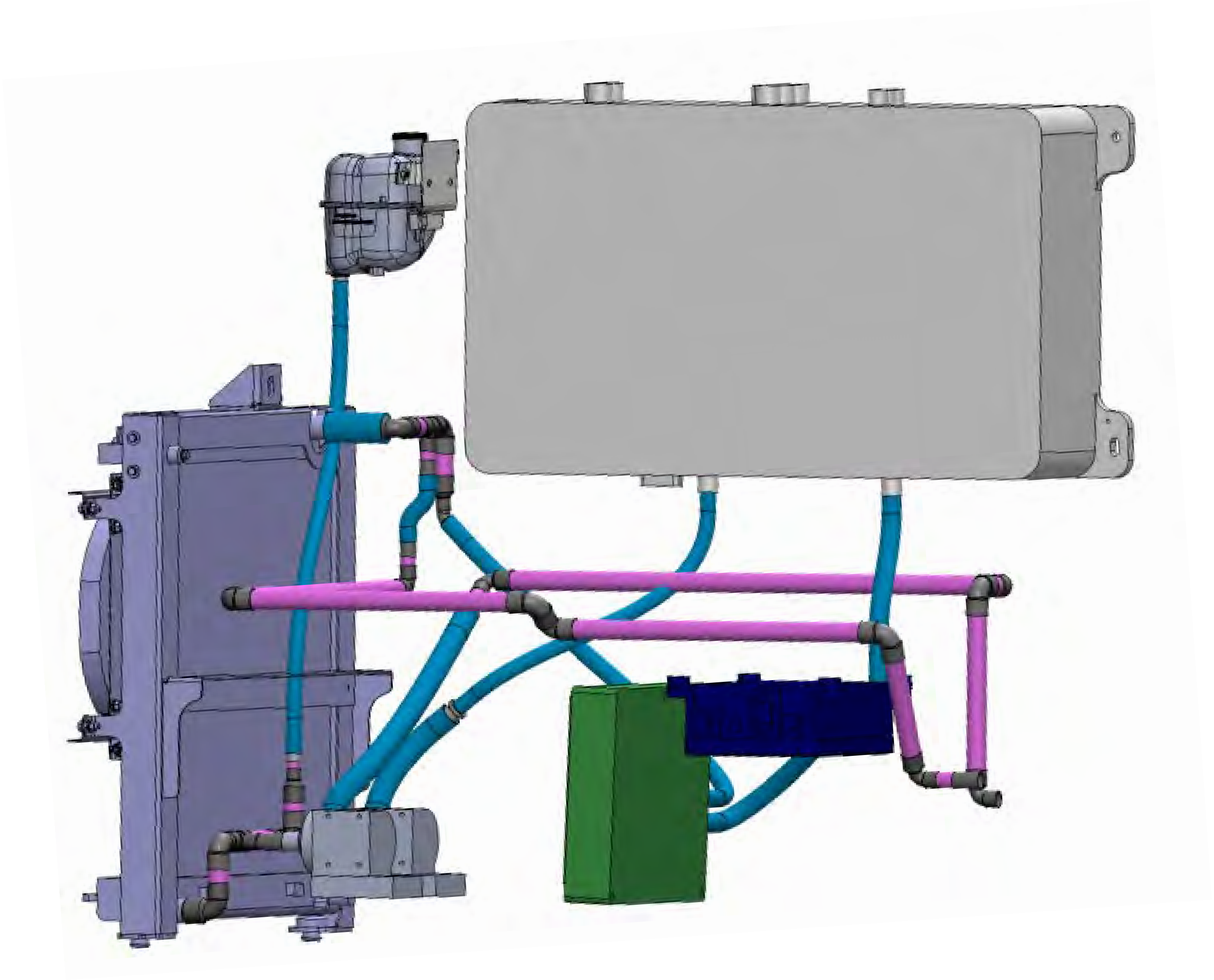
- The heater uses DC high voltage from the HVDM to heat the internal coil
- The internal pump is 12 volt powered
- You may diagnose the pump and enable signal
- Do not stick your finger into the coolant to check for heat, use a temp gun
- The cooling system is separate from the heater coolant system

Cooling System

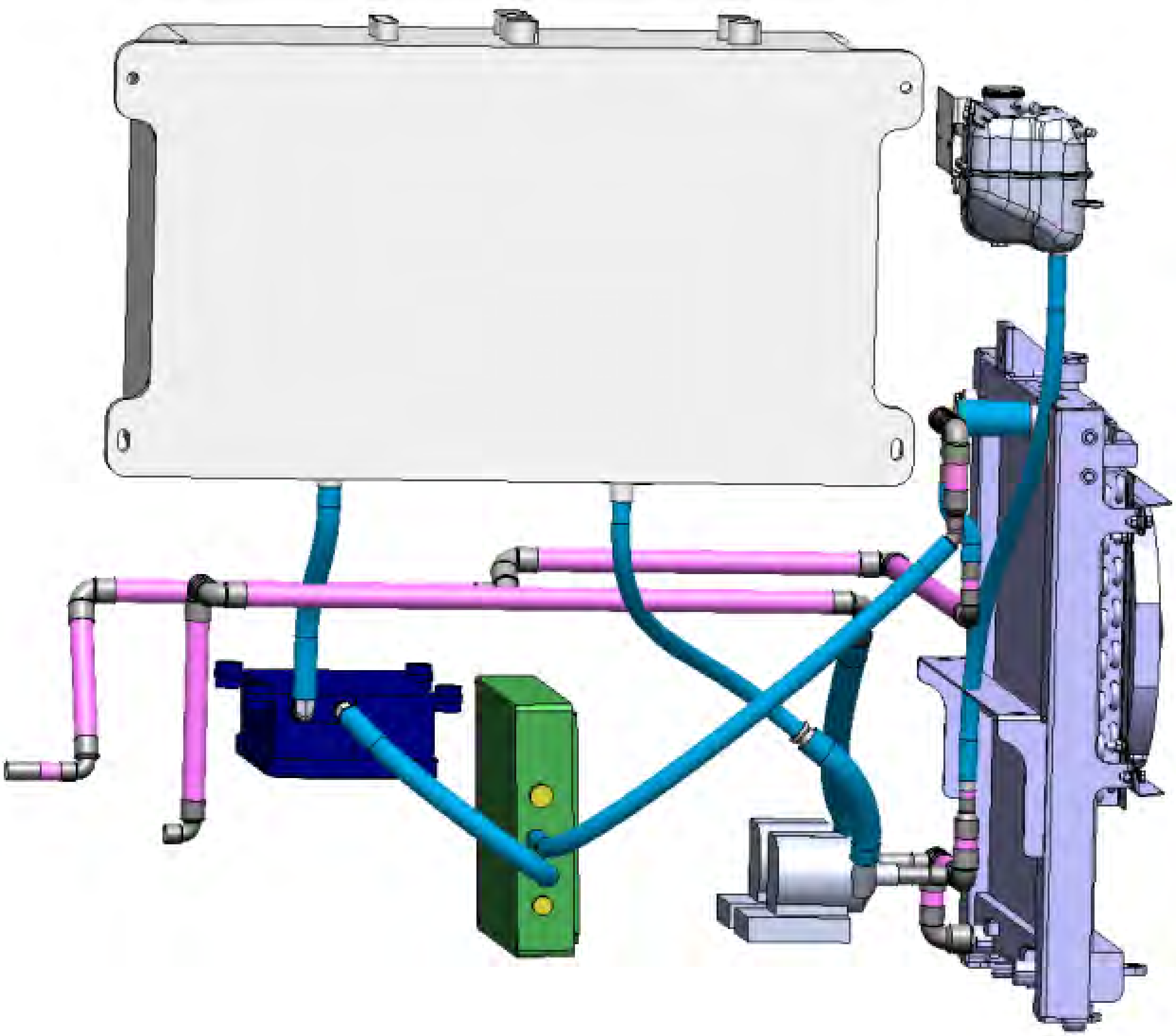
- The electric drive system has two independent cooling loops
  - Inverter cooling uses right pump
    - Radiator, pump, ICU, DC-DC, accessory Inverter (Lenze), radiator
  - Drive motor cooling left pump
    - Radiator, pump, drive motor, radiator
    - Supply right side
    - Return left side

  - This system shares a common radiator that feeds both pumps,
    - The inverter cooling is located on the right side of the PCAS
    - The motor cooling pump is located on the left side of the PCAS

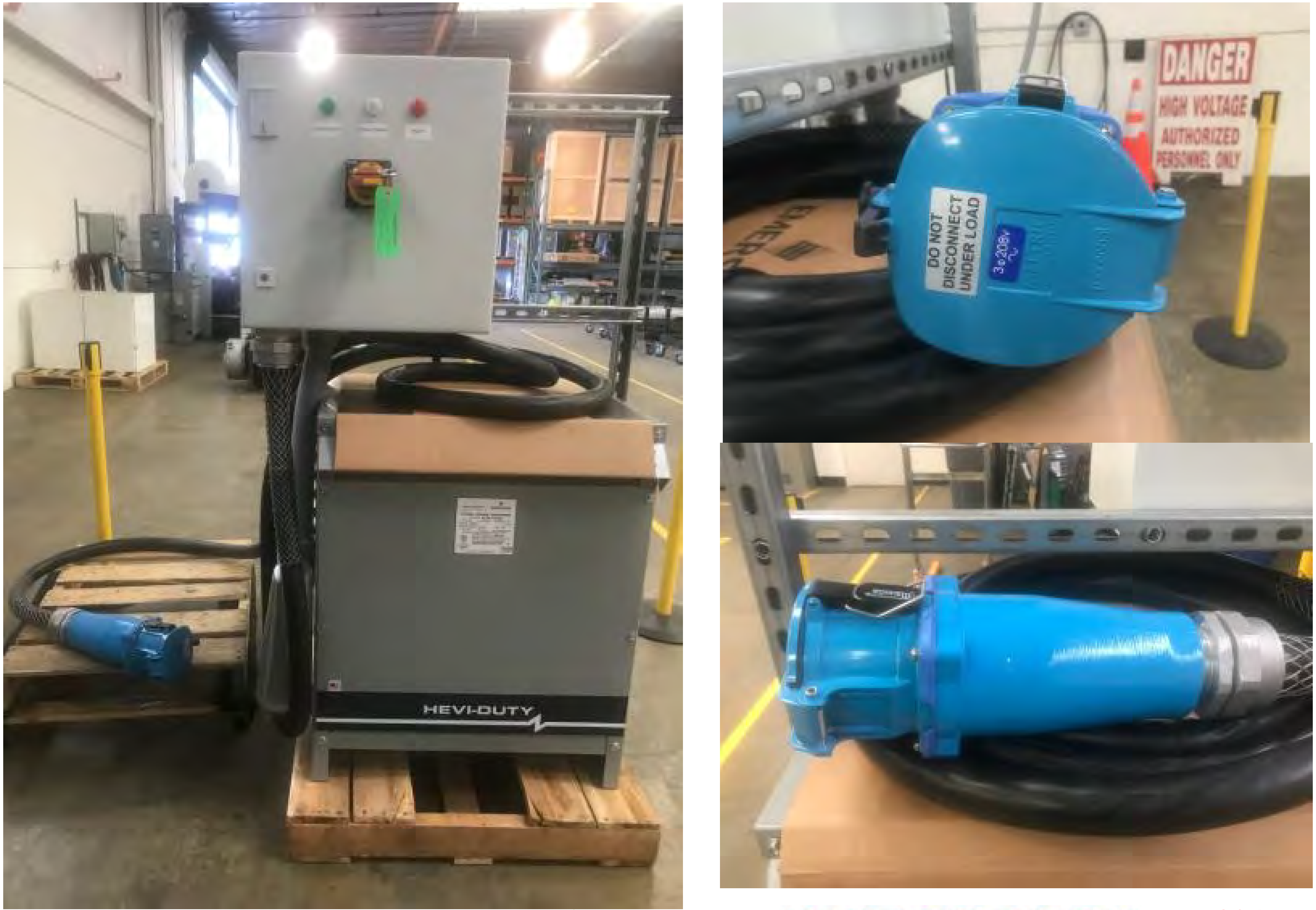
Cooling Loops (Left)



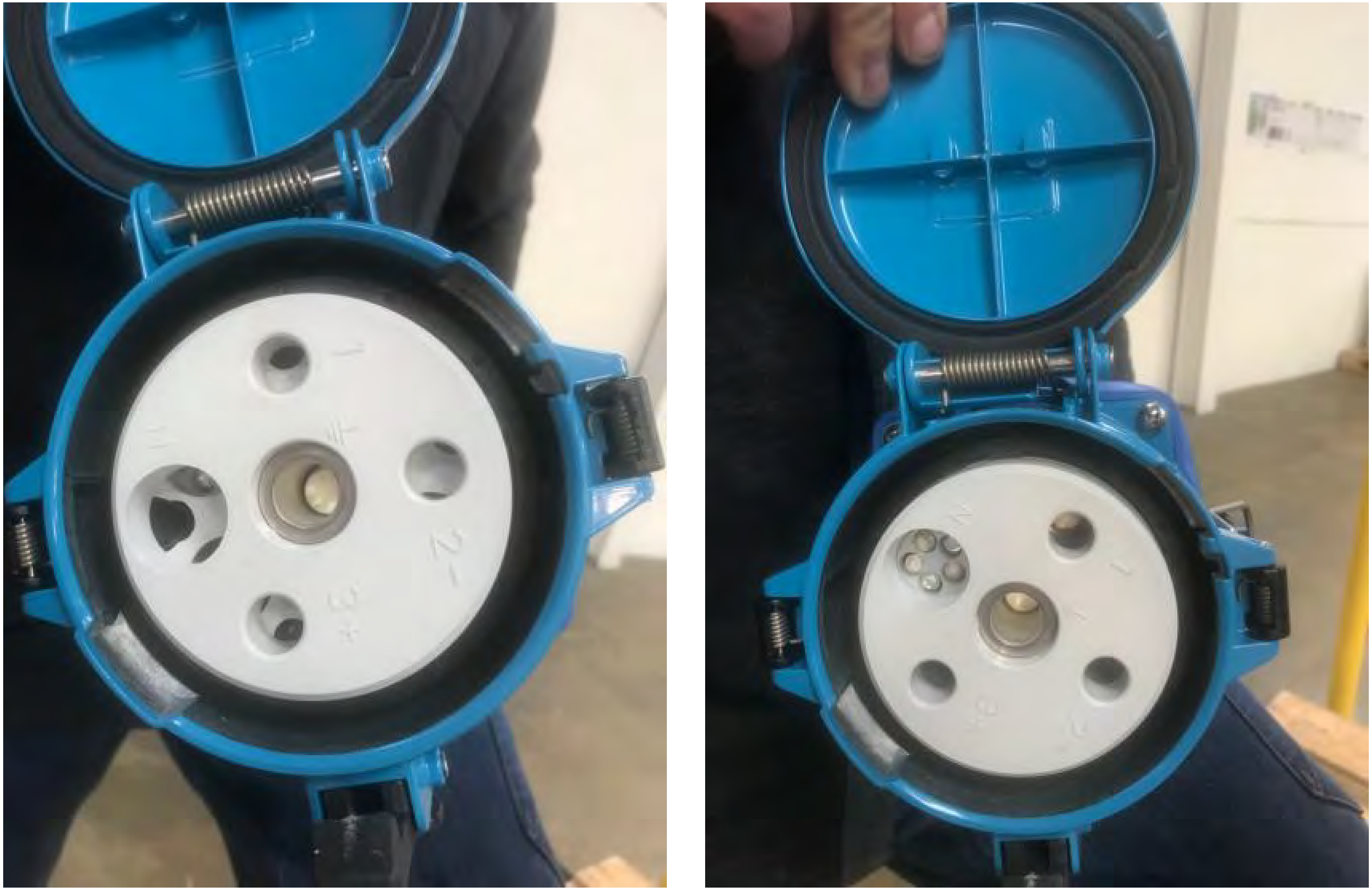
Cooling Loops (Right)



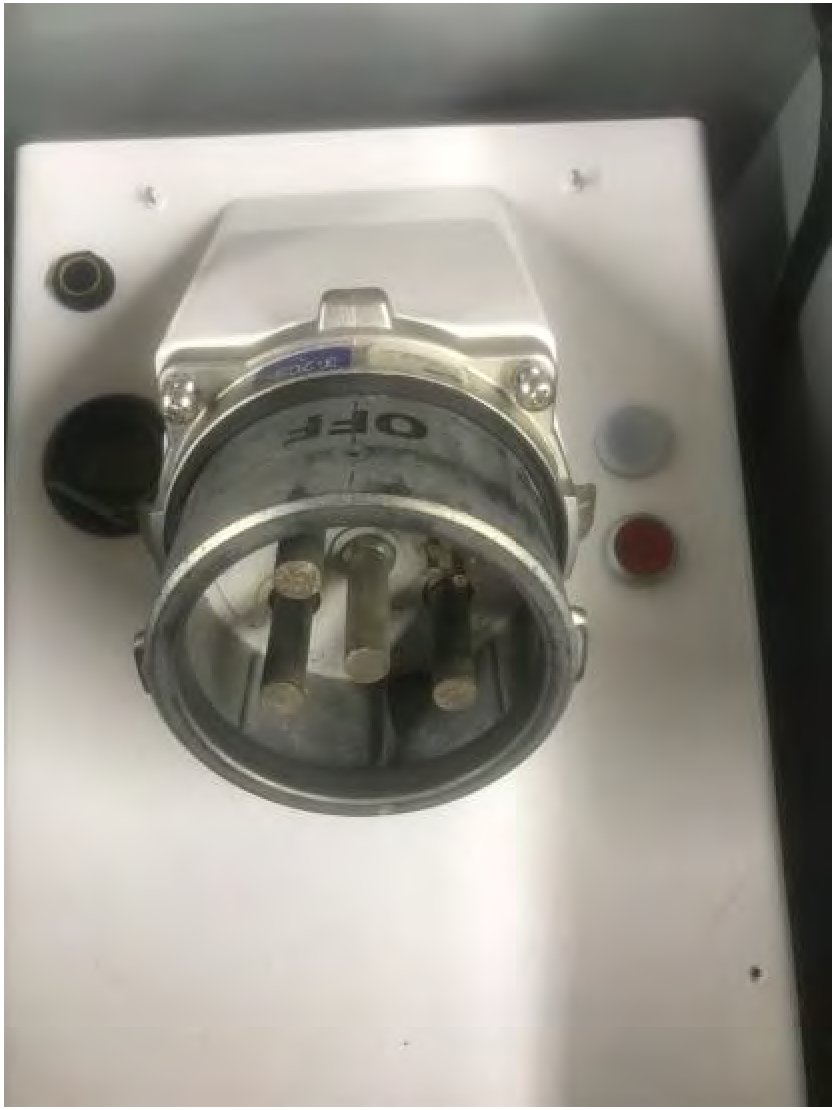
EVSE Charge Station



EVSE Charge Station



Vehicle Side Charge Box



T2E DAILY INSPECTION FORM

KALMAR OTTAWA

TRUCK # ________________ DRIVER NAME ____ DATE _____________

PERFORM THE FOLLOWING

	COMPLETE		COMPLETE		COMPLETE
CHECK BATTERY CHARGE LEVEL		CHECK ENGINE COOLANT LEVEL		CHECK HYDRAULIC TANK OIL LEVEL	
CHECK AIR INTAKE DUCTS		DRAIN WATER FROM AIR TANKS		INSPECT CONDITION OF BATTERY BOXES	

CHECK THE FOLLOWING ITEMS AND INDICATE IF "OK" OR "REPAIR NEEDED". CIRCLE LOCATON ON DRAWINGS IF NECESSARY. DESCRIBE PROBLEMS IN REMARKS AREA AT BOTTOM OF PAGE.

	OK	REPAIR NEEDED		OK	REPAIR NEEDED		OK	REPAIR NEEDED
STEPS / HANDLES / PLATFORMS			STEERING			BACKUP LIGHTS		
STARTER			THROTTLE			BRAKE LIGHTS		
NEUTRAL START			BOOM OPERATION			FLOOD LIGHT (S)		
BACKUP ALARM			5TH WHEEL RELEASE			STROBE LIGHT		
HEATER / DEFROSTER / AC			SERVICE BRAKES			MARKER LIGHTS *(IF APPLICABLE)*		
MIRRORS			PARK BRAKE			CAB SUSPENSION / LATCH		
DOORS			HORN(S)			FLUID LEAKS		
WINDOWS			TRAILER AIR LINES			MUD FLAPS / FENDERS		
WIPERS			TRAILER LIGHT CORD			TIRES		
SEAT			HEAD LIGHTS			DAMAGE		
SEAT BELT			SIGNAL LIGHTS					

REMARKS:

T2e Operators Manual Supplement

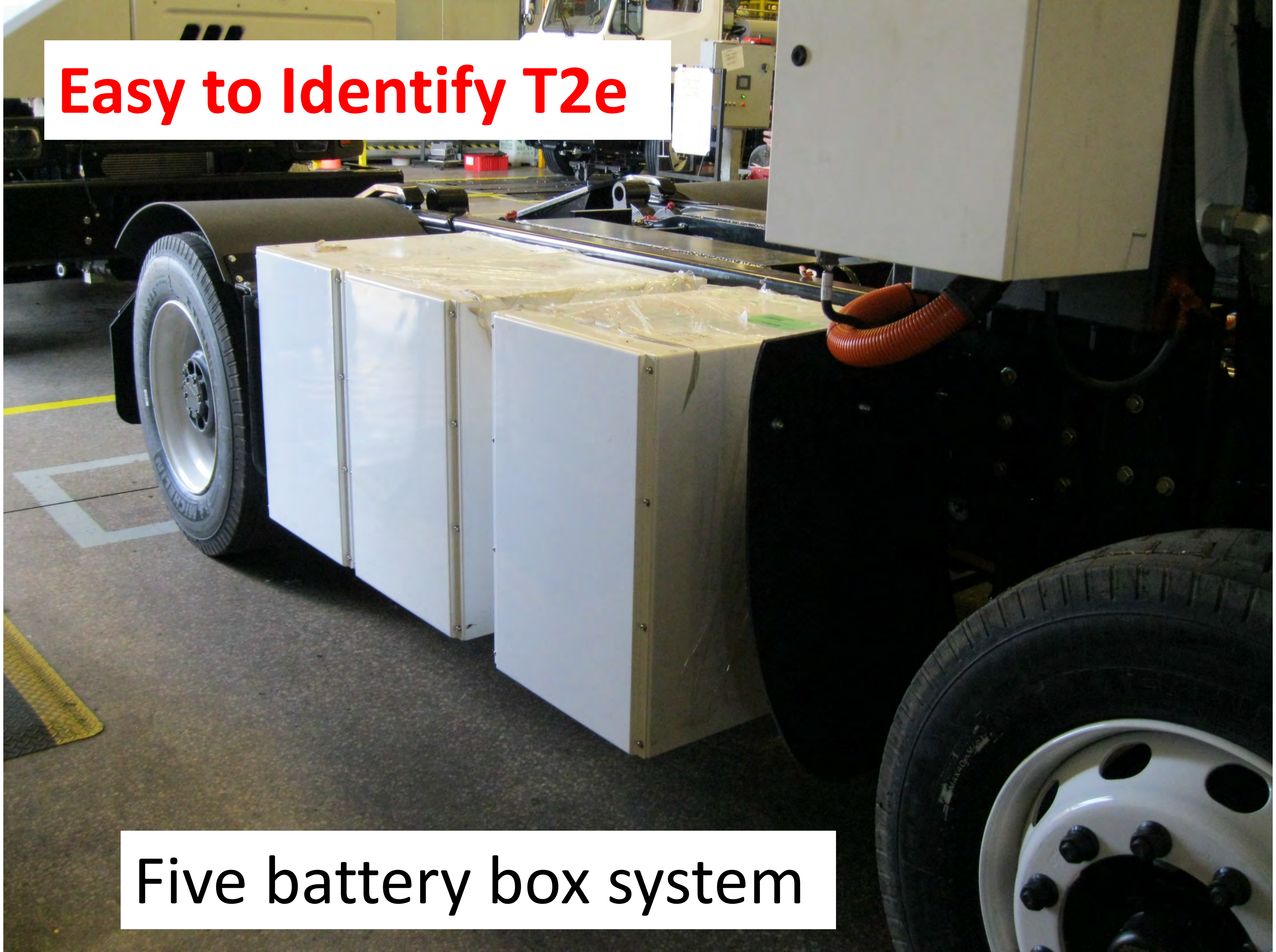
Operators Comfort

- Transparency: The design and concept of the electrical truck is to make it **TRANSPARENT** to the Kalmar diesel truck.
- The operator will see very few change as far as driving the truck, operating controls, daily inspections, options and features, comfort, visibility, and most of all the safety of the truck.
- Operator's may notice how quiet the T2e performs.

T2e Safety

- Orange Cables – High Voltage – In the Operator's Manual, any voltage above 30 volts should be considered potentially dangerous and is referred to as High Voltage.
- As an operator, never touch or mess with an orange wire or cable on the T2e truck.

Easy to Identify T2e



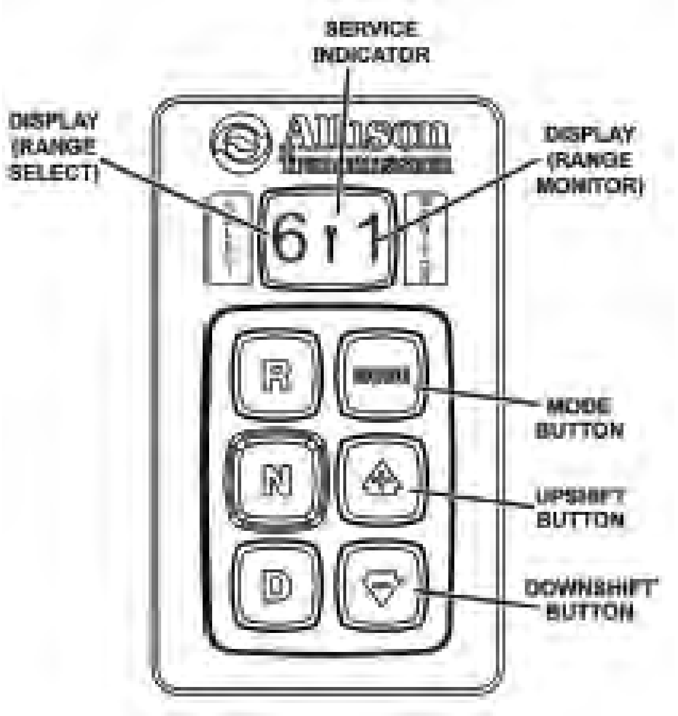
Five battery box system

Vehicle Identification and Operation

- There are many ways to identify an electrical vehicle. If you look at the outside you might see stickers or a vehicle wrap that identifies it as a electric. The battery packs are mounted to the outside of the frame on both sides of truck. On the Kalmar units, if you lift the cab you will notice there is no conventional engine and transmission. The engine has been replaced with electric inverters and three phase electric motors that run the AC, heater, hydraulic unit for steering and boom, air compressor and essential components.

How it works

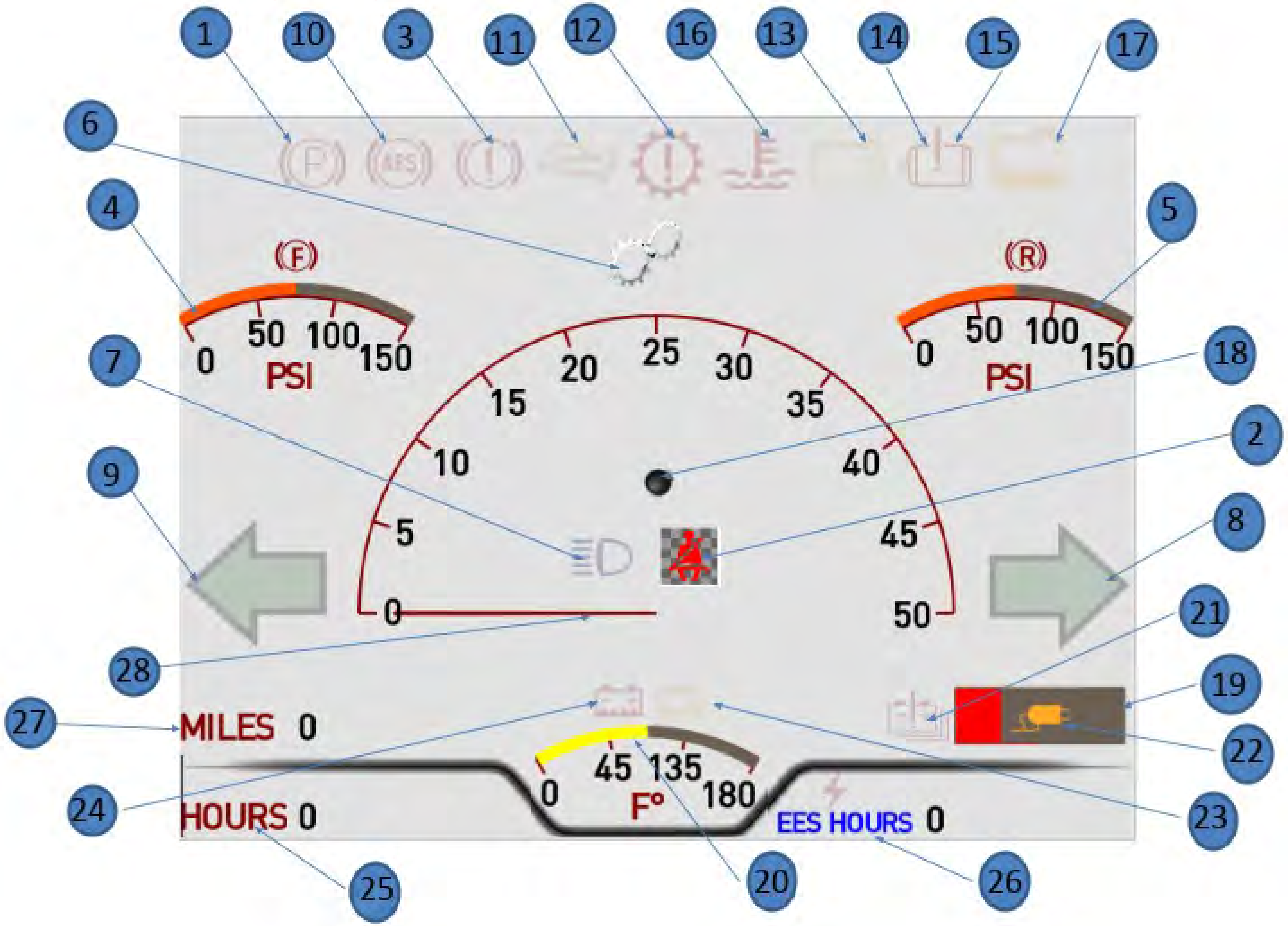
- The Kalmar T2e utilizes High Voltage Batteries to run electric motors to power the rear drivetrain, and all the accessories.
- All the shifting is controlled through the standard Allison push button shift pad.
- Operator’s will need to charge the High Voltage batteries at every opportunity. Breaks, lunch and in between shifts.



Allison push button shifter

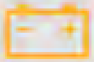
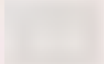
Opportunity Charging

Dash Display Index

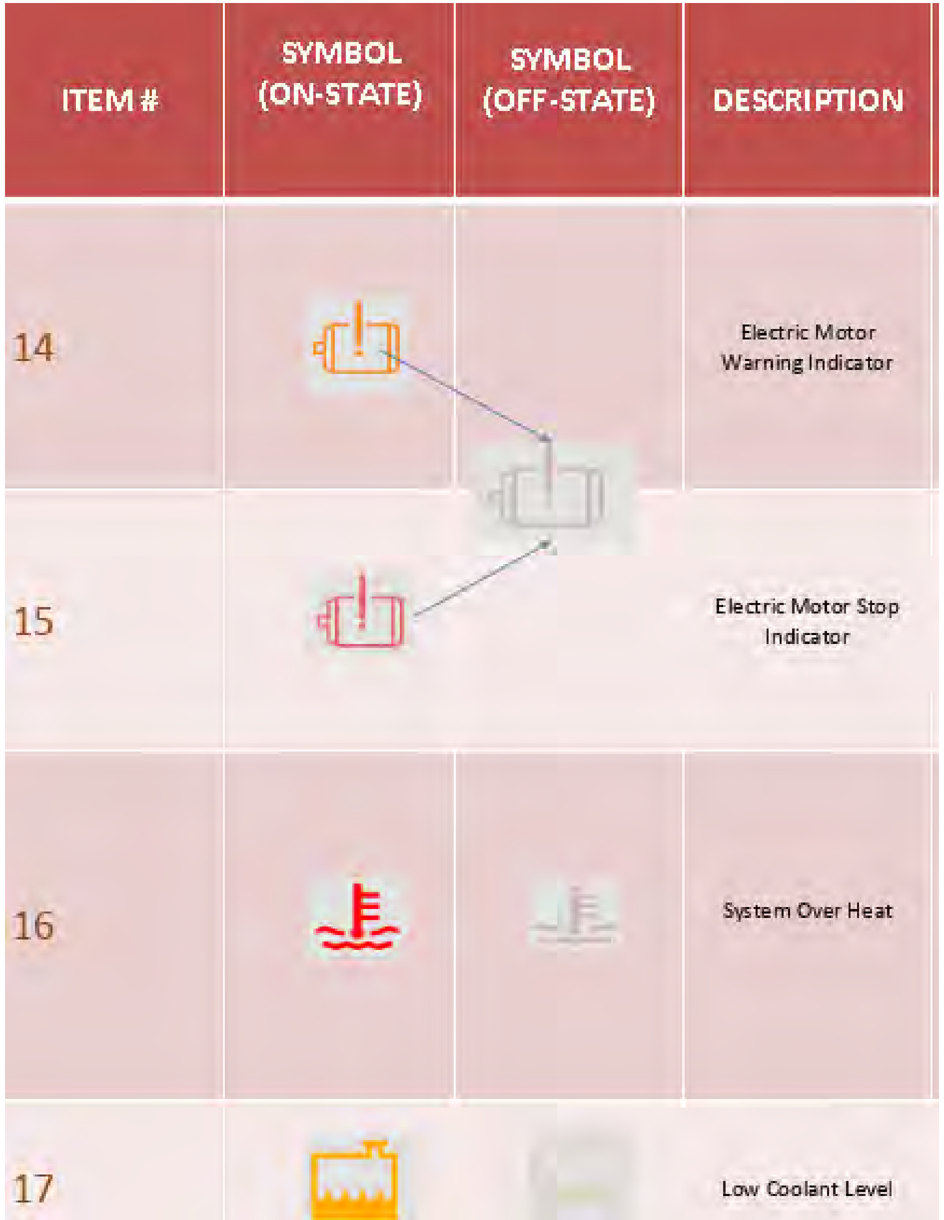


Dash Display Features

ITEM #	SYMBOL (ON-STATE)	SYMBOL (OFF-STATE)	DESCRIPTION
1	(P)	(P)	Park Brake lamp
2		Hidden Image	Seat belt
3	(!)	(!)	Low Air Warning Lamp
4	(F) 0 50 100 150 PSI	(F) 0 50 100 150 PSI	Front Air Pressure Gauge
5	(R) 0 50 100 150 PSI	(R) 0 50 100 150 PSI	Rear Air Pressure Gauge
6		Current Gear Status	Transmission Gear
7	≣D	≣D	High Beam

ITEM #	SYMBOL (ON-STATE)	SYMBOL (OFF-STATE)	DESCRIPTION
8	➡	➡	Right Turn signal
9	⬅	⬅	Left Turn Signal
10	(ABS)	(ABS)	ABS/EBS Amber Warning Signal (Powered Vehicle)
11			Service Indicator
12			Transmission Error
13			High Voltage Energy Storage Discharge Power

Dash Display Features



ITEM #	SYMBOL (ON-STATE)	SYMBOL (OFF-STATE)	DESCRIPTION
14			Electric Motor Warning Indicator
15			Electric Motor Stop Indicator
16			System Over Heat
17			Low Coolant Level

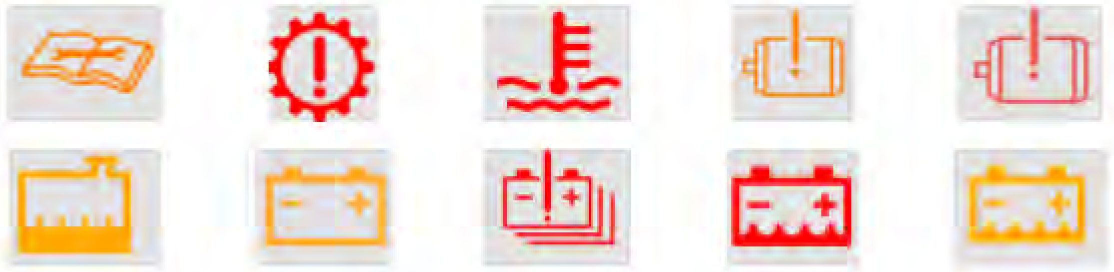
ITEM #	SYMBOL (ON-STATE)	SYMBOL (OFF-STATE)	DESCRIPTION
18	●	●	Propulsion System Active
19			Battery Pack Remaining Charge
20	0 45 135 F° 180	0 45 135 F° 180	Battery Highest cell Temperature
21		Hidden Image	Charging Error

Dash Display Features

ITEM #	SYMBOL (ON-STATE)	SYMBOL (OFF-STATE)	DESCRIPTION
22		Hidden Image	HVES1 Internal Charger Status
23		Hidden Image	HVES1 Discharge Power Limit Due to Battery Temperature
24		Hidden Image	High battery cell temperature

ITEM #	SYMBOL (ON-STATE)	SYMBOL (OFF-STATE)	DESCRIPTION
25	DISPLAYING TOTAL BATTERY HOURS	HOURS 0	Battery Hours Meter
26	DISPLAYING TOTAL TRUCK HOURS	EES HOURS 0	Truck Hour Meter
27	Displaying Actual Traveled Distance	MILES 0	Total vehicle distance
28	Displaying actual speed		Wheel-Based Vehicle Speed

If any of these indicators are lit, please contact one of the following people:

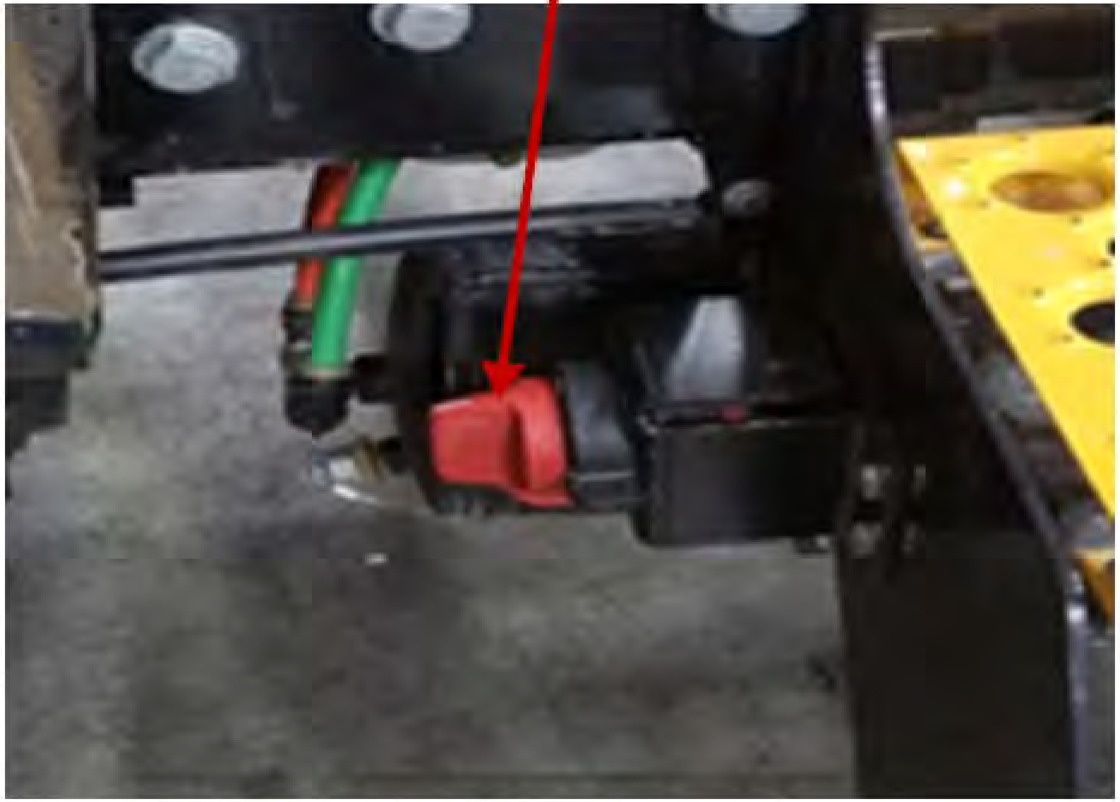


1. Harry Meyer
   Vice President, Manufacturing
   TransPortation Power Inc.
   Office: +858-842-2167
   Mobile: +619-922-5216
   Harry@transpowerusa.com

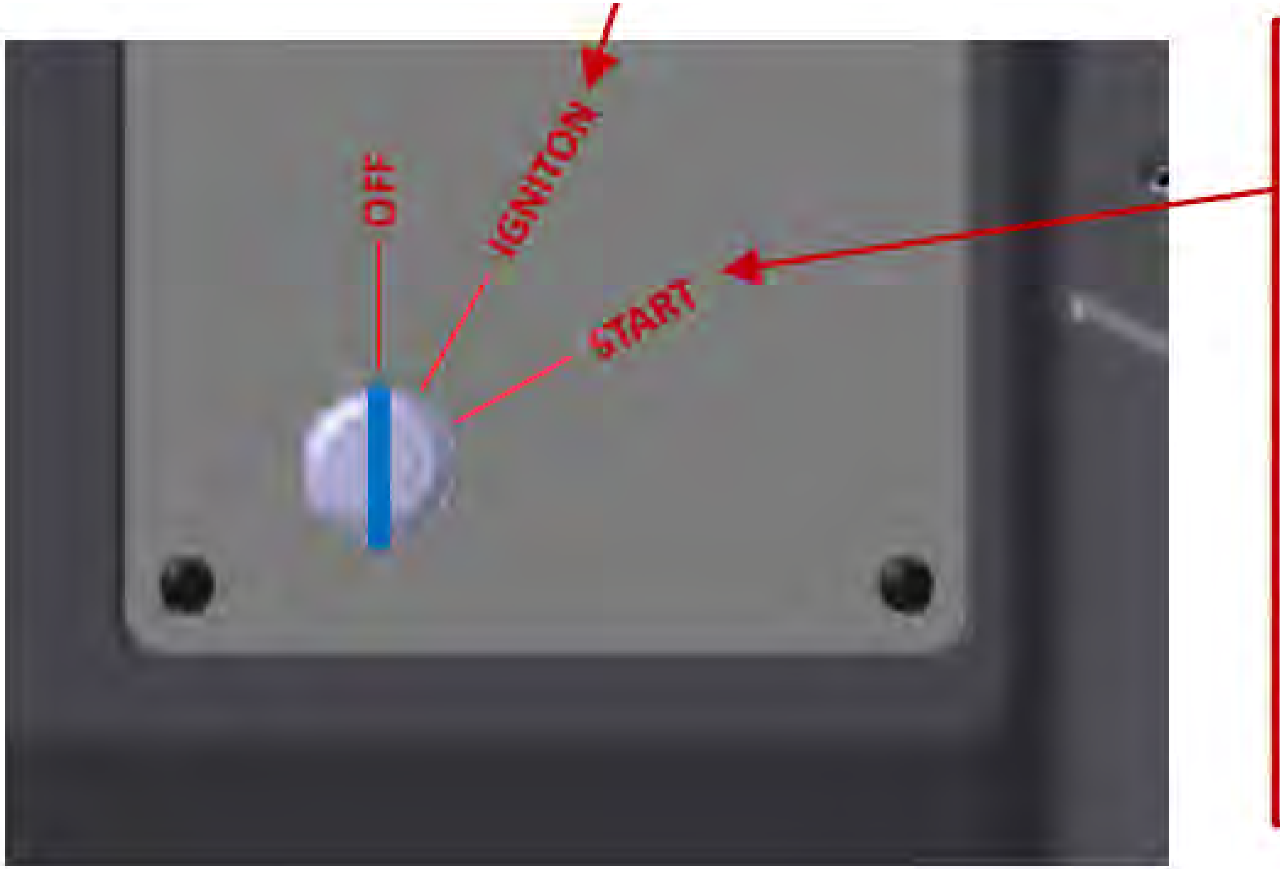
2. Warren Chase
   Field Service Representative
   Office: 785.229.7126
   Warren.chase@kalmarglobal.com

Kalmar T2e Start Up Procedures

1) Make sure the battery disconnect switch is in the on position.



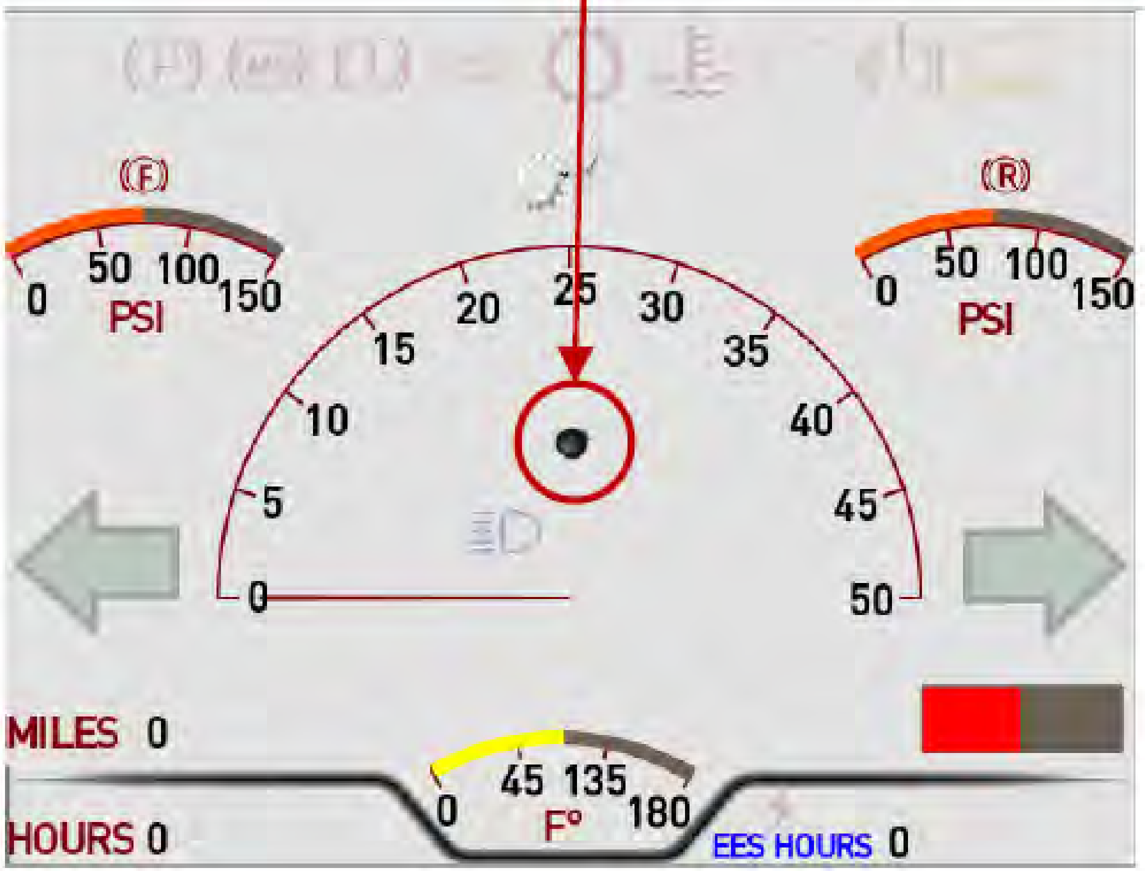
T2e Start Up



2) Turn the ignition switch to the second position ("START") and release. This activates the high voltage electrical systems on the tractor.

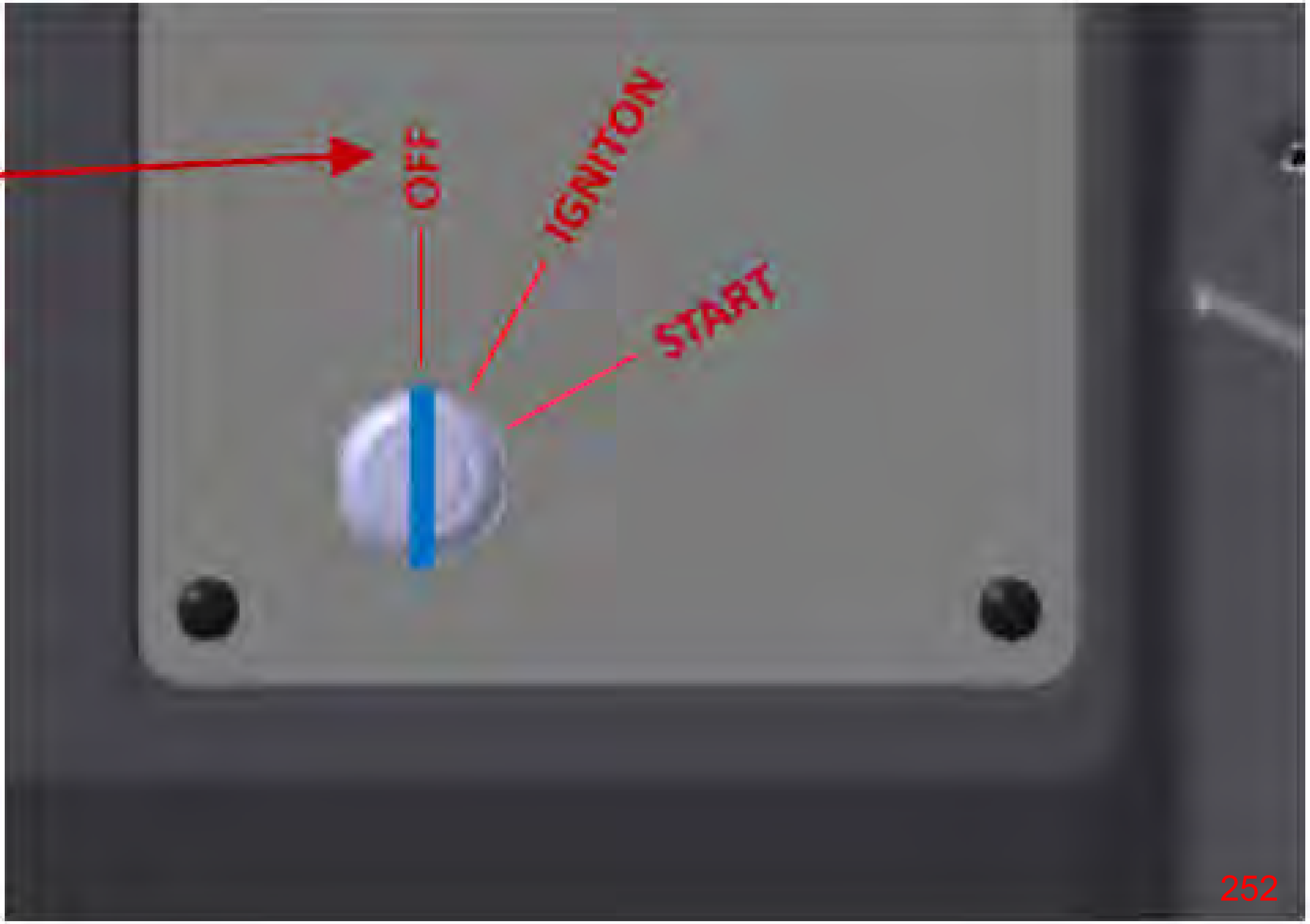
T2e Start Up

3) Once this indicator turns “GREEN”, a gear selection can be made and the tractor can be put into motion.



Shutdown Procedure

1. Turn the ignition switch to the "OFF" position .



T2e Charging Procedures

1. The red switch must be on during the charging mode. This switch should only be turned off if the truck is going to be down for several days.

2. Open the charge box on the right side of the truck.

   Used the provided key to unlock the door.

3. Inside the charge box is the socket the charge cord will plug into.

4. Open the cover on the charge cord, hold open while inserting the charge cord into the socket by lining up the 2 slots, turn right until it stops. Push in with a little force until it bottoms out. Use the 2 lever locks to keep in place.

5. The charge station has a red and yellow disconnect switch. The red switch should always be on unless the truck isn't going to be in use for several days.

6. With the switch on, the GREEN LIGHT should illuminate. After approximately 90 seconds the WHITE LIGHT will illuminate.

7. Check the box on the side of the truck. After about 90 seconds the WHITE LIGHT and the PERCENTAGE GAUGE will illuminate. During the charge process, the white light should be flashing.

8. Charging is in process. Depending on the SOC (State Of Charge), it may take 2-4 hours to complete the cycle.

9. If the truck must be returned to service before it has fully charged, the charging process may be stopped by pushing the red button. "Opportunity charging" during breaks would be an example of the use of this.

10. When the batteries have reached their full state of charge the WHITE LIGHT and the PERCENTAGE GAUGE will not be illuminated.

1.

Before disconnecting the charge cord, make sure the WHITE LIGHTS are off on both boxes. This indicates that there is no power on the charge cord.

2.

Push the red button on the bottom of the head of the cord to unlock. Than unlatch the side locks.

Pull cord off the socket and return cord to the charge station. Close door on charge box on truck.

3. If the unit is not going to be used soon after the charging is complete, turn “OFF” the disconnect switch on the left step of truck.

TransPower® **Feel the POWER!**

HD EV Charging Station

Station Specifications:

Grid (AC) Input Voltage	208VAC or 480VAC, 3 phase (Using Step Down Transformer)
Grid (AC) Current Rating	194A @ 208VAC or 84A @ 480VAC (w/ XFMR)
EVSE Console Dimensions / Weight	20” x 20” x 15” / ~70 lbs,
Power Rating	70 kVA (kW)
EVSE Internal Protection	250A load + Ground Fault Detection / Interrupt
Recommended AC Grid Circuit Protection	250A (208VAC) or 125A (480VAC)
Charge Cable Length / weight	15 feet (25’ or 40’ optional) / ~100 pounds

Features:

- Safe, reliable Electric Vehicle Supply Equipment (EVSE) for AC connection of Heavy Duty Electric and Plug-In Hybrid Trucks and Buses
- Finger-safe, marine grade twist lock connector
- Wall, pedestal or transformer mounting optional
- 480VAC Delta-Wye Step-Down / Isolation Transformer optional
- Cable Management System optional
- Able to power multiple EVSE Consoles of a single larger 480VAC-208VAC transformer
- All UL rated equipment inside
    - Site System UL Certification available upon request; Console UL certification expected in 2018
- Built in manual disconnect w/lockout-tagout

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info@transpowerusa.com · www.transpowerusa.com · (858) 449-4629

C-PORT Final Report

Appendix B: Taylor Top Handler Final Report

The California Air Resources Board - G16-DEMO-003
Off-Road Advanced Technology Demonstration Project Grant
C-PORT, Port of Long Beach

Final Equipment Summary Report for Taylor Machine Works, Inc.

Taylor Zero Vehicle Emissions ZLC-906 Loaded Container Handlers

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1.0 PROJECT Overview: Port of Long Beach - ARB POLB C-PORT

The California Air Resources Board ("CARB" or "Grantor"), awarded an Off-Road Advanced Technology Demonstration Project grant, titled the C-PORT project, to City of Long Beach's Harbor Department that included the development of the Taylor Zero Vehicle emissions battery-electric loaded container handler. The Grant Award Number for the Grant is G16-DEMO-003.

Project Description: The objectives of the Grant are to design and field demonstrate off-road advanced technologies for three (3) battery-electric top handlers. Subgrantee (Taylor's) portion of the Project involves the design, manufacturing and demonstration of three (3) battery-electric top handlers with requirements set forth in the Scope of Work.

2.0 PROJECT Goals:

The goal of this task is to plan, design, and build three zero-emission top handlers for demonstration at Long Beach Container Terminal (1) and SSA Marine (2) and provide associated BYD charging stations. Taylor partnered with BYD to… Below is the report on efforts for the Taylor zero-emission top handlers project. The following key efforts were undertaken to complete the design and manufacture of the zero-emission (ZE) top handlers:

- Review vehicle build specifications and functional requirements.
- Finalize engineering bill of materials (BOM) and order components for each vehicle.
- Design, fabricate, and build vehicle, components, systems, and subsystems.
- Conduct tests, certifications, quality checks, and validations for vehicle components, systems, subsystems, and safety elements.
- Conduct drivability testing, visual quality assurance, final road or operational test, and pre-delivery test.
- Obtain sign-off authorization to release truck, commission the demonstration vehicles, and deliver vehicles to the demonstrator
- Provide the required EVSE, by BYD.

As related to the scope of work within the City and Taylor contract, Taylor completed the following tasks:

Task number	**Task**	**Completion date**
Task 3.1a	Attend Initial Kick-Off Meeting	October 26, 2018
Task 3.1b	Battery-Electric Top Handler Project Management	Monthly through July
Task 3.1c	Battery-Electric Top Handler Design	September 05, 2018

Task 3.1d	Battery-Electric Top Handler Component Ordering	June 11, 2019
Task 3.1e	Battery-Electric Top Handler Build	September 05, 2019
Task 3.1f	Provide Charging Infrastructure	December 12, 2019
Task 3.1g	Battery-Electric Top Handler Delivery/Commission/Training	Training November 14, 2019 – SSA Training January 02, 2020 - LBCT
Task 3.1h	Battery-Electric Top Handler Demonstration	SSA: January 27, 2020 - December 31, 2020 LBCT: February 3, 2020 - July 25, 2021
Task 3.1i	Submit Draft & Final Reports/Attend Final Meeting	Completed at the C-PORT project close-out meeting, August 10 2021

This Final Equipment Summary Report provides a summary of the items listed above for three zero-emission top handlers. These top handlers, designed and built for demonstration at LBCT and SSA, have identical design specifications and functional capabilities (Unit 43144 at LBCT had Air Conditioning and Over height Lugs installed in the field after delivery). The below discussion applies to the following three units:

- **Taylor ZLC-906, Serial Number 43144, delivered August, 2019 (LBCT).**
- **Taylor ZLC-906, Serial Number 43145, delivered September, 2019 (SSA Marine).**
- **Taylor ZLC-906, Serial Number 43146, delivered September, 2019 (SSA Marine).**

Unit ID# **Serial Number 43144, delivered August, 2019 (LBCT).**

TAYLOR MACHINE WORKS, INC.
LOUISVILLE, MISSISSIPPI, U.S.A.

MODEL: [illegible] TYPE: [illegible] SERIAL NO: [illegible] YEAR: [illegible]

BASIC MODEL CAPACITY [illegible] LBS. @ [illegible] " LOAD CENTER

SAFE WORKING CAPACITY WITH EQUIPPED OPTIONS:

[illegible] LBS. @ [illegible] " LOAD CENTER -OR-

[illegible] LBS. @ [illegible] " CTR. LOAD TO CTR. DRIVE AXLE UP TO [illegible] " LIFT HEIGHT

SAFE CAPACITY WITH MAST VERTICAL, LOADS LATERALLY CENTERED, EVENLY DISTRIBUTED AND EQUIPPED AS SHOWN. DO NOT OVERLOAD. CAPACITY IS GREATLY REDUCED WHEN MAST IS TILTED FORWARD.

TOTAL VEHICLE WEIGHT [illegible] LBS. (±5%) STEER AXLE WEIGHT 58800 LBS. (±5%)

BATTERY TYPE [illegible] BATTERY MODEL [illegible] NOMINAL VOLTAGE [illegible] V

MAXIMUM AMPERE-HOUR CAPACITY [illegible] AH @ [illegible] HOURS

MIN. WEIGHT OF BATTERIES [illegible] LBS. MAX. WEIGHT OF BATTERIES [illegible] LBS.

TOTAL VEHICLE WEIGHT (WITHOUT BATTERIES) [illegible] LBS. (±5%)

TIRE SPECIFICATIONS

AXLE	SIZE	PLY RATING	PRESSURE
DRIVE	1800X25	40	145
STEER	1800X25	40	145

WHEEL LUG NUT TORQUE PROCEDURE

WHEEL AND MOUNTS REQUIRE RUN-IN PERIOD ON A NEW VEHICLE AND AFTER EACH TIRE CHANGE. TORQUE BEFORE VEHICLE IS PUT IN SERVICE AND EACH 10 HOURS UNTIL WHEELS ARE SEATED. CARE SHOULD BE TAKEN TO KEEP GREASE AND OTHER FOREIGN MATERIAL FROM RIM SEATING SURFACES.

⚠ CAUTION: DO NOT OVERTORQUE.

AXLE	STUD SIZE	WRENCH SIZE	TORQUE-FT. LBS.
DRIVE	M 18 2.0	1 1/16	275
STEER	3/4 10 NC	1 1/16	150

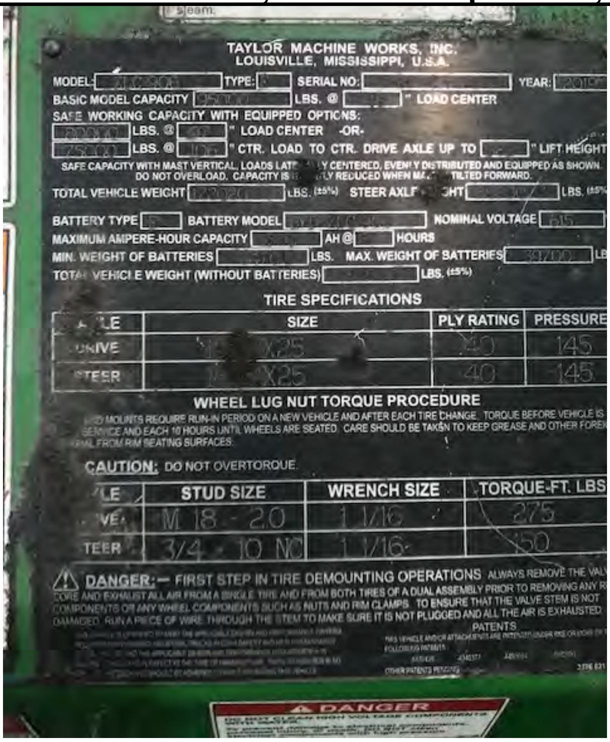
⚠ DANGER: — FIRST STEP IN TIRE DEMOUNTING OPERATIONS. ALWAYS REMOVE THE VALVE CORE AND EXHAUST ALL AIR FROM A SINGLE TIRE AND FROM BOTH TIRES OF A DUAL ASSEMBLY PRIOR TO REMOVING ANY RIM COMPONENTS OR ANY WHEEL COMPONENTS SUCH AS NUTS AND RIM CLAMPS. TO ENSURE THAT THE VALVE STEM IS NOT DAMAGED, RUN A PIECE OF WIRE THROUGH THE STEM TO MAKE SURE IT IS NOT PLUGGED AND ALL THE AIR IS EXHAUSTED.

PATENTS

Source: Taylor Machine Works, Inc.

Source: Taylor Machine Works, Inc.

Unit ID# **Serial Number 43145, delivered September, 2019 (SSA).**



TAYLOR MACHINE WORKS, INC.
LOUISVILLE, MISSISSIPPI, U.S.A.

MODEL: [illegible] TYPE: [illegible] SERIAL NO: YEAR: 2019

BASIC MODEL CAPACITY [illegible] LBS. @ [illegible] " LOAD CENTER

SAFE WORKING CAPACITY WITH EQUIPPED OPTIONS:

[illegible] LBS. @ [illegible] " LOAD CENTER -OR-

[illegible] LBS. @ [illegible] " CTR. LOAD TO CTR. DRIVE AXLE UP TO [illegible] " LIFT HEIGHT

SAFE CAPACITY WITH MAST VERTICAL, LOADS LAT[illegible]Y CENTERED, EVENLY DISTRIBUTED AND EQUIPPED AS SHOWN. DO NOT OVERLOAD. CAPACITY IS [illegible]LY REDUCED WHEN MA[illegible] TILTED FORWARD.

TOTAL VEHICLE WEIGHT [illegible] LBS. (±5%) STEER AXLE [illegible]GHT [illegible] LBS. (±5%)

BATTERY TYPE [illegible] BATTERY MODEL [illegible] NOMINAL VOLTAGE 615

MAXIMUM AMPERE-HOUR CAPACITY [illegible] AH @ [illegible] HOURS

MIN. WEIGHT OF BATTERIES [illegible] LBS. MAX. WEIGHT OF BATTERIES 39700 LB

TOTAL VEHICLE WEIGHT (WITHOUT BATTERIES) [illegible] LBS. (±5%)

TIRE SPECIFICATIONS

[illegible]LE	SIZE	PLY RATING	PRESSURE
[illegible]RIVE	[illegible]X25	40	145
[illegible]TEER	[illegible]X25	40	145

WHEEL LUG NUT TORQUE PROCEDURE

[illegible] MOUNTS REQUIRE RUN-IN PERIOD ON A NEW VEHICLE AND AFTER EACH TIRE CHANGE. TORQUE BEFORE VEHICLE IS [illegible] SERVICE AND EACH 10 HOURS UNTIL WHEELS ARE SEATED. CARE SHOULD BE TAKEN TO KEEP GREASE AND OTHER FOREI[illegible] [illegible] FROM RIM SEATING SURFACES.

CAUTION: DO NOT OVERTORQUE.

[illegible]LE	STUD SIZE	WRENCH SIZE	TORQUE-FT. LBS
[illegible]VE	M 18 - 2.0	1 1/16	275
[illegible]TEER	3/4 - 10 NC	1 1/16	[illegible]50

DANGER: — FIRST STEP IN TIRE DEMOUNTING OPERATIONS ALWAYS REMOVE THE VAL[illegible] CORE AND EXHAUST ALL AIR FROM A SINGLE TIRE AND FROM BOTH TIRES OF A DUAL ASSEMBLY PRIOR TO REMOVING ANY R[illegible] COMPONENTS OR ANY WHEEL COMPONENTS SUCH AS NUTS AND RIM CLAMPS. TO ENSURE THAT THE VALVE STEM IS NOT DAMAGED, RUN A PIECE OF WIRE THROUGH THE STEM TO MAKE SURE IT IS NOT PLUGGED AND ALL THE AIR IS EXHAUSTED.

PATENTS

OTHER PATENTS PENDING

DANGER

Source: Taylor Machine Works, Inc.

Source: Taylor Machine Works, Inc.

Unit ID# **Serial Number 43146, delivered September, 2019 (SSA).**

Source: Taylor Machine Works, Inc.

Source: Taylor Machine Works, Inc.

3.0 Functional Requirements and Technical Specifications:

Below is a summary of the technical specifications and functional requirements for the C-PORT Taylor units.

Taylor Zero-Emission Top Handlers

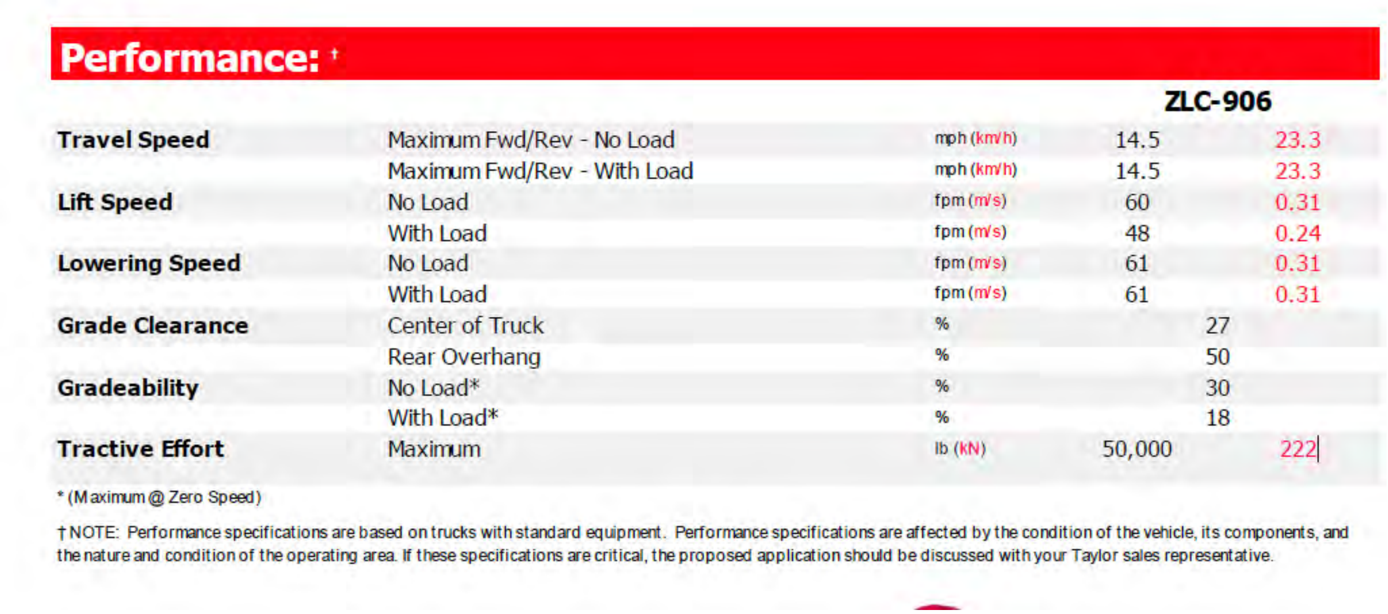
For this project, three zero-emission top handlers were designed and built for demonstration. Since the three top handlers have identical functional capabilities and technical design specifications, the below discussion pertains to all Taylor units.

Equipment review, build specifications and functional requirement tasks were accomplished in the initial stages of Taylor research and development (R&D) normally considered Conceptualization and Feasibility. Taylor uses comprehensive internal processes to document and organize these efforts since they often span the responsibilities of many technical personnel. The Taylor Sales Request for Engineering (SRE) process is the centralized internal process for completing the review of new product development in all project scopes. The process includes human resource workflow controls to organize tasks, document work, and control information flow into other departments such as Accounting for cost feasibility analysis.

To summarize the ZLC equipment review process, Taylor Engineering organized participated in conferences with LBCT and SSA Terminal management, Long Beach Port personnel, Energy Commission personnel, suppliers, users and managers to interview and study work duty cycles, performance requirements, and application requirements to ensure the units met the functional requirements of the project. These functional requirements are the baseline for design and build specifications.

The preliminary design and build specifications are combined with essential safety and functional requirements defined by industry standard practices, design and safety standards, and comprehensive safety reviews. The

ZLC Series was designed to meet or exceed all requirements outlined in OSHA 29 CFR 1910.178 for use, ANSI/ITSDF B56.1 for use and design, and UL 583 for electrical safety and fire prevention.
Below are the functional requirements of the zero-emission (ZE) top handlers. These requirements are comparable to conventional diesel fueled technology and there were no deviations from the base performance requirements for the ZLC-906 design. Taylor reviewed and confirmed these requirements.



Performance: †

			ZLC-906	
Travel Speed	Maximum Fwd/Rev - No Load	mph (km/h)	14.5	23.3
	Maximum Fwd/Rev - With Load	mph (km/h)	14.5	23.3
Lift Speed	No Load	fpm (m/s)	60	0.31
	With Load	fpm (m/s)	48	0.24
Lowering Speed	No Load	fpm (m/s)	61	0.31
	With Load	fpm (m/s)	61	0.31
Grade Clearance	Center of Truck	%	27	
	Rear Overhang	%	50	
Gradeability	No Load*	%	30	
	With Load*	%	18	
Tractive Effort	Maximum	lb (kN)	50,000	222

* (Maximum @ Zero Speed)

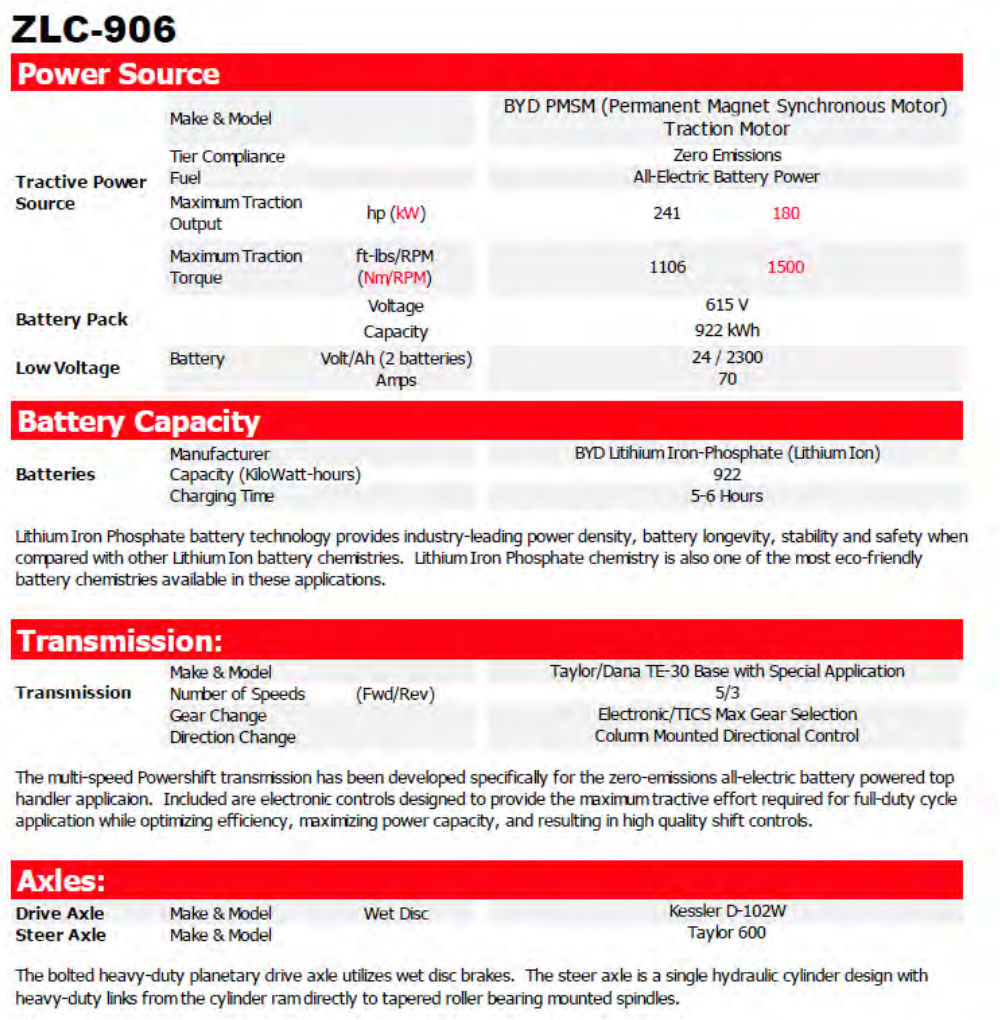
† NOTE: Performance specifications are based on trucks with standard equipment. Performance specifications are affected by the condition of the vehicle, its components, and the nature and condition of the operating area. If these specifications are critical, the proposed application should be discussed with your Taylor sales representative.

DISCLAIMER:

This vehicle is certified to meet the applicable design and performance criteria required for Powered Industrial Trucks in OSHA Safety and Health Standards, Title 29 CFR. Part 1910.178, and the applicable design and performance requirements in ANSI B56.1 and UL 583 that were in effect at the time of manufacture. These standards also apply to the user and should be adhered to while operating this vehicle.

All specifications are subject to change without notice. Some operating data may be affected by the condition of the vehicle, how it is operated and the nature and condition of the operating area. If these specifications are critical, contact the factory.

The following are Taylor’s technical and design specifications for the ZLC-906.



ZLC-906

Power Source

Tractive Power Source	Make & Model		BYD PMSM (Permanent Magnet Synchronous Motor) Traction Motor	
	Tier Compliance		Zero Emissions	
	Fuel		All-Electric Battery Power	
	Maximum Traction Output	hp (kW)	241	180
	Maximum Traction Torque	ft-lbs/RPM (Nm/RPM)	1106	1500
Battery Pack		Voltage	615 V	
		Capacity	922 kWh	
Low Voltage	Battery	Volt/Ah (2 batteries)	24 / 2300	
		Amps	70	

Battery Capacity

Batteries	Manufacturer	BYD Lithium Iron-Phosphate (Lithium Ion)
	Capacity (KiloWatt-hours)	922
	Charging Time	5-6 Hours

Lithium Iron Phosphate battery technology provides industry-leading power density, battery longevity, stability and safety when compared with other Lithium Ion battery chemistries. Lithium Iron Phosphate chemistry is also one of the most eco-friendly battery chemistries available in these applications.

Transmission:

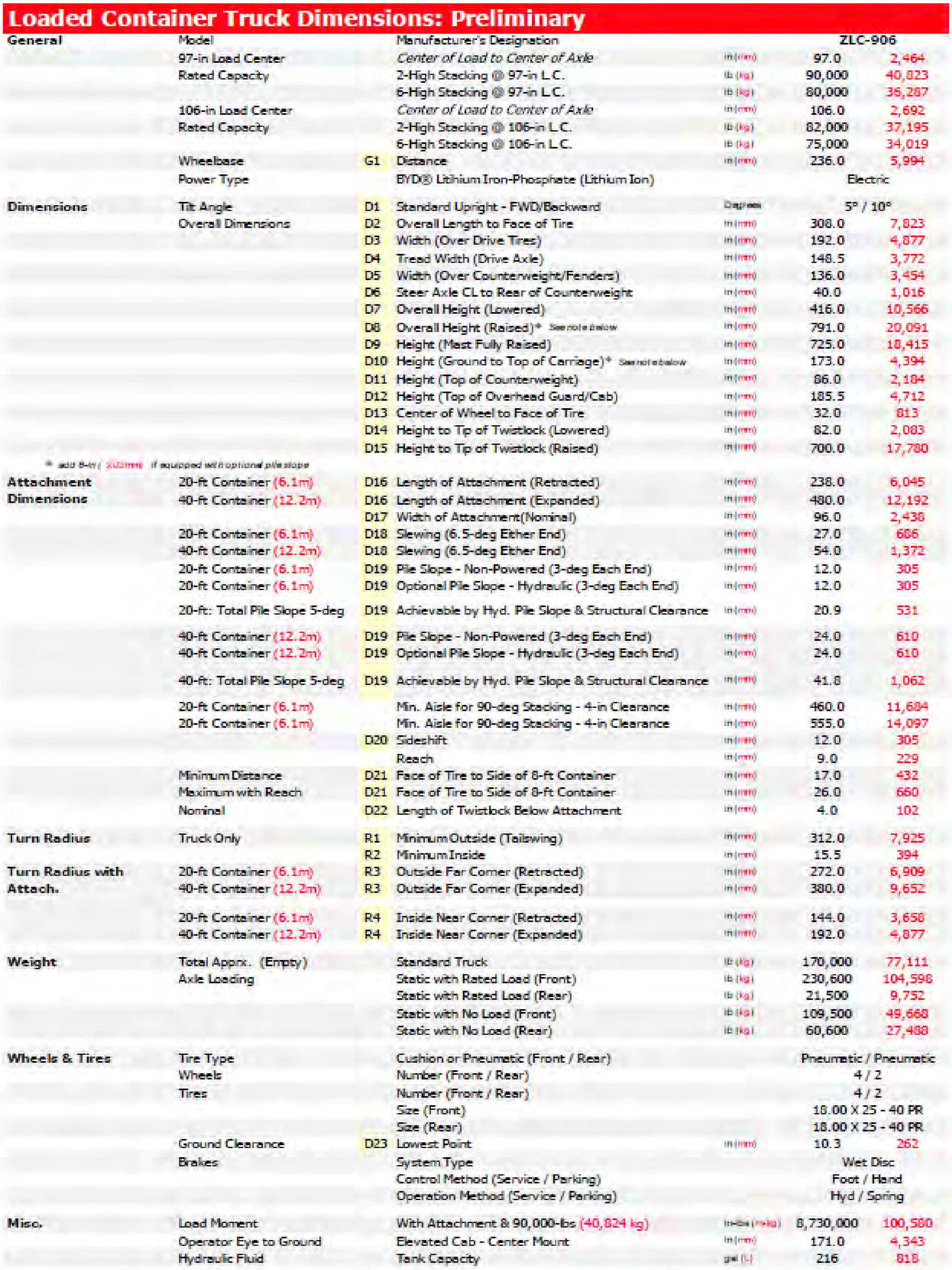
Transmission	Make & Model		Taylor/Dana TE-30 Base with Special Application
	Number of Speeds	(Fwd/Rev)	5/3
	Gear Change		Electronic/TICS Max Gear Selection
	Direction Change		Column Mounted Directional Control

The multi-speed Powershift transmission has been developed specifically for the zero-emissions all-electric battery powered top handler applicaion. Included are electronic controls designed to provide the maximum tractive effort required for full-duty cycle application while optimizing efficiency, maximizing power capacity, and resulting in high quality shift controls.

Axles:

Drive Axle	Make & Model	Wet Disc	Kessler D-102W
Steer Axle	Make & Model		Taylor 600

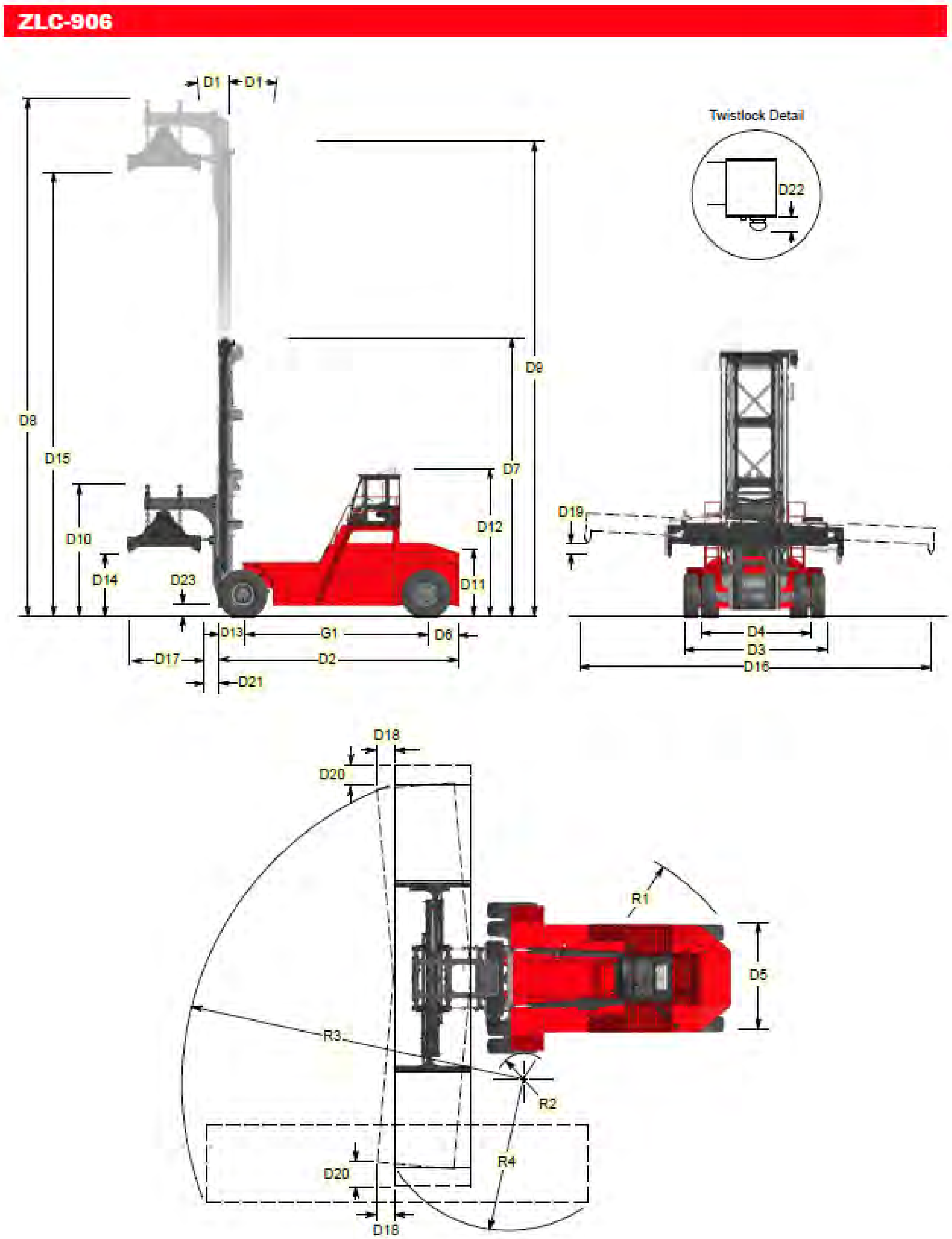
The bolted heavy-duty planetary drive axle utilizes wet disc brakes. The steer axle is a single hydraulic cylinder design with heavy-duty links from the cylinder ram directly to tapered roller bearing mounted spindles.

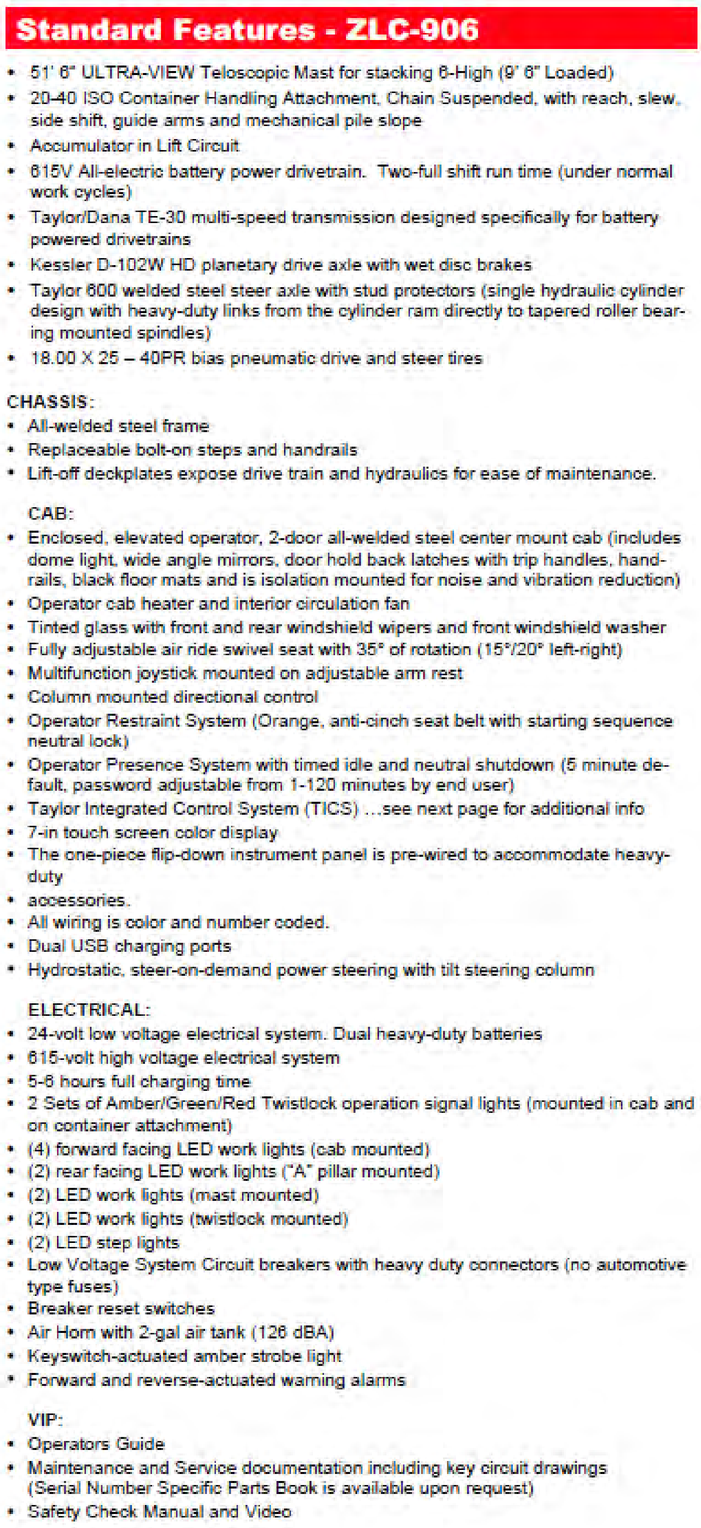


Loaded Container Truck Dimensions: Preliminary

General	Model		Manufacturer's Designation		ZLC-906	
	97-in Load Center		*Center of Load to Center of Axle*	in (mm)	97.0	2,464
	Rated Capacity		2-High Stacking @ 97-in L.C.	lb (kg)	90,000	40,823
			6-High Stacking @ 97-in L.C.	lb (kg)	80,000	36,287
	106-in Load Center		*Center of Load to Center of Axle*	in (mm)	106.0	2,692
	Rated Capacity		2-High Stacking @ 106-in L.C.	lb (kg)	82,000	37,195
			6-High Stacking @ 106-in L.C.	lb (kg)	75,000	34,019
	Wheelbase	G1	Distance	in (mm)	236.0	5,994
	Power Type		BYD® Lithium Iron-Phosphate (Lithium Ion)		Electric	
Dimensions	Tilt Angle	D1	Standard Upright - FWD/Backward	Degrees	5° / 10°	
	Overall Dimensions	D2	Overall Length to Face of Tire	in (mm)	308.0	7,823
		D3	Width (Over Drive Tires)	in (mm)	192.0	4,877
		D4	Tread Width (Drive Axle)	in (mm)	148.5	3,772
		D5	Width (Over Counterweight/Fenders)	in (mm)	136.0	3,454
		D6	Steer Axle CL to Rear of Counterweight	in (mm)	40.0	1,016
		D7	Overall Height (Lowered)	in (mm)	416.0	10,566
		D8	Overall Height (Raised)* See note below	in (mm)	791.0	20,091
		D9	Height (Mast Fully Raised)	in (mm)	725.0	18,415
		D10	Height (Ground to Top of Carriage)* See note below	in (mm)	173.0	4,394
		D11	Height (Top of Counterweight)	in (mm)	86.0	2,184
		D12	Height (Top of Overhead Guard/Cab)	in (mm)	185.5	4,712
		D13	Center of Wheel to Face of Tire	in (mm)	32.0	813
		D14	Height to Tip of Twistlock (Lowered)	in (mm)	82.0	2,083
		D15	Height to Tip of Twistlock (Raised)	in (mm)	700.0	17,780
Attachment Dimensions	20-ft Container (6.1m)	D16	Length of Attachment (Retracted)	in (mm)	238.0	6,045
	40-ft Container (12.2m)	D16	Length of Attachment (Expanded)	in (mm)	480.0	12,192
		D17	Width of Attachment(Nominal)	in (mm)	96.0	2,438
	20-ft Container (6.1m)	D18	Slewing (6.5-deg Either End)	in (mm)	27.0	686
	40-ft Container (12.2m)	D18	Slewing (6.5-deg Either End)	in (mm)	54.0	1,372
	20-ft Container (6.1m)	D19	Pile Slope - Non-Powered (3-deg Each End)	in (mm)	12.0	305
	20-ft Container (6.1m)	D19	Optional Pile Slope - Hydraulic (3-deg Each End)	in (mm)	12.0	305
	20-ft: Total Pile Slope 5-deg	D19	Achievable by Hyd. Pile Slope & Structural Clearance	in (mm)	20.9	531
	40-ft Container (12.2m)	D19	Pile Slope - Non-Powered (3-deg Each End)	in (mm)	24.0	610
	40-ft Container (12.2m)	D19	Optional Pile Slope - Hydraulic (3-deg Each End)	in (mm)	24.0	610
	40-ft: Total Pile Slope 5-deg	D19	Achievable by Hyd. Pile Slope & Structural Clearance	in (mm)	41.8	1,062
	20-ft Container (6.1m)		Min. Aisle for 90-deg Stacking - 4-in Clearance	in (mm)	460.0	11,684
	20-ft Container (6.1m)		Min. Aisle for 90-deg Stacking - 4-in Clearance	in (mm)	555.0	14,097
		D20	Sideshift	in (mm)	12.0	305
			Reach	in (mm)	9.0	229
	Minimum Distance	D21	Face of Tire to Side of 8-ft Container	in (mm)	17.0	432
	Maximum with Reach	D21	Face of Tire to Side of 8-ft Container	in (mm)	26.0	660
	Nominal	D22	Length of Twistlock Below Attachment	in (mm)	4.0	102
Turn Radius	Truck Only	R1	Minimum Outside (Tailswing)	in (mm)	312.0	7,925
		R2	Minimum Inside	in (mm)	15.5	394
Turn Radius with Attach.	20-ft Container (6.1m)	R3	Outside Far Corner (Retracted)	in (mm)	272.0	6,909
	40-ft Container (12.2m)	R3	Outside Far Corner (Expanded)	in (mm)	380.0	9,652
	20-ft Container (6.1m)	R4	Inside Near Corner (Retracted)	in (mm)	144.0	3,658
	40-ft Container (12.2m)	R4	Inside Near Corner (Expanded)	in (mm)	192.0	4,877
Weight	Total Apprx. (Empty)		Standard Truck	lb (kg)	170,000	77,111
	Axle Loading		Static with Rated Load (Front)	lb (kg)	230,600	104,598
			Static with Rated Load (Rear)	lb (kg)	21,500	9,752
			Static with No Load (Front)	lb (kg)	109,500	49,668
			Static with No Load (Rear)	lb (kg)	60,600	27,488
Wheels & Tires	Tire Type		Cushion or Pneumatic (Front / Rear)		Pneumatic / Pneumatic	
	Wheels		Number (Front / Rear)		4 / 2	
	Tires		Number (Front / Rear)		4 / 2	
			Size (Front)		18.00 X 25 - 40 PR	
			Size (Rear)		18.00 X 25 - 40 PR	
	Ground Clearance	D23	Lowest Point	in (mm)	10.3	262
	Brakes		System Type		Wet Disc	
			Control Method (Service / Parking)		Foot / Hand	
			Operation Method (Service / Parking)		Hyd / Spring	
Misc.	Load Moment		With Attachment & 90,000-lbs (40,824 kg)	in-lbs (m-kg)	8,730,000	100,580
	Operator Eye to Ground		Elevated Cab - Center Mount	in (mm)	171.0	4,343
	Hydraulic Fluid		Tank Capacity	gal (L)	216	818

* add 8-in (203mm if equipped with optional pile slope


ZLC-906
D1
D1
Twistlock Detail
D22
D9
D8
D15
D7
D12
D19
D10
D14
D23
D11
D13
G1
D6
D17
D2
D21
D4
D3
D16
D18
D20
R1
D5
R3
R2
R4
D20
D18



Standard Features - ZLC-906

- 51' 6" ULTRA-VIEW Telescopic Mast for stacking 6-High (9' 6" Loaded)
- 20-40 ISO Container Handling Attachment, Chain Suspended, with reach, slew, side shift, guide arms and mechanical pile slope
- Accumulator in Lift Circuit
- 615V All-electric battery power drivetrain. Two-full shift run time (under normal work cycles)
- Taylor/Dana TE-30 multi-speed transmission designed specifically for battery powered drivetrains
- Kessler D-102W HD planetary drive axle with wet disc brakes
- Taylor 600 welded steel steer axle with stud protectors (single hydraulic cylinder design with heavy-duty links from the cylinder ram directly to tapered roller bearing mounted spindles)
- 18.00 X 25 – 40PR bias pneumatic drive and steer tires

CHASSIS:
- All-welded steel frame
- Replaceable bolt-on steps and handrails
- Lift-off deckplates expose drive train and hydraulics for ease of maintenance.

CAB:
- Enclosed, elevated operator, 2-door all-welded steel center mount cab (includes dome light, wide angle mirrors, door hold back latches with trip handles, handrails, black floor mats and is isolation mounted for noise and vibration reduction)
- Operator cab heater and interior circulation fan
- Tinted glass with front and rear windshield wipers and front windshield washer
- Fully adjustable air ride swivel seat with 35° of rotation (15°/20° left-right)
- Multifunction joystick mounted on adjustable arm rest
- Column mounted directional control
- Operator Restraint System (Orange, anti-cinch seat belt with starting sequence neutral lock)
- Operator Presence System with timed idle and neutral shutdown (5 minute default, password adjustable from 1-120 minutes by end user)
- Taylor Integrated Control System (TICS) …see next page for additional info
- 7-in touch screen color display
- The one-piece flip-down instrument panel is pre-wired to accommodate heavy-duty
- accessories.
- All wiring is color and number coded.
- Dual USB charging ports
- Hydrostatic, steer-on-demand power steering with tilt steering column

ELECTRICAL:
- 24-volt low voltage electrical system. Dual heavy-duty batteries
- 615-volt high voltage electrical system
- 5-6 hours full charging time
- 2 Sets of Amber/Green/Red Twistlock operation signal lights (mounted in cab and on container attachment)
- (4) forward facing LED work lights (cab mounted)
- (2) rear facing LED work lights ("A" pillar mounted)
- (2) LED work lights (mast mounted)
- (2) LED work lights (twistlock mounted)
- (2) LED step lights
- Low Voltage System Circuit breakers with heavy duty connectors (no automotive type fuses)
- Breaker reset switches
- Air Horn with 2-gal air tank (126 dBA)
- Keyswitch-actuated amber strobe light
- Forward and reverse-actuated warning alarms

VIP:
- Operators Guide
- Maintenance and Service documentation including key circuit drawings (Serial Number Specific Parts Book is available upon request)
- Safety Check Manual and Video

Serviceability

Taylor Container Handlers are designed with ease of maintenance and serviceability as a key priority. The Zero Emissions ZLC-906 eliminates service requirements normally encountered with diesel engine driven powertrains. The electric traction and pump motors are maintenance free as is the high-voltage battery pack. Internal system controls monitor the battery conditions and provide information to the user when faults occur or when attention is required. All daily checks across the Taylor product line can be accessed from either the ground or running board, ensuring that operators can complete these requirements with ease. Also, the side service doors and removable deck panels open to expose the drivetrain and hydraulics to provide easy access for service and inspection.

Flip-down Dash with Color/Number Coded Wiring (Standard)

Spin-on Breather, Wire Mesh Strainer & Replaceable Internal Element (Standard)

Lightweight Deck Lids and Easy Access to Heavy Duty Circuit Breaker Panel

Easy Access for Steer Axle Maintenance

Hydraulic & Brakes

The ZLC-906 features hydraulic systems, including pumps and valves, which maximize performance and efficiency and minimize power consumption. Joystick controls can be tuned for operator comfort and optimized control. The hydraulic tank features a spin-on breather, wire mesh strainers, full-flow 10-micron return line filters and a replaceable internal element. The hydraulic oil and wet disc brakes are cooled by an air to oil cooler separate from the transmission cooler. Taylor strives to keep things simple and user friendly.

Taylor Integrated Control System (TICS)

The TICS system is a vehicle electronic control system comprised of multiple components including an operator display module, which provides integrated control of the battery, electronic and hydraulic systems on the truck. J1939 CANbus technology allows all machine data to be accessed through the 7-in. touch screen color display (located in the cab) and allows controllers and sensors to communicate with minimal wiring between the components. The display indicates battery system, transmission, hydraulic, and controls information as well as active warnings, battery state of charge, maintenance data and man/machine interface data. The display also allows service personnel to access data needed during troubleshooting (such as sensor status and controller outputs). Machine functions can be tuned through this display and are password protected.

...TICS gives customers the ability to customize operation parameters of their Taylor lift truck, perform diagnostics, and monitor key functions including battery state of charge. The TICS interface is simple, easy to understand and user friendly. The TICS diagnostic ability is key to quick repair and less downtime. Troubleshooting and diagnosing most problems can be done by the customer's own mechanic, without the need for a service tech with a detached computer. There are multiple options available including, but not limited to, scale systems, modem based fleet tracking and the Vision Plus™ pedestrian detection system.

4.0 Engineering Bill Of Materials:

Below is documentation of the final Engineering Bill of Materials (BOM) for the Taylor zero-emission top handlers. The certification process is discussed in detail in Section 6.0: Equipment Testing and Certification. See below for the Bill of Materials for each unit

4.1 Taylor Bill of Materials for Unit P43144

EBM	Catalog Page	Description
ENGINE		
01 2567		BYD ELECTRONIC DRIVE
		1005 232 - DRIVE MOTOR QTY = 1
		1005 327 - DRIVE MOTOR QTY = 1
ELECTRICAL		
06 2696	06-269600	MAIN ELEC>ZLC>DREAM
06A2585		SPRDR ELEC>2040TPA
06C0225	06C-0223	DUAL MON FWD/REV>XLC
		2000 517 - SV COLOR LCD MONIT QTY = 1
		2000 518 - SV COLOR CAMERA QTY = 1
		2000 517 - SV COLOR LCD MONIT QTY = 1
		2000 518 - SV COLOR CAMERA QTY = 1
06I0295	06I-269600	BATT/CBL>FLMNG RIV>ZLC
		2340 032 - 8D BATT INTERSTATE QTY = 2
		2316 804 - BATTERY DISCONNECT QTY = 1
06J0055		CAN JYSTK 11 BTN ZLC
06K0046	06K-0046	SEATBELT SEQ LGT>GREEN
		2319 413 - STROBEBEACON12/24V QTY = 1
		2319 417 - OBSREPBY 2319-988 QTY = 1
06L0363		LED>CAB/MST>50WATT
		2008 011 - 24V LIGHT SWITCH QTY = 1
		2320 026 - N4402 LED 50W,12/2 QTY = 2
		2320 025 - N4402 LED 50W,12/2 QTY = 2
		2320 026 - N4402 LED 50W,12/2 QTY = 2
06M0211		LED>2 FRT CAB LGTS WIDE
		2320 026 - N4402 LED 50W,12/2 QTY = 2
06N0089		LED>2 REV ACTVTD LGT
		2320 025 - N4402 LED 50W,12/2 QTY = 2
06P0120		FTNG/PLUG>NO BRK LGTS
06Q0052		ELEC BOXES
06T0051		CAB TILT ELEC>ZLC
06U0045	06U-0045	24/12 CNVRTR>DUEL15A
		CD 06U 0045 - 24V TO 12V CNVRTR QTY = 1
INSTRUMENTS		
07M0039	07M-0039	TYLRTRK PRO HDWR 3YR
		2326 360 - 4G TELEMATICS GATE QTY = 1
TRANSMISSION		

09 2396		TE30 LU/DAMP>ZLC
		2547 092 - 15.5LMTE30510-1 QTY = 1
09A2390	09A-2390	TRANS COOL>TE30 ZLC
09B2178	09B-2178	TE30 TRANS FLTR&FILL
09F0211		APC300>ELESFT>TE30>ZLC
		2546 076 - APC312 KIT FOR TE1 QTY = 1
DRIVE SHAFT		
11 2220		DRIVELINE>KESSLER
		1931 230 - DRIVE LINE 9C X 23 QTY = 1
STEER AXLE		
13 2284		STEER AXLE>XLC
	13-166	I 1 26 5095 - STEER AXLE ASY QTY = 1
13B0029		HI-PRS STR RIM MTG HDWR
		2065 104 - STUD 3/4-10 NC 4" QTY = 30
		I 0 26 5102 - STEER STUD PROTECT QTY = 2
13E0002		STEER AXLE BUMPER
		3260 051 - STEER AXLE BUMPER QTY = 2
DRIVE AXLE		
14 2500		KSLR D102> TE30
	14-273	2070 388 - D102 W/REV CARRIER QTY = 1
BRAKE CTRL		
15 2746		BRK/KESSLER>ZLC W/CAB TILT
15H0032	15H-0032	AIR HORN XLC
		2243 482 - 24V AIR COMPRESSOR QTY = 1
		2243 476 - 2 GAL AIR TANK QTY = 1
		2243 563 - VALVE ST1 SAFETY QTY = 1
		2315 022 - AIR HORN 275C QTY = 1
15V0047		DUAL PEDAL>1600PSI
		I 1 25 1725 - BRAKE PEDAL 1600 P QTY = 2
STEER CTRL		
16 2456	16-2456	STEERING>ZLC
16A2112		STEER CONT>XLC/XEC
	16-273	2536 328 - TILT STEER COLUMN3 QTY = 1
		2485 003 - STEERING WHEEL 16 QTY = 1
		2485 004 - HORNBUTTONW/TRUMPE QTY = 1
16C0006		STR WHEEL SPNR KNOB
		2485 005 - WHEEL SPINNER KNOB QTY = 1
TIRES		
17 2891		1800X25 40PR Y69L4 YOKHMA SMTH/RIMEX RIM
	17-156	I 1 05 0523 - 25X13 RIMEX/KESSLE QTY = 4
		2660 140 - 25 X 7.0 DUAL SPAC QTY = 2
	17-156	I 1 05 0523 - 25X13 RIMEX/KESSLE QTY = 2
		I 1 05 0522 - 25X13 STEMS QTY = 1
MAINFRAME		
18 2488		CHASSIS>ZLC976
		I 1 01 4065 - CHASSIS WLDT QTY = 1
BODY/HULL		
19 3180	19-306	BDYHULL>ZLC>DREAM CAB
CAB/CANOPY		
20 2459		ENCLOSED DREAM CAB(REV-A)
20A2556		HEAT ONLY/AC HOLE PLUGS
20B0063	20B-001	DOOR HOLD BACK

20F0128		TOP SKYLIGHT WIPER
		3250 872 - WIPER MOTOR QTY = 1
		3250 873 - WIPER ARM QTY = 1
		3250 871 - WIPER BLADE QTY = 1
20G0063		DUAL CAB FAN
		2008 - 24VOLT CAB FAN QTY = 2
20H0350	20H-0350	HTER/DEF>ZLC
20T0036		CAB TILT>ZLC>DREAM CAB
20V0066		SUNVISOR/SKYLIGHT PULL SCREEN
		3250 869 - SUNSHADE PULL SCRE QTY = 1
		3250 870 - SUN VISOR QTY = 1
20W0092		JOYSTICK MNT ONLY
SEAT		
21 2429		AIR SUSP>BLACK VNYL
	21-074	3226 420 - SEARS AIR SUSP-VIN QTY = 1
		3226 316 - RIGHT HAND ARM RES QTY = 1
21C0039		ARM REST MOUNT
		I 1 28 3012 - JYSTK ARM REST MT QTY = 1
HYD. SYSTEM		
22 3252	22-3252	MAIN HYD>ZLC
22A4238	22A-4238	CARR/2040TPA SPRDR HYD>XLC
	24-220	2797 430 - SPREADER VALVE-24V QTY = 1
22D0062		CAB TILT>ZLC
	26A-037	2782 241 - CAB TILT CYL QTY = 2
22K0056		HYD FAN MOTOR PLMBING
22L0192		LIFT HOSE/51.5' MST
22P0034		PILE SLOPE HYD
22T0118		HYD TANK>ZLC976
	22-654	I 1 22 1083 - HYD TANK-130 GAL-U QTY = 1
		2720 137 - STRAINER 16" LG QTY = 1
22Z0037		SHIPPING PLUG>LIFT PIPE
MAST GROUP		
27 2612		MAST HDWR>XLC
	27-332	I 1 17 9978 - MAIN ROLLER ASY QTY = 4
	27-262	I 1 16 3125 - CHAIN ROLLER ASY QTY = 2
27Q0086		6-HI MAST ELEC
		I 1 29 2327 - MAST ROLLER CABLE QTY = 1
27T0611	27B-049	51'6" MAST>XLC
		I 1 16 3144 - 51'6" INNER MAST W QTY = 1
		I 1 16 3141 - 51'6" OUTER MAST W QTY = 1
	26-775	2772 385 - D77X309 CYL TXLC97 QTY = 2
		- QTY =
CARRIAGE		
28 1198		SPREADER CARR>XLC
		I 1 20 0872 - SPREADER CARRIAGE QTY = 1
	27-332	I 1 17 9978 - MAIN ROLLER ASY QTY = 4
	26A-110	I 1 26 4927 - 4 1/4 SLEW CYL ASY QTY = 2
	26A-112	I 1 26 4928 - 4 3/4 SS CYL ASY QTY = 1
28J0002		SPDR HANGER CHAIN
		I 1 19 0099 - HANGER CHAIN ASY QTY = 4
MISC. ATTACH		
29 3517	29A-422	2040 TPA SPREADER
		I 1 36 6298 - RH EXP FRAME QTY = 1

		I 1 36 6323 - CENTER FRAME QTY = 1
	26A-060	I 1 26 4689 - EXP CYL ASY QTY = 2
	26-114	I 1 26 4520 - OBSREPBY I-1-26-52 QTY = 2
29A2024		PILE SLOPE
	26A-110	I 1 26 4964 - 4 1/4 PILE SLOPE C QTY = 4
29B0018		ON-CONT PROX(PLUNGER)
		I 0 36 5593 - TWISTLOCK PLUNGER QTY = 4
29T0007		DIRECT READ TWL PROX
		I 1 36 5796 - PROX SWITCH ASY QTY = 8

PLATES/DECAL

30 2333		DECALS>ZLC SERIES>DREAM CAB
30D0008		TEAMTRAC DECAL
30H0069		ATTACH DECALS>ZLC
30J0005		TWSTLK SWT DECAL
30P0007		RED/BLACK PAINT>LRGE
30R0005		CAB TILT>ENGLISH DECALS

PETRO-CHEM

32 2569	32-406	CWT>ZLC976

SHIPPING

33V0005		COVER PL>VIS PLUS
36E0017		LED STEP LGT/SWT
		2320 021 - LED LIGHT 12/24 QTY = 2
36N0006		ATTACH LGTS>SPRDRBOX
		3260 053 - GRN LIGHT 30MM CAB QTY = 1
		3260 054 - RED LIGHT 30MM CAB QTY = 1
		3260 055 - YEL LIGHT 30MM CAB QTY = 1
36Q0003		TWSTLK OVRD SWT (IN CAB)
		2309 218 - SWITCH 3POSITION12 QTY = 1
06AJ0001		2040TPA 40'PROX JUMPER
06AL0001		TWSTLK WORK LGTS
		2320 016 - N2401 WIDE FLOOD L QTY = 2
30GR0001		GREASE>LARGE
	31-700	FILTER ELEMENT CHART
		1189 101 - 1"8NCX7 LONG HH BO QTY = 2
		1270 600 - SCREW 10-24NCX1 QTY = 8
		1339 001 - NUT HEX #10-24NC QTY = 8
		1387 003 - INT-EXT TOOTH LOCK QTY = 8
		2404 833 - LIFT PANEL HANDLE QTY = 2
		2695 006 - MT/DM 1800-23.5 QTY = 6
		3251 122 - REAR DECK PLATE QTY = 2
		I 0 01 5288 - LOAD SENSE MT QTY = 1
		I 0 0111669 - REAR GRILL RETAINE QTY = 1
		I 0 0113076 - TILT CYL PIN RET QTY = 2
		I 0 0116412 - AC POWER SUPPLY MT QTY = 1
		I 0 0116413 - MUD COVER QTY = 1
		I 0 0116440 - STR JUNCTION BOX M QTY = 1
		I 0 0116566 - CWT CVR CONNECTOR QTY = 1
		I 0 0116646 - STR HOSE CLAMP BKT QTY = 1
		I 0 0116654 - HEAT DEVELOPER MT QTY = 1
		I 0 0116660 - REVERSE CAMERA MT QTY = 1
		I 0 0116670 - SHAFT COVER BASE QTY = 1
		I 0 02 2853 - LH WHEEL CAVITY CR QTY = 1
		I 0 02 2854 - RH WHEEL CAVITY CR QTY = 1

I 0 02 2926 - REAR LIFT TAP PL QTY = 4
I 0 2312082 - LIFT PANEL HANDLE QTY = 2
I 0 2313416 - COOLANT TANK MOUNT QTY = 1
I 0 2313440 - HYD CLR MOUNT BKT QTY = 1
I 0 2313660 - COOLANT TANK MNT QTY = 1
I 0 2313711 - TOP BATTERY DOOR QTY = 1
I 0 2313712 - BOT BATTERY DOOR QTY = 1
I 0 2811581 - STROBE MT SUPPORT QTY = 1
I 0 2811582 - RH REAR LIGHT MT QTY = 1
I 0 2811583 - LH REAR LIGHT MT QTY = 1
I 0 2811586 - CONVERTER BRACKET QTY = 1
I 0 2811590 - ATTCH LT BKT WORTH QTY = 1
I 0 30 1817 - TILT HOSE SUPT BKT QTY = 2
I 0 30 1871 - STEER PIPE CLAMP QTY = 1
I 0 30 1880 - SPREADER SUPPLY MT QTY = 3
I 0 30 1904 - COMP/TANK MNT ZLC QTY = 1
I 0 30 1921 - CLAMP BRACKET QTY = 3
I 0 30 1947 - CAB HOSE CLAMP PLT QTY = 3
I 0 30 1949 - AC BRACKET QTY = 2
I 1 01 4265 - MOTOR CONTROLLER M QTY = 1
I 1 01 4266 - TOP MTR CNTRLLR MT QTY = 1
I 1 23 6954 - CABLE CHUTE WLDT QTY = 1
I 1 28 3119 - STROBE MOUNT STAND QTY = 1
I 1 29 2992 - TL LED ASY CIR QTY = 1
I 1 30 0453 - HYD HOSE TRAY WLDT QTY = 1
I 1 30 0473 - FRT HNDRL WLDT QTY = 1
I 1 32 3034 - HOSE 1 X 33 QTY = 1
I 1 32 3514 - HOSE ASSY 1/2 X 36 QTY = 1
I 1 32 4576 - HOSE 1 1/4 X 39 QTY = 1
I 1 32 5488 - HOSE 1 X 55 QTY = 1
I 1 32 7105 - HOSE 3/4 X 53 QTY = 1
I 1 32 9004 - HOSE 3/8 X 96 QTY = 1
I 1 32 9832 - HOSE 3/4 X 212 QTY = 1
I 1 32 9848 - HOSE 1 1/2 X 35 QTY = 1
I 1 32 9852 - HOSE 1 1/4 X 52 QTY = 1
I 1 32 9854 - HOSE 1 X 63 QTY = 1
I 1 32 9864 - HOSE 3/8 X 30 QTY = 1
I 1 32 9949 - HOSE 1 X 24 QTY = 1
I 1 32 9950 - HOSE 1 X 69 QTY = 1

Additional Information

DELIVERED TO:
LONG BEACH CONTAINER
350 PIER D AVE
LONG BEACH, CA 90802-6230

BODY (COLOR) - RED
CAB (COLOR) - BLACK
FRONT-END (COLOR) - BLACK
01 PAINT RED W/BLACK CAB&FRT END
02 NOTE: WHITE STRIPES ARE TO BE PAINTED ON
OUTSIDE TIRES
03 IQAN PROGRAM LC04200

		***
05	TABS:	
06	01-0000	
07	01-0001	
08	01-0002	
09	09-0000	
10	13-0000	
11	15-0000	
12	16-0000	
13	17-0000	
14	22-0000	
15	27-0000	
16	30-0000	
		CYLINDER INFORMATION SHEET
		PART # DESCRIPTION SERIAL #
		1005 231 STEERING PUMP MOTOR 119001602
		1005 233 LIFT PUMP MOTOR 11900251
		1005 327 DRIVE MOTOR 119100001
	14-273	2070 388 D102 W/REV CARRIER 741993
	09-199	2547 092 15.5LMTE30510-1 ABEA111087
		2748 461 PUMP TXLC975/6 W/CUM N01903749
		2748 530 PGP130TRIPLEPUMP J041903056
	26-775	2772 385 D77X309 CYL TXLC976 F08181237
	26-775	5239 288 SEAL KIT
	26-775	2772 385 D77X309 CYL TXLC976 F08181238
	26-775	5239 288 SEAL KIT
		2797 373 VG80 HOIST/TILT VALV H04191123
	24-220	2797 430 SPREADER VALVE-24VDC H01193346
		2797 458 24V SINGLE BRAKE MAN BL0328RG
	21-074	3226 420 SEARS AIR SUSP-VINYL 1952 01 29 19
	26-114	I 1 26 4520 OBSREPBY I-1-26-5211 17297605
	26-114	5239 135 SEAL KIT
	26-114	I 1 26 4520 OBSREPBY I-1-26-5211 17297606
	26-114	5239 135 SEAL KIT
	26A-060	I 1 26 4689 EXP CYL ASY 18891252
	26A-060	5239 294 SEAL KIT
	26A-060	I 1 26 4689 EXP CYL ASY 18891256
	26A-060	5239 294 SEAL KIT
	26A-095	I 1 26 4888 7 1/4 STEER CYL ASY M03180055
	26A-095	5239 338 SEAL KIT/I 1 26 4888
	26A-110	I 1 26 4927 4 1/4 SLEW CYL ASY 19084726
	26A-110	5239 350 SEAL KIT
	26A-110	I 1 26 4927 4 1/4 SLEW CYL ASY 19084727
	26A-110	5239 350 SEAL KIT

26A-112	I 1 26 4928 4 3/4 SS CYL ASY 1794970 7
26A-112	5239 352 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 1794980 11
26A-110	5239 350 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 1794980 7
26A-110	5239 350 SEAL KIT
26A-168	I 1 26 5128 7 1/4 HYDRAULIC CYL 19472185
26A-168	5239 290 SEAL KIT
26A-168	I 1 26 5128 7 1/4 HYDRAULIC CYL 19472186
26A-168	5239 290 SEAL KIT
20-546	I 1 28 3010 CAB ASSY-H9600A-REVA 72814670

Capacity Information

STR.AXLE CHASSIS WT. 070800 LBS

BASIC CAPACITY 095000 LBS @ 048.00 L.C.

CAPACITY AS EQUIPPED 090000 LBS @ 097.00 L.C. UP TO 00182" LIFT

082000 LBS @ 106.00 L.C. UP TO 00182" LIFT

080000 LBS @ 097.00 L.C. UP TO 00582" LIFT

075000 LBS @ 106.00 L.C. UP TO 00582" LIFT

000000 LBS @ 000.00 L.C. UP TO 00000" LIFT

000000 LBS @ 000.00 L.C. UP TO 00000" LIFT

000000 LBS @ 000.00 L.C. UP TO 00000" LIFT

WT. ON STEER AXLE 058800

WT. ON DRIVE AXLE 114160

TOTAL WEIGHT 172960

4.2 Taylor Bill of Materials for Unit P43145

EBM	Catalog Page	Description
ENGINE		
01 2567		BYD ELECTRONIC DRIVE
		1005 232 - DRIVE MOTOR QTY = 1
		1005 327 - DRIVE MOTOR QTY = 1
ELECTRICAL		
06 2696	06-269600	MAIN ELEC>ZLC>DREAM
06A2585		SPRDR ELEC>2040TPA
06I0295	06I-269600	BATT/CBL>FLMNG RIV>ZLC
		2340 032 - 8D BATT INTERSTATE QTY = 2
		2316 804 - BATTERY DISCONNECT QTY = 1
06J0055		CAN JYSTK 11 BTN ZLC
06L0372		LED>CAB/MST
		2008 011 - 24V LIGHT SWITCH QTY = 1
		2320 023 - 50WATT LED WORKLIG QTY = 2
		2320 023 - 50WATT LED WORKLIG QTY = 2
		2320 023 - 50WATT LED WORKLIG QTY = 2
06M0212		LED>2 FRT CAB LGTS
		2320 023 - 50WATT LED WORKLIG QTY = 2
06N0096		LED REV ACTVTD
		2320 022 - 21WATT LED WORKLIG QTY = 2
06P0120		FTNG/PLUG>NO BRK LGTS
06Q0052		ELEC BOXES
06T0051		CAB TILT ELEC>ZLC
06U0045	06U-0045	24/12 CNVRTR>DUEL15A
		CD 06U 0045 - 24V TO 12V CNVRTR QTY = 1
06V0025		ADD ON XA MODULE
		2326 027 - IQAN XA2 QTY = 1
INSTRUMENTS		
07M0039	07M-0039	TYLRTRK PRO HDWR 3YR
		2326 360 - 4G TELEMATICS GATE QTY = 1
TRANSMISSION		
09 2396		TE30 LU/DAMP>ZLC
		2547 092 - 15.5LMTE30510-1 QTY = 1
09A2390	09A-2390	TRANS COOL>TE30 ZLC
09B2178	09B-2178	TE30 TRANS FLTR&FILL
09F0211		APC300>ELESFT>TE30>ZLC
		2546 076 - APC312 KIT FOR TE1 QTY = 1
DRIVE SHAFT		
11 2220		DRIVELINE>KESSLER
		1931 230 - DRIVE LINE 9C X 23 QTY = 1
STEER AXLE		
13 2284		STEER AXLE>XLC
	13-166	I 1 26 5095 - STEER AXLE ASY QTY = 1
13B0029		HI-PRS STR RIM MTG HDWR
		2065 104 - STUD 3/4-10 NC 4" QTY = 30
		I 0 26 5102 - STEER STUD PROTECT QTY = 2
13E0002		STEER AXLE BUMPER

		3260 051 - STEER AXLE BUMPER QTY = 2
DRIVE AXLE		
14 2500		KSLR D102> TE30
	14-273	2070 388 - D102 W/REV CARRIER QTY = 1
BRAKE CTRL		
15 2746		BRK/KESSLER>ZLC W/CAB TILT
15H0032	15H-0032	AIR HORN XLC
		2243 482 - 24V AIR COMPRESSOR QTY = 1
		2243 476 - 2 GAL AIR TANK QTY = 1
		2243 563 - VALVE ST1 SAFETY QTY = 1
		2315 022 - AIR HORN 275C QTY = 1
15V0047		DUAL PEDAL>1600PSI
		I 1 25 1725 - BRAKE PEDAL 1600 P QTY = 2
STEER CTRL		
16 2456	16-2456	STEERING>ZLC
16A2112		STEER CONT>XLC/XEC
	16-273	2536 328 - TILT STEER COLUMN3 QTY = 1
		2485 003 - STEERING WHEEL 16 QTY = 1
		2485 004 - HORNBUTTONW/TRUMPE QTY = 1
16C0006		STR WHEEL SPNR KNOB
		2485 005 - WHEEL SPINNER KNOB QTY = 1
TIRES		
17 2949		1800X25 40PR YOKO Y69 IND4/BLK SIDEWALLS
		2694 229 - 1800X25X40 YOKO QTY = 4
	17-157	I 1 05 0521 - 25X13 OTR 5PC/KESS QTY = 4
MAINFRAME		
18 2488		CHASSIS>ZLC976
		I 1 01 4065 - CHASSIS WLDT QTY = 1
BODY/HULL		
19 3180	19-306	BDYHULL>ZLC>DREAM CAB
CAB/CANOPY		
20 2464	20-550	ENCLOSED DREAM CAB(REV-B)
20A2556		HEAT ONLY/AC HOLE PLUGS
20B0063	20B-001	DOOR HOLD BACK
20F0128		TOP SKYLIGHT WIPER
		3250 872 - WIPER MOTOR QTY = 1
		3250 873 - WIPER ARM QTY = 1
		3250 871 - WIPER BLADE QTY = 1
20G0063		DUAL CAB FAN
		2008 - 24VOLT CAB FAN QTY = 2
20H0350	20H-0350	HTER/DEF>ZLC
20T0036		CAB TILT>ZLC>DREAM CAB
20W0092		JOYSTICK MNT ONLY
SEAT		
21 2429		AIR SUSP>BLACK VNYL
	21-074	3226 420 - SEARS AIR SUSP-VIN QTY = 1
		3226 316 - RIGHT HAND ARM RES QTY = 1
21C0039		ARM REST MOUNT
		I 1 28 3012 - JYSTK ARM REST MT QTY = 1
HYD. SYSTEM		
22 3252	22-3252	MAIN HYD>ZLC
22A4238	22A-4238	CARR/2040TPA SPRDR HYD>XLC

	24-220	2797 430 - SPREADER VALVE-24V QTY = 1
22D0062		CAB TILT>ZLC
	26A-037	2782 241 - CAB TILT CYL QTY = 2
22K0056		HYD FAN MOTOR PLMBING
22L0192		LIFT HOSE/51.5' MST
22P0034		PILE SLOPE HYD
22T0118		HYD TANK>ZLC976
	22-654	I 1 22 1083 - HYD TANK-130 GAL-U QTY = 1
		2720 137 - STRAINER 16" LG QTY = 1
22U0016		SLEW FLOAT/24V>TXLC
		3376 480 - SLEW FLOAT BOTH CY QTY = 1
		3376 481 - SLEW FLOAT EACH CY QTY = 1
22Z0037		SHIPPING PLUG>LIFT PIPE

MAST GROUP

27 2612		MAST HDWR>XLC
	27-332	I 1 17 9978 - MAIN ROLLER ASY QTY = 4
	27-262	I 1 16 3125 - CHAIN ROLLER ASY QTY = 2
27H0044		ITS SIGNAL SYSTEM
27Q0086		6-HI MAST ELEC
		I 1 29 2327 - MAST ROLLER CABLE QTY = 1
27T0611	27B-049	51'6" MAST>XLC
		I 1 16 3144 - 51'6" INNER MAST W QTY = 1
		I 1 16 3141 - 51'6" OUTER MAST W QTY = 1
	26-775	2772 385 - D77X309 CYL TXLC97 QTY = 2
		- QTY =

CARRIAGE

28 1198		SPREADER CARR>XLC
		I 1 20 0872 - SPREADER CARRIAGE QTY = 1
	27-332	I 1 17 9978 - MAIN ROLLER ASY QTY = 4
	26A-110	I 1 26 4927 - 4 1/4 SLEW CYL ASY QTY = 2
	26A-112	I 1 26 4928 - 4 3/4 SS CYL ASY QTY = 1
28J0002		SPDR HANGER CHAIN
		I 1 19 0099 - HANGER CHAIN ASY QTY = 4

MISC. ATTACH

29 3518	29A-423	2040TPA SPDR>OH LUGS
		I 1 36 6297 - EXP FRAME W/OH LUG QTY = 2
		I 1 36 6323 - CENTER FRAME QTY = 1
	26A-060	I 1 26 4689 - EXP CYL ASY QTY = 2
	26-114	I 1 26 4520 - OBSREPBY I-1-26-52 QTY = 2
29A2024		PILE SLOPE
	26A-110	I 1 26 4964 - 4 1/4 PILE SLOPE C QTY = 4
29B0018		ON-CONT PROX(PLUNGER)
		I 0 36 5593 - TWISTLOCK PLUNGER QTY = 4
29C0006		CONTAINER DEFLECTOR
		I 1 36 6191 - CONT DEFLECTOR WLD QTY = 2
29T0007		DIRECT READ TWL PROX
		I 1 36 5796 - PROX SWITCH ASY QTY = 8

PLATES/DECAL

30 2333		DECALS>ZLC SERIES>DREAM CAB
30D0008		TEAMTRAC DECAL
30H0069		ATTACH DECALS>ZLC
30J0005		TWSTLK SWT DECAL
30N0018		YEL TAPE>SSA GRN/YEL TRUCKS

30P0011		JDGREEN/YELL PAINT>LRGE
30R0005		CAB TILT>ENGLISH DECALS
PETRO-CHEM		
32 2569	32-406	CWT>ZLC976
36E0017		LED STEP LGT/SWT
		2320 021 - LED LIGHT 12/24 QTY = 2
36N0006		ATTACH LGTS>SPRDRBOX
		3260 053 - GRN LIGHT 30MM CAB QTY = 1
		3260 054 - RED LIGHT 30MM CAB QTY = 1
		3260 055 - YEL LIGHT 30MM CAB QTY = 1
36Q0003		TWSTLK OVRD SWT (IN CAB)
		2309 218 - SWITCH 3POSITION12 QTY = 1
06AJ0001		2040TPA 40'PROX JUMPER
06AL0002		LED T/L WORKLGTS
		2320 022 - 21WATT LED WORKLIG QTY = 2
30GR0001		GREASE>LARGE
	31-700	FILTER ELEMENT CHART
		1189 101 - 1"8NCX7 LONG HH BO QTY = 2
		2695 006 - MT/DM 1800-23.5 QTY = 6
		I 0 01 5288 - LOAD SENSE MT QTY = 1
		I 0 0111669 - REAR GRILL RETAINE QTY = 1
		I 0 0113076 - TILT CYL PIN RET QTY = 2
		I 0 0116201 - MOTOR MT HOLD DOWN QTY = 2
		I 0 0116412 - AC POWER SUPPLY MT QTY = 1
		I 0 0116413 - MUD COVER QTY = 1
		I 0 0116440 - STR JUNCTION BOX M QTY = 1
		I 0 0116566 - CWT CVR CONNECTOR QTY = 1
		I 0 0116646 - STR HOSE CLAMP BKT QTY = 1
		I 0 0116654 - HEAT DEVELOPER MT QTY = 1
		I 0 0116660 - REVERSE CAMERA MT QTY = 1
		I 0 0116670 - SHAFT COVER BASE QTY = 1
		I 0 02 2853 - LH WHEEL CAVITY CR QTY = 1
		I 0 02 2854 - RH WHEEL CAVITY CR QTY = 1
		I 0 02 2926 - REAR LIFT TAP PL QTY = 4
		I 0 2313416 - COOLANT TANK MOUNT QTY = 1
		I 0 2313440 - HYD CLR MOUNT BKT QTY = 1
		I 0 2313660 - COOLANT TANK MNT QTY = 1
		I 0 2313711 - TOP BATTERY DOOR QTY = 1
		I 0 2313712 - BOT BATTERY DOOR QTY = 1
		I 0 2811586 - CONVERTER BRACKET QTY = 1
		I 0 2811590 - ATTCH LT BKT WORTH QTY = 1
		I 0 30 1817 - TILT HOSE SUPT BKT QTY = 2
		I 0 30 1871 - STEER PIPE CLAMP QTY = 1
		I 0 30 1904 - COMP/TANK MNT ZLC QTY = 1
		I 0 30 1947 - CAB HOSE CLAMP PLT QTY = 3
		I 0 30 1949 - AC BRACKET QTY = 2
		I 0 30 1951 - CAB HOSE BLKHD BKT QTY = 1
		I 1 01 4194 - MOTOR CONTLR WLDT QTY = 1
		I 1 01 4265 - MOTOR CONTROLLER M QTY = 1
		I 1 01 4266 - TOP MTR CNTRLLR MT QTY = 1
		I 1 23 6954 - CABLE CHUTE WLDT QTY = 1
		I 1 29 2992 - TL LED ASY CIR QTY = 1
		I 1 30 0453 - HYD HOSE TRAY WLDT QTY = 1
		I 1 30 0473 - FRT HNDRL WLDT QTY = 1

I 1 32 3034 - HOSE 1 X 33 QTY = 1
I 1 32 4576 - HOSE 1 1/4 X 39 QTY = 1
I 1 32 5488 - HOSE 1 X 55 QTY = 1
I 1 32 7105 - HOSE 3/4 X 53 QTY = 1
I 1 32 9004 - HOSE 3/8 X 96 QTY = 1
I 1 32 9832 - HOSE 3/4 X 212 QTY = 1
I 1 32 9848 - HOSE 1 1/2 X 35 QTY = 1
I 1 32 9852 - HOSE 1 1/4 X 52 QTY = 1
I 1 32 9949 - HOSE 1 X 24 QTY = 1
I 1 32 9950 - HOSE 1 X 69 QTY = 1

Additional Information

DELIVERED TO:
SSA
1521 PIER J AVE
LONG BEACH, CA 90802

BODY (COLOR) - JD GREEN
CAB (COLOR) - BLACK
FRONT-END (COLOR) - BLACK

01		PAINT JD GREEN&YELLOW W/BLACK CAB&FRT END
02		IQAN PROGRAM LC04200
05	TABS:	
06	01-0000	
07	01-0001	
08	01-0002	
09	09-0000	
10	13-0000	
11	15-0000	
12	16-0000	
13	17-0000	
14	22-0000	
15	27-0000	
16	30-0000	
		CYLINDER INFORMATION SHEET
		PART # DESCRIPTION SERIAL #
	14-273	2070 388 D102 W/REV CARRIER 741996
	09-199	2547 092 15.5LMTE30510-1 ABEA111088
		2748 461 PUMP TXLC975/6 W/CUM N041903712
		2748 530 PGP130TRIPLEPUMP C06L109
	26-775	2772 385 D77X309 CYL TXLC976 F08181226
	26-775	5239 288 SEAL KIT

26-775	2772 385 D77X309 CYL TXLC976 F08181244
26-775	5239 288 SEAL KIT
	2797 373 VG80 HOIST/TILT VALV H0718606
	2797 457 SINGLE SEC.L90VALVE 19143322025001
21-074	3226 420 SEARS AIR SUSP-VINYL 044071923019
26-114	I 1 26 4520 OBSREPBY I-1-26-5211 17297607
26-114	5239 135 SEAL KIT
26-114	I 1 26 4520 OBSREPBY I-1-26-5211 17613851
26-114	5239 135 SEAL KIT
26A-060	I 1 26 4689 EXP CYL ASY 18891254
26A-060	5239 294 SEAL KIT
26A-060	I 1 26 4689 EXP CYL ASY 18891343
26A-060	5239 294 SEAL KIT
26A-095	I 1 26 4888 7 1/4 STEER CYL ASY H03190069
26A-095	5239 338 SEAL KIT/I 1 26 4888
26A-110	I 1 26 4927 4 1/4 SLEW CYL ASY 193390015
26A-110	5239 350 SEAL KIT
26A-110	I 1 26 4927 4 1/4 SLEW CYL ASY 193390016
26A-110	5239 350 SEAL KIT
26A-112	I 1 26 4928 4 3/4 SS CYL ASY 17949709
26A-112	5239 352 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 190856913
26A-110	5239 350 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 190856914
26A-110	5239 350 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 190856915
26A-110	5239 350 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 190856918
26A-110	5239 350 SEAL KIT
26A-168	I 1 26 5128 7 1/4 HYDRAULIC CYL 19472181
26A-168	5239 290 SEAL KIT
26A-168	I 1 26 5128 7 1/4 HYDRAULIC CYL 19472182
26A-168	5239 290 SEAL KIT
20-546	I 1 28 3010 CAB ASSY-H9600A-REVA GTDTAY000004DM

Capacity Information

STR.AXLE CHASSIS WT. 071120 LBS

BASIC CAPACITY 095000 LBS @ 048.00 L.C.

CAPACITY AS EQUIPPED 090000 LBS @ 097.00 L.C. UP TO 00182" LIFT

082000 LBS @ 106.00 L.C. UP TO 00182" LIFT

080000 LBS @ 097.00 L.C. UP TO 00582" LIFT

075000 LBS @ 106.00 L.C. UP TO 00582" LIFT

000000 LBS @ 000.00 L.C. UP TO 00000" LIFT

000000 LBS @ 000.00 L.C. UP TO 00000" LIFT

000000 LBS @ 000.00 L.C. UP TO 00000" LIFT

WT. ON STEER AXLE 058500

WT. ON DRIVE AXLE 114700

TOTAL WEIGHT 173200

4.3 Taylor Bill of Materials for Unit P43146

EBM	Catalog Page	Description
ENGINE		
01 2567		BYD ELECTRONIC DRIVE
		1005 232 - DRIVE MOTOR QTY = 1
		1005 327 - DRIVE MOTOR QTY = 1
ELECTRICAL		
06 2696	06-269600	MAIN ELEC>ZLC>DREAM
06A2585		SPRDR ELEC>2040TPA
06I0295	06I-269600	BATT/CBL>FLMNG RIV>ZLC
		2340 032 - 8D BATT INTERSTATE QTY = 2
		2316 804 - BATTERY DISCONNECT QTY = 1
06J0055		CAN JYSTK 11 BTN ZLC
06L0372		LED>CAB/MST
		2008 011 - 24V LIGHT SWITCH QTY = 1
		2320 023 - 50WATT LED WORKLIG QTY = 2
		2320 023 - 50WATT LED WORKLIG QTY = 2
		2320 023 - 50WATT LED WORKLIG QTY = 2
06M0212		LED>2 FRT CAB LGTS
		2320 023 - 50WATT LED WORKLIG QTY = 2
06N0096		LED REV ACTVTD
		2320 022 - 21WATT LED WORKLIG QTY = 2
06P0120		FTNG/PLUG>NO BRK LGTS
06Q0052		ELEC BOXES
06T0051		CAB TILT ELEC>ZLC
06U0045	06U-0045	24/12 CNVRTR>DUEL15A
		CD 06U 0045 - 24V TO 12V CNVRTR QTY = 1
06V0025		ADD ON XA MODULE
		2326 027 - IQAN XA2 QTY = 1
INSTRUMENTS		
07M0039	07M-0039	TYLRTRK PRO HDWR 3YR
		2326 360 - 4G TELEMATICS GATE QTY = 1
TRANSMISSION		
09 2396		TE30 LU/DAMP>ZLC
		2547 092 - 15.5LMTE30510-1 QTY = 1
09A2390	09A-2390	TRANS COOL>TE30 ZLC
09B2178	09B-2178	TE30 TRANS FLTR&FILL
09F0211		APC300>ELESFT>TE30>ZLC
		2546 076 - APC312 KIT FOR TE1 QTY = 1
DRIVE SHAFT		
11 2220		DRIVELINE>KESSLER
		1931 230 - DRIVE LINE 9C X 23 QTY = 1
STEER AXLE		
13 2284		STEER AXLE>XLC
	13-166	I 1 26 5095 - STEER AXLE ASY QTY = 1
13B0029		HI-PRS STR RIM MTG HDWR
		2065 104 - STUD 3/4-10 NC 4" QTY = 30
		I 0 26 5102 - STEER STUD PROTECT QTY = 2
13E0002		STEER AXLE BUMPER

		3260 051 - STEER AXLE BUMPER QTY = 2

DRIVE AXLE

14 2500		KSLR D102> TE30
	14-273	2070 388 - D102 W/REV CARRIER QTY = 1

BRAKE CTRL

15 2746		BRK/KESSLER>ZLC W/CAB TILT
15H0032	15H-0032	AIR HORN XLC
		2243 482 - 24V AIR COMPRESSOR QTY = 1
		2243 476 - 2 GAL AIR TANK QTY = 1
		2243 563 - VALVE ST1 SAFETY QTY = 1
		2315 022 - AIR HORN 275C QTY = 1
15V0047		DUAL PEDAL>1600PSI
		I 1 25 1725 - BRAKE PEDAL 1600 P QTY = 2

STEER CTRL

16 2456	16-2456	STEERING>ZLC
16A2112		STEER CONT>XLC/XEC
	16-273	2536 328 - TILT STEER COLUMN3 QTY = 1
		2485 003 - STEERING WHEEL 16 QTY = 1
		2485 004 - HORNBUTTONW/TRUMPE QTY = 1
16C0006		STR WHEEL SPNR KNOB
		2485 005 - WHEEL SPINNER KNOB QTY = 1

TIRES

17 2949		1800X25 40PR YOKO Y69 IND4/BLK SIDEWALLS
		2694 229 - 1800X25X40 YOKO QTY = 4
	17-157	I 1 05 0521 - 25X13 OTR 5PC/KESS QTY = 4

MAINFRAME

18 2488		CHASSIS>ZLC976
		I 1 01 4065 - CHASSIS WLDT QTY = 1

BODY/HULL

19 3180	19-306	BDYHULL>ZLC>DREAM CAB

CAB/CANOPY

20 2464	20-550	ENCLOSED DREAM CAB(REV-B)
20A2556		HEAT ONLY/AC HOLE PLUGS
20B0063	20B-001	DOOR HOLD BACK
20F0128		TOP SKYLIGHT WIPER
		3250 872 - WIPER MOTOR QTY = 1
		3250 873 - WIPER ARM QTY = 1
		3250 871 - WIPER BLADE QTY = 1
20G0063		DUAL CAB FAN
		2008 - 24VOLT CAB FAN QTY = 2
20H0350	20H-0350	HTER/DEF>ZLC
20Q0052		FRT GD>2"WIRE MESH>45DEG
		I 1 28 2940 - FRONT GUARD 45 DEG QTY = 1
20T0036		CAB TILT>ZLC>DREAM CAB
20W0092		JOYSTICK MNT ONLY

SEAT

21 2429		AIR SUSP>BLACK VNYL
	21-074	3226 420 - SEARS AIR SUSP-VIN QTY = 1
		3226 316 - RIGHT HAND ARM RES QTY = 1
21C0039		ARM REST MOUNT
		I 1 28 3012 - JYSTK ARM REST MT QTY = 1

HYD. SYSTEM

22 3252	22-3252	MAIN HYD>ZLC
22A4238	22A-4238	CARR/2040TPA SPRDR HYD>XLC
	24-220	2797 430 - SPREADER VALVE-24V QTY = 1
22D0062		CAB TILT>ZLC
	26A-037	2782 241 - CAB TILT CYL QTY = 2
22K0056		HYD FAN MOTOR PLMBING
22L0192		LIFT HOSE/51.5' MST
22P0034		PILE SLOPE HYD
22T0118		HYD TANK>ZLC976
	22-654	I 1 22 1083 - HYD TANK-130 GAL-U QTY = 1
		2720 137 - STRAINER 16" LG QTY = 1
22U0016		SLEW FLOAT/24V>TXLC
		3376 480 - SLEW FLOAT BOTH CY QTY = 1
		3376 481 - SLEW FLOAT EACH CY QTY = 1
22Z0037		SHIPPING PLUG>LIFT PIPE

MAST GROUP

27 2612		MAST HDWR>XLC
	27-332	I 1 17 9978 - MAIN ROLLER ASY QTY = 4
	27-262	I 1 16 3125 - CHAIN ROLLER ASY QTY = 2
27H0044		ITS SIGNAL SYSTEM
27Q0086		6-HI MAST ELEC
		I 1 29 2327 - MAST ROLLER CABLE QTY = 1
27T0611	27B-049	51'6" MAST>XLC
		I 1 16 3144 - 51'6" INNER MAST W QTY = 1
		I 1 16 3141 - 51'6" OUTER MAST W QTY = 1
	26-775	2772 385 - D77X309 CYL TXLC97 QTY = 2
		- QTY =

CARRIAGE

28 1198		SPREADER CARR>XLC
		I 1 20 0872 - SPREADER CARRIAGE QTY = 1
	27-332	I 1 17 9978 - MAIN ROLLER ASY QTY = 4
	26A-110	I 1 26 4927 - 4 1/4 SLEW CYL ASY QTY = 2
	26A-112	I 1 26 4928 - 4 3/4 SS CYL ASY QTY = 1
28J0002		SPDR HANGER CHAIN
		I 1 19 0099 - HANGER CHAIN ASY QTY = 4

MISC. ATTACH

29 3518	29A-423	2040TPA SPDR>OH LUGS
		I 1 36 6297 - EXP FRAME W/OH LUG QTY = 2
		I 1 36 6323 - CENTER FRAME QTY = 1
	26A-060	I 1 26 4689 - EXP CYL ASY QTY = 2
	26-114	I 1 26 4520 - OBSREPBY I-1-26-52 QTY = 2
29A2024		PILE SLOPE
	26A-110	I 1 26 4964 - 4 1/4 PILE SLOPE C QTY = 4
29B0018		ON-CONT PROX(PLUNGER)
		I 0 36 5593 - TWISTLOCK PLUNGER QTY = 4
29C0006		CONTAINER DEFLECTOR
		I 1 36 6191 - CONT DEFLECTOR WLD QTY = 2
29T0007		DIRECT READ TWL PROX
		I 1 36 5796 - PROX SWITCH ASY QTY = 8

PLATES/DECAL

30 2333		DECALS>ZLC SERIES>DREAM CAB
30D0008		TEAMTRAC DECAL
30H0069		ATTACH DECALS>ZLC

30J0005		TWSTLK SWT DECAL
30N0018		YEL TAPE>SSA GRN/YEL TRUCKS
30P0011		JDGREEN/YELL PAINT>LRGE
30R0005		CAB TILT>ENGLISH DECALS
PETRO-CHEM		
32 2569	32-406	CWT>ZLC976
36E0017		LED STEP LGT/SWT
		2320 021 - LED LIGHT 12/24 QTY = 2
36N0006		ATTACH LGTS>SPRDRBOX
		3260 053 - GRN LIGHT 30MM CAB QTY = 1
		3260 054 - RED LIGHT 30MM CAB QTY = 1
		3260 055 - YEL LIGHT 30MM CAB QTY = 1
36Q0003		TWSTLK OVRD SWT (IN CAB)
		2309 218 - SWITCH 3POSITION12 QTY = 1
06AJ0001		2040TPA 40'PROX JUMPER
06AL0002		LED T/L WORKLGTS
		2320 022 - 21WATT LED WORKLIG QTY = 2
30GR0001		GREASE>LARGE
	31-700	FILTER ELEMENT CHART
		1189 101 - 1"8NCX7 LONG HH BO QTY = 2
		2695 006 - MT/DM 1800-23.5 QTY = 6
		I 0 01 5288 - LOAD SENSE MT QTY = 1
		I 0 0111669 - REAR GRILL RETAINE QTY = 1
		I 0 0113076 - TILT CYL PIN RET QTY = 2
		I 0 0116201 - MOTOR MT HOLD DOWN QTY = 2
		I 0 0116412 - AC POWER SUPPLY MT QTY = 1
		I 0 0116413 - MUD COVER QTY = 1
		I 0 0116440 - STR JUNCTION BOX M QTY = 1
		I 0 0116445 - CABLE COVER PL QTY = 1
		I 0 0116566 - CWT CVR CONNECTOR QTY = 1
		I 0 0116646 - STR HOSE CLAMP BKT QTY = 1
		I 0 0116654 - HEAT DEVELOPER MT QTY = 1
		I 0 0116660 - REVERSE CAMERA MT QTY = 1
		I 0 0116670 - SHAFT COVER BASE QTY = 1
		I 0 02 2926 - REAR LIFT TAP PL QTY = 4
		I 0 2313416 - COOLANT TANK MOUNT QTY = 1
		I 0 2313440 - HYD CLR MOUNT BKT QTY = 1
		I 0 2313660 - COOLANT TANK MNT QTY = 1
		I 0 2313711 - TOP BATTERY DOOR QTY = 1
		I 0 2313712 - BOT BATTERY DOOR QTY = 1
		I 0 2811586 - CONVERTER BRACKET QTY = 1
		I 0 2811590 - ATTCH LT BKT WORTH QTY = 1
		I 0 30 1817 - TILT HOSE SUPT BKT QTY = 2
		I 0 30 1871 - STEER PIPE CLAMP QTY = 1
		I 0 30 1904 - COMP/TANK MNT ZLC QTY = 1
		I 0 30 1947 - CAB HOSE CLAMP PLT QTY = 3
		I 0 30 1949 - AC BRACKET QTY = 2
		I 0 30 1951 - CAB HOSE BLKHD BKT QTY = 1
		I 1 01 4194 - MOTOR CONTLR WLDT QTY = 1
		I 1 01 4257 - TRANS MOTOR MOUNT QTY = 1
		I 1 01 4265 - MOTOR CONTROLLER M QTY = 1
		I 1 01 4266 - TOP MTR CNTRLLR MT QTY = 1
		I 1 23 6954 - CABLE CHUTE WLDT QTY = 1
		I 1 29 2992 - TL LED ASY CIR QTY = 1

		I 1 30 0453 - HYD HOSE TRAY WLDT QTY = 1
		I 1 30 0473 - FRT HNDRL WLDT QTY = 1

Additional Information

		DELIVERED TO:
		SSA
		1521 PIER J AVE
		LONG BEACH, CA 90802
		BODY (COLOR) - JD GREEN
		CAB (COLOR) - BLACK
		FRONT-END (COLOR) - BLACK
01		PAINT JD GREEN & YELLOW W/BLACK CAB&FRT END
02		IQAN PROGRAM LC04200
05	TABS:	
06	01-0000	
07	01-0001	
08	01-0002	
09	09-0000	
10	13-0000	
11	15-0000	
12	16-0000	
13	17-0000	
14	22-0000	
15	27-0000	
16	30-0000	
		CYLINDER INFORMATION SHEET
		PART # DESCRIPTION SERIAL #
		1005 231 STEERING PUMP MOTOR 119001601
		1005 233 LIFT PUMP MOTOR 119002050
		1005 327 DRIVE MOTOR 11910003
	14-273	2070 388 D102 W/REV CARRIER 749759
	09-199	2547 092 15.5LMTE30510-1 ABEA109933
	26-775	2772 385 D77X309 CYL TXLC976 F0719338
	26-775	5239 288 SEAL KIT
	26-775	2772 385 D77X309 CYL TXLC976 F0719342
	26-775	5239 288 SEAL KIT
		2797 373 VG80 HOIST/TILT VALV H03182644
		2797 457 SINGLE SEC.L90VALVE 19143322025002
		2797 458 24V SINGLE BRAKE MAN DK0271MW
	21-074	3226 420 SEARS AIR SUSP-VINYL 044071923018
	26-114	I 1 26 4520 OBSREPBY I-1-26-5211 19072002
	26-114	5239 135 SEAL KIT
	26-114	I 1 26 4520 OBSREPBY I-1-26-5211 19072003
	26-114	5239 135 SEAL KIT
	26A-060	I 1 26 4689 EXP CYL ASY 193125315
	26A-060	5239 294 SEAL KIT
	26A-060	I 1 26 4689 EXP CYL ASY 19312539
	26A-060	5239 294 SEAL KIT
	26A-095	I 1 26 4888 7 1/4 STEER CYL ASY M06190382

26A-095	5239 338 SEAL KIT/I 1 26 4888
26A-110	I 1 26 4927 4 1/4 SLEW CYL ASY 19084863
26A-110	5239 350 SEAL KIT
26A-110	I 1 26 4927 4 1/4 SLEW CYL ASY 19084865
26A-110	5239 350 SEAL KIT
26A-112	I 1 26 4928 4 3/4 SS CYL ASY 19085132
26A-112	5239 352 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 193391710
26A-110	5239 350 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 193391711
26A-110	5239 350 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 19969751
26A-110	5239 350 SEAL KIT
26A-110	I 1 26 4964 4 1/4 PILE SLOPE CYL 19969752
26A-110	5239 350 SEAL KIT
26A-168	I 1 26 5128 7 1/4 HYDRAULIC CYL 19472183
26A-168	5239 290 SEAL KIT
26A-168	I 1 26 5128 7 1/4 HYDRAULIC CYL 19472184
26A-168	5239 290 SEAL KIT
20-546	I 1 28 3010 CAB ASSY-H9600A-REVA GTDTAY0000030M

Capacity Information

STR.AXLE CHASSIS WT. 070720 LBS
BASIC CAPACITY 095000 LBS @ 048.00 L.C.
CAPACITY AS EQUIPPED 090000 LBS @ 097.00 L.C. UP TO 00182" LIFT
082000 LBS @ 106.00 L.C. UP TO 00182" LIFT
080000 LBS @ 097.00 L.C. UP TO 00582" LIFT
075000 LBS @ 106.00 L.C. UP TO 00582" LIFT
000000 LBS @ 000.00 L.C. UP TO 00000" LIFT
000000 LBS @ 000.00 L.C. UP TO 00000" LIFT
000000 LBS @ 000.00 L.C. UP TO 00000" LIFT
WT. ON STEER AXLE 058800
WT. ON DRIVE AXLE 113220
TOTAL WEIGHT 172020

5.0 Manufacturing Report:

Below is documentation of Taylor's design and fabrication efforts for the zero-emission top handlers.

These machines were built off of the main production line in Taylor's R&D facility due to the prototype nature of the builds. Taylor Machine Works is a vertically integrated manufacturer and not just an assembly plant. A large portion of all components are machined and built on site. Over the course of this Prototype build process for the ZLC Zero Emission Container Handlers, thousands of man hours and tens of thousands of individual parts and processes are invested into the success of these units. Once documented through this prototype process and demonstrated on site, necessary changes (if needed) can be identified and the units can be set up for standard production build processes.

Figure 1: Battery System Installation (battery pack (foreground) and partially assembled chassis (background))

Source: Taylor Machine Works

Figure 2: Electric Drive System (includes implement drive motor, steering drive motor, and related motor inverters)

Source: Taylor Machine Works

Figure 3: Operational Stage (includes fully assembled truck with mast and spreader. Unit is fully assembled and being prepared for testing)

Source: Taylor Machine Works

Figure 4: Testing and Safety Audit (includes operating unit, fully lifted and fully loaded using test loads. Unit located and operating at the Load Test Facility)

Source: Taylor Machine Works

Figure 5: Battery pack analysis (includes a partially assemble battery pack including batter modules and battery pack system hardware)

Source: Taylor Machine Works

6.0 Equipment Testing and Certification:

New Product Development milestones include specific tasks for testing functional safety, certification, and validation for vehicle components, systems, and subsystems. Taylor Engineering R&D is separated into discrete tasks with respective personnel responsible for planning, evaluation, testing and determination of project goal completion. In general, this portion of product development within the Taylor system is termed “prototyping”. However, prototyping includes a comprehensive set of tasks, goals, and evaluations.

To support the Taylor Engineering staff, and due to the amount of new technology on the ZLC top handler including motors, power inverters, powertrain control, battery containment, vehicle controls, etc., Taylor coordinated heavily during the prototype planning, build, validation and testing processes with its suppliers. Individual components were delivered for assembly validated, tested, and certified where possible.

For powered industrial lift trucks, including top handlers, their use is governed by OSHA 29 CFR 1910.178. Contained in the OSHA standard is a requirement to purchase and operate equipment according to the requirements of ANSI/ITSDF B56.1 which is the overarching safety standard for units operated in North America. Also included in these standards are requirements for approved electric trucks, which are designated “E” to meet the requirements of UL 583 for fire protection and safety. Taylor contracted Intertek, a nationally recognized testing laboratory (NRTL) to oversee and audit, to the extent possible, the design to meet the UL 583 standard. This included a full operational safety audit. In the “pre-production” phase, a requirement of the grant application, many components do not carry full certification due to the prototype nature and likelihood of modifications learned during the demonstration.

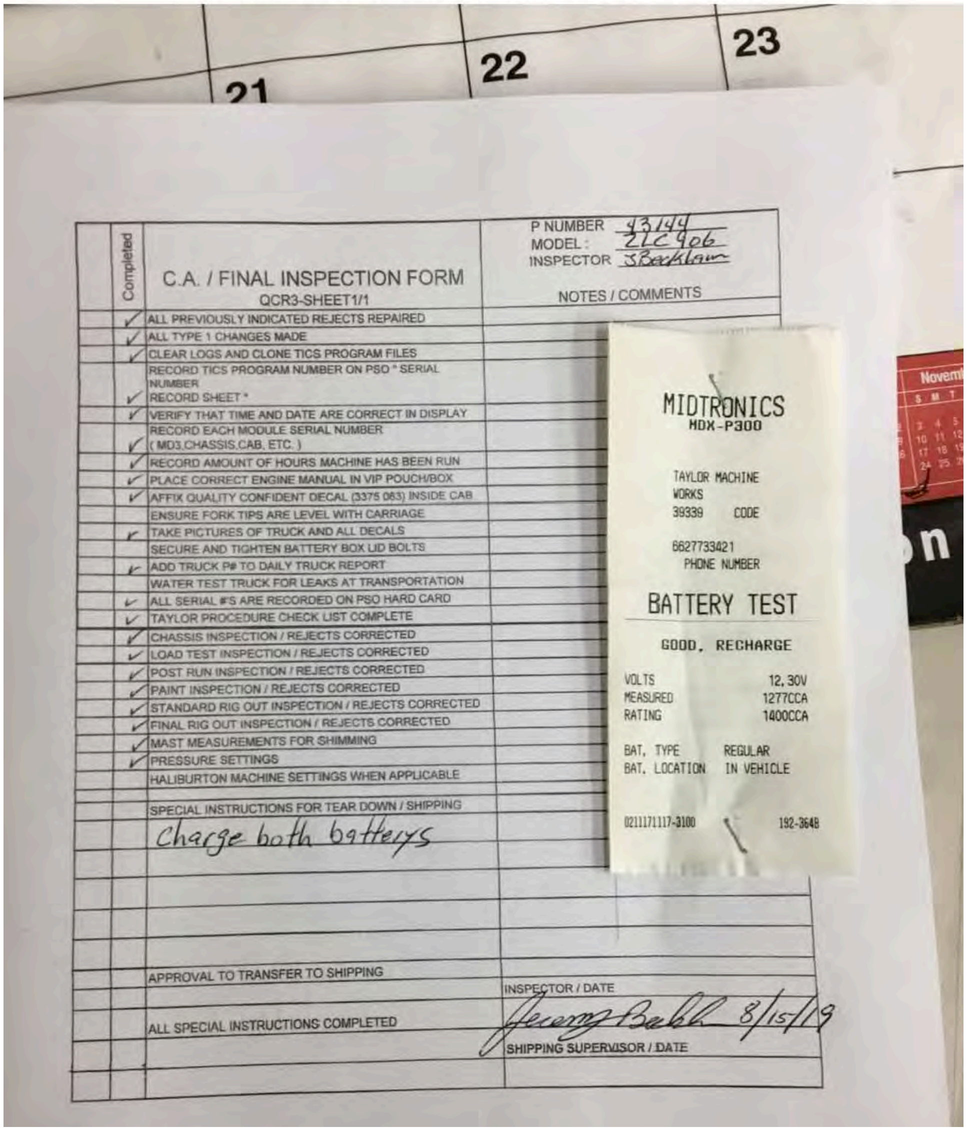
The Taylor top handlers were fully audited for safety relative to the applicable standard referenced above, including the third-party safety audit provided by Intertek. The units were delivered meeting all requirement for the pre-production units.

As the last step before preparing the demonstration units for delivery, Taylor tested the onboard charging equipment with the BYD Charging System with success. The BYD Charging System is a 200 kW system with two 100 kW (each) charging cables. Charging time ranges from five to six hours, depending on the state of the batteries. The electric top handlers passed performance testing conducted prior to delivery.

7.0 Operational Evaluation and Delivery Authorization:

Below is documentation of operational testing and quality assurance and pre-delivery inspection (PDI) results. This section also documents that Taylor released the units to be shipped to its local distributor, Cal-Lift, for assembly at LBCT and SSA.

Asset Number: 40004061146 Asset Identifier: 43144 Element: CAF #1



Completed	C.A. / FINAL INSPECTION FORM QCR3-SHEET1/1	P NUMBER 43144 MODEL: ZLC 906 INSPECTOR J Backlam NOTES / COMMENTS
✓	ALL PREVIOUSLY INDICATED REJECTS REPAIRED	
✓	ALL TYPE 1 CHANGES MADE	
✓	CLEAR LOGS AND CLONE TICS PROGRAM FILES	
✓	RECORD TICS PROGRAM NUMBER ON PSO " SERIAL NUMBER RECORD SHEET "	
✓	VERIFY THAT TIME AND DATE ARE CORRECT IN DISPLAY	
✓	RECORD EACH MODULE SERIAL NUMBER (MD3,CHASSIS,CAB, ETC.)	
✓	RECORD AMOUNT OF HOURS MACHINE HAS BEEN RUN	
✓	PLACE CORRECT ENGINE MANUAL IN VIP POUCH/BOX	
✓	AFFIX QUALITY CONFIDENT DECAL (3375 063) INSIDE CAB	
	ENSURE FORK TIPS ARE LEVEL WITH CARRIAGE	
✓	TAKE PICTURES OF TRUCK AND ALL DECALS	
	SECURE AND TIGHTEN BATTERY BOX LID BOLTS	
✓	ADD TRUCK P# TO DAILY TRUCK REPORT	
	WATER TEST TRUCK FOR LEAKS AT TRANSPORTATION	
✓	ALL SERIAL #'S ARE RECORDED ON PSO HARD CARD	
✓	TAYLOR PROCEDURE CHECK LIST COMPLETE	
✓	CHASSIS INSPECTION / REJECTS CORRECTED	
✓	LOAD TEST INSPECTION / REJECTS CORRECTED	
✓	POST RUN INSPECTION / REJECTS CORRECTED	
✓	PAINT INSPECTION / REJECTS CORRECTED	
✓	STANDARD RIG OUT INSPECTION / REJECTS CORRECTED	
✓	FINAL RIG OUT INSPECTION / REJECTS CORRECTED	
✓	MAST MEASUREMENTS FOR SHIMMING	
✓	PRESSURE SETTINGS	
	HALIBURTON MACHINE SETTINGS WHEN APPLICABLE	
	SPECIAL INSTRUCTIONS FOR TEAR DOWN / SHIPPING	
	Charge both batterys	
	APPROVAL TO TRANSFER TO SHIPPING	INSPECTOR / DATE
	ALL SPECIAL INSTRUCTIONS COMPLETED	Jeremy Babb 8/15/19 SHIPPING SUPERVISOR / DATE

MIDTRONICS
HDX-P300

TAYLOR MACHINE
WORKS
39339 CODE

6627733421
PHONE NUMBER

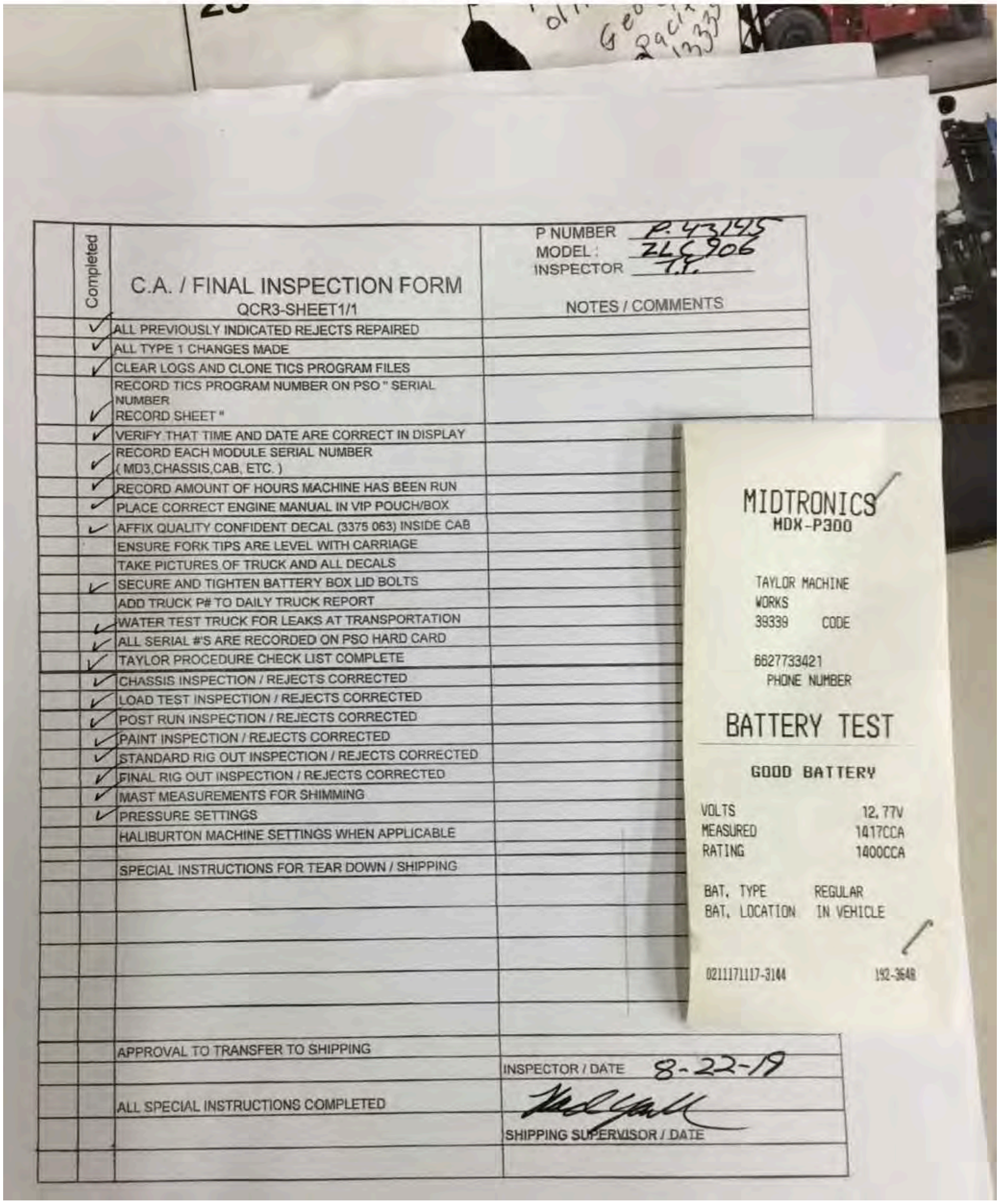
BATTERY TEST

GOOD, RECHARGE

VOLTS	12.30V
MEASURED	1277CCA
RATING	1400CCA
BAT. TYPE	REGULAR
BAT. LOCATION	IN VEHICLE

0211171117-3100 192-364B

Asset Number: 40004061165 Asset Identifier: 43145 Element: CAF #1



P NUMBER P. 43145
MODEL : ZLC 906
INSPECTOR T.Y.

Completed	C.A. / FINAL INSPECTION FORM QCR3-SHEET1/1	NOTES / COMMENTS
✓	ALL PREVIOUSLY INDICATED REJECTS REPAIRED	
✓	ALL TYPE 1 CHANGES MADE	
✓	CLEAR LOGS AND CLONE TICS PROGRAM FILES	
✓	RECORD TICS PROGRAM NUMBER ON PSO " SERIAL NUMBER RECORD SHEET "	
✓	VERIFY THAT TIME AND DATE ARE CORRECT IN DISPLAY	
✓	RECORD EACH MODULE SERIAL NUMBER (MD3,CHASSIS,CAB, ETC.)	
✓	RECORD AMOUNT OF HOURS MACHINE HAS BEEN RUN	
✓	PLACE CORRECT ENGINE MANUAL IN VIP POUCH/BOX	
✓	AFFIX QUALITY CONFIDENT DECAL (3375 063) INSIDE CAB	
	ENSURE FORK TIPS ARE LEVEL WITH CARRIAGE	
	TAKE PICTURES OF TRUCK AND ALL DECALS	
✓	SECURE AND TIGHTEN BATTERY BOX LID BOLTS	
	ADD TRUCK P# TO DAILY TRUCK REPORT	
✓	WATER TEST TRUCK FOR LEAKS AT TRANSPORTATION	
✓	ALL SERIAL #'S ARE RECORDED ON PSO HARD CARD	
✓	TAYLOR PROCEDURE CHECK LIST COMPLETE	
✓	CHASSIS INSPECTION / REJECTS CORRECTED	
✓	LOAD TEST INSPECTION / REJECTS CORRECTED	
✓	POST RUN INSPECTION / REJECTS CORRECTED	
✓	PAINT INSPECTION / REJECTS CORRECTED	
✓	STANDARD RIG OUT INSPECTION / REJECTS CORRECTED	
✓	FINAL RIG OUT INSPECTION / REJECTS CORRECTED	
✓	MAST MEASUREMENTS FOR SHIMMING	
✓	PRESSURE SETTINGS	
	HALIBURTON MACHINE SETTINGS WHEN APPLICABLE	
	SPECIAL INSTRUCTIONS FOR TEAR DOWN / SHIPPING	
	APPROVAL TO TRANSFER TO SHIPPING	INSPECTOR / DATE 8-22-19
	ALL SPECIAL INSTRUCTIONS COMPLETED	SHIPPING SUPERVISOR / DATE

MIDTRONICS
MDX-P300

TAYLOR MACHINE
WORKS
39339 CODE

6627733421
PHONE NUMBER

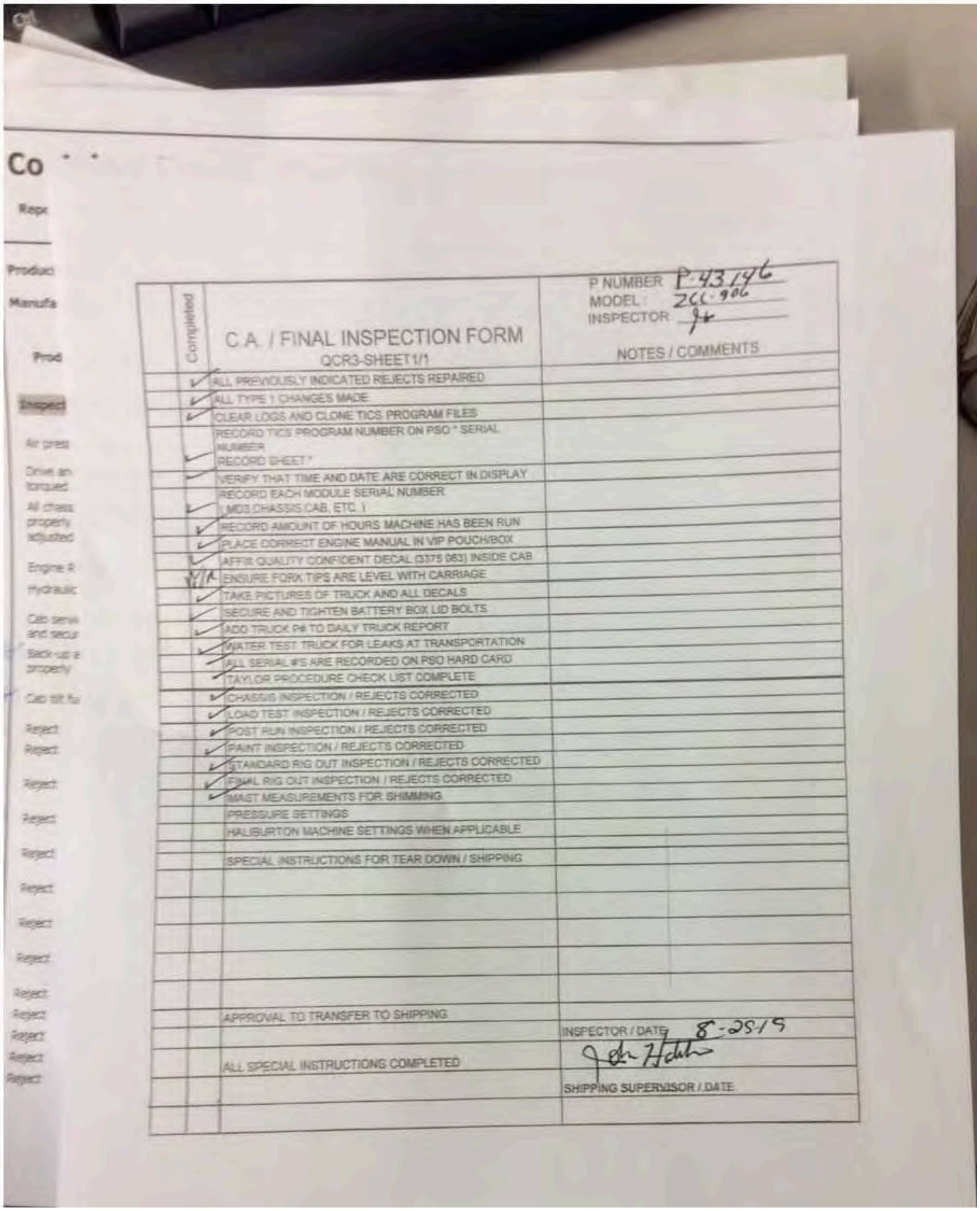
BATTERY TEST

GOOD BATTERY

VOLTS	12.77V
MEASURED	1417CCA
RATING	1400CCA
BAT. TYPE	REGULAR
BAT. LOCATION	IN VEHICLE

0211171117-3144 192-3648

Asset Number: 40004061182 Asset Identifier: 43146 Element: CAF #1



P NUMBER P-43146
MODEL ZLC-906
INSPECTOR JH

Completed	C.A. / FINAL INSPECTION FORM QCR3-SHEET1/1	NOTES / COMMENTS
✓	ALL PREVIOUSLY INDICATED REJECTS REPAIRED	
✓	ALL TYPE 1 CHANGES MADE	
✓	CLEAR LOGS AND CLONE TICS PROGRAM FILES	
✓	RECORD TICS PROGRAM NUMBER ON PSO " SERIAL NUMBER RECORD SHEET "	
✓	VERIFY THAT TIME AND DATE ARE CORRECT IN DISPLAY	
✓	RECORD EACH MODULE SERIAL NUMBER (MD3,CHASSIS,CAB, ETC.)	
✓	RECORD AMOUNT OF HOURS MACHINE HAS BEEN RUN	
✓	PLACE CORRECT ENGINE MANUAL IN VIP POUCH/BOX	
✓	AFFIX QUALITY CONFIDENT DECAL (3375 063) INSIDE CAB	
N/A	ENSURE FORK TIPS ARE LEVEL WITH CARRIAGE	
✓	TAKE PICTURES OF TRUCK AND ALL DECALS	
✓	SECURE AND TIGHTEN BATTERY BOX LID BOLTS	
✓	ADD TRUCK P# TO DAILY TRUCK REPORT	
✓	WATER TEST TRUCK FOR LEAKS AT TRANSPORTATION	
✓	ALL SERIAL #'S ARE RECORDED ON PSO HARD CARD	
✓	TAYLOR PROCEDURE CHECK LIST COMPLETE	
✓	CHASSIS INSPECTION / REJECTS CORRECTED	
✓	LOAD TEST INSPECTION / REJECTS CORRECTED	
✓	POST RUN INSPECTION / REJECTS CORRECTED	
✓	PAINT INSPECTION / REJECTS CORRECTED	
✓	STANDARD RIG OUT INSPECTION / REJECTS CORRECTED	
✓	FINAL RIG OUT INSPECTION / REJECTS CORRECTED	
✓	MAST MEASUREMENTS FOR SHIMMING	
	PRESSURE SETTINGS	
	HALIBURTON MACHINE SETTINGS WHEN APPLICABLE	
	SPECIAL INSTRUCTIONS FOR TEAR DOWN / SHIPPING	
	APPROVAL TO TRANSFER TO SHIPPING	
		INSPECTOR / DATE 8-25-19
	ALL SPECIAL INSTRUCTIONS COMPLETED	John Hatch
		SHIPPING SUPERVISOR / DATE

8.0 Operational Event Summary:

-1-23-20 **P43144** High Voltage System Error. Voltage leakage detection. Problem was the in cab heater circuit had moisture in the box. Issue is resolved. 1 day downtime.

-1-29-20 **P43146** Cracked differential Drive motor. Issue is resolved. Down time from 1-28-2020 to 2-6-2020

-2-26-20 Chargers tripping out at **SSA**. Fernando Villasenor went and turned the setting in the chargers up to .5 and it charged to 100 percent without fail. No run time lost.

-2-27-20 **P43145** High Voltage system error. Issue resolved. No down time

-2-27-20 **P43145** 1 On-Board-Charger rack not charging. Issue not resolved coordinating with BYD on getting repairs. Truck is not down but takes twice as long to charge.

-3-12-20 **P43145 SSA.** High System Voltage error. Truck down. Found issue with battery pack #4 service switch. This unit was down until end of March but the issue resolved above should have it back up ASAP. It still has the OBC(on-board Charger) issue that causes it to charge at a slower rate. BYD is engaged and working on this. Covid-19 travel restrictions are having some effect on response times from their end and ours.

-3-11-19 **P43146 SSA** Truck Down. Leak spotted which led to diagnosing a cracked drive motor. This unit was down the rest of March due to parts and travel restrictions. The repair is in process now (1st week of April) and should be complete ASAP.

-P43144 at LBCT has no issues and is operational.

- 4-25-20 **P43144 at LBCT** had and transmission oil leak and was repaired the next day.

- **P43145 SSA** has been running without issue but it does have a bad OBC (detailed in March post) which is set to be replaced this week.

-4-7-20 **P43146 SSA** Drive motor was replaced. We experienced some issues with install which were resolved on 4-10-20 and the unit was put back into service on 4-13-20.

P43145 SSA OBC (On Board Charger) was replaced on 5-7-20 and has been running without any additional issues.

P43144 at LBCT and P43146 SSA have reported no issues in May.

P43144 at LBCT In Service. No issues reported in June

P43145 at SSA In Service. No issues reported in June

P43146 at SSA lift steer motor coupling broke on 6-22-20 and was repaired next day 6-23-20.

P43144 at LBCT In Service. No issues reported in July

P43145 at SSA In Service. No issues reported in July

P43146 at SSA In Service. No issues reported in July

P43144 at LBCT In Service. No issues reported in Aug.

P43145 at SSA In Service. No issues reported in Aug.

P43146 at SSA In Service. Aug 11th Machine down(Failure of a nylon coupling). Aug 16th Coupling replaced and machine returned to service.

P43144 at LBCT In Service. No issues reported in September

P43145 at SSA In Service. No issues reported in September

P43146 at SSA In Service. No issues reported in September

P43144 at LBCT In Service. No issues reported in October

P43145 at SSA In Service. No issues reported in October

P43146 at SSA In Service. No issues reported in October

P43144 at LBCT In Service. No issues reported in November

P43145 at SSA In Service. No issues reported in November

P43146 at SSA In Service. No issues reported in November

P43144 at LBCT In Service. No issues reported in December

P43145 at SSA In Service. No issues reported in December

P43146 at SSA In Service. No issues reported in December

P43144 at LBCT Unit down for all of JAN while Cal Lift installed Over height Lugs (Wiring harness and BMS work also). Unit is now back in service (2-5-21).

P43145 at SSA In Service. No issues reported in January

P43146 at SSA In Service. No issues reported in January

P43144 at LBCT Unit back in service (2-5-21). A/C not operational so breaker remained off but all other issues at this time were resolved. New issues (will elaborate more on March report) reported by LBCT include dba type noise complaint, Inching function not adjusted properly and Cabin Heater breaker which correlates to A/C issue above. Cal Lift is on site this week and I should get an update to how they addressed these issues. Note: Our Taylor West Coast Service Rep Rob Anatra and our Factory based ZLC service *specialist Justin Straight have offered to visit Jeff at LBCT the week of the 22nd to discuss these issues and ensure that they have been addressed to his satisfaction.*

P43145 at SSA In Service. No issues reported in February

P43146 at SSA In Service. No issues reported in February

P43144 at LBCT In Service. No issues reported in March

P43145 at SSA In Service. No issues reported in March

P43146 at SSA In Service. No issues reported in March

P43144 at LBCT was down due to a coupling failure on the pump. It was down from April 14 until April 23 when the update to the pump and motor was done. Unit is back in service.

P43145 at SSA In Service. No issues reported in April

P43146 at SSA In Service. No issues reported in April

P43144 at LBCT was taken out of service May 20th due to:

- The spindle shims on the steer axle are incorrect and the wheels have been rubbing on the steer axle
- The display on the charger panel is not working
- The decal on the front of the charging unit that illustrates the LED's and charging status has fallen off

It was returned to service on June 7th

P43145 at SSA In Service. No issues reported in May

P43146 at SSA In Service. No issues reported in Ma

9.0 Run Time Reporting:

9.1 ZLC-906 P-43144 Long Beach Container Terminal.

NOTE: These data are sourced Taylor's own internal data collection system, values may vary from the C-PORT data collector's equipment, calibration and analysis, and can be outside the scope of the CARB Appendix F requirements.

See below for the final data.

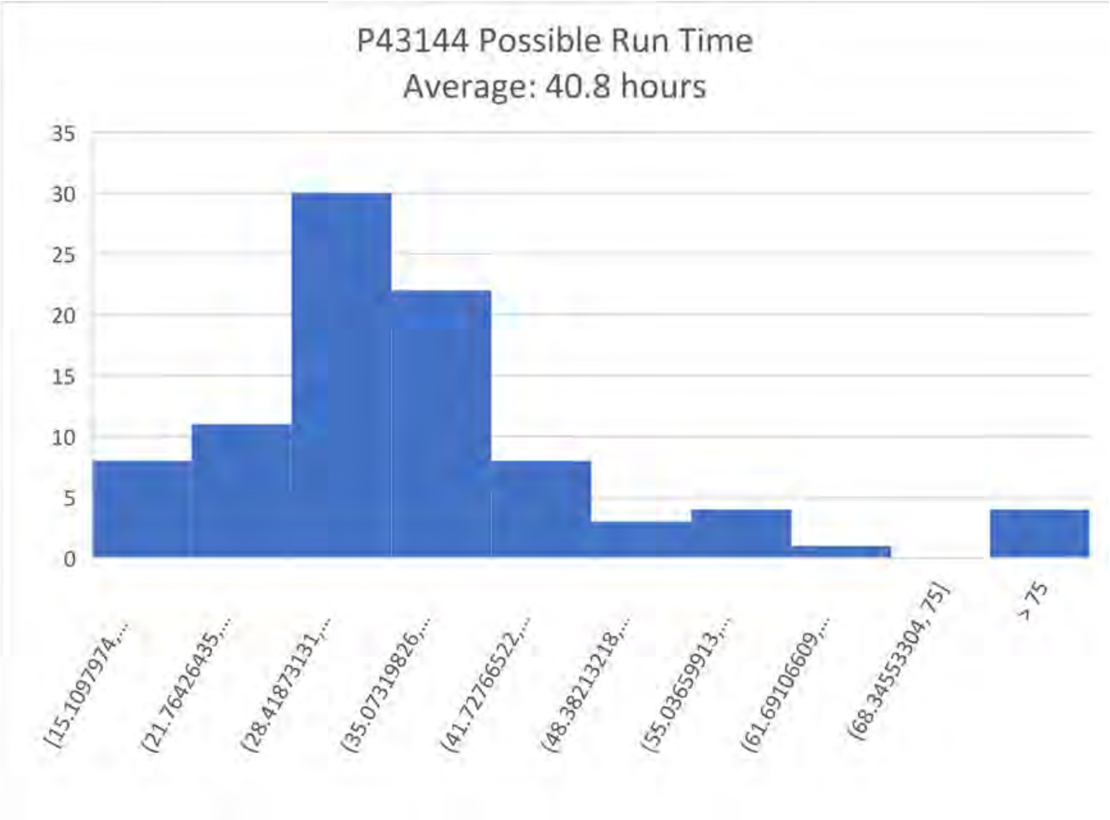
Index:	Date	Cummulative Run Time (h)	State of Charge Used (%)	SOC Energy Per Hour (kWh/h)	Calculated Run Time @95% of 922 kWh
1	2020-04-24	0.033929722	0.199996948	54.34680104	16.11686398
2	2020-07-10	0.050899444	0.300003052	54.34299269	16.11799345
3	2020-08-25	0.254494722	1.099998474	39.85145878	21.97912014
4	2020-08-26	0.152695278	0.599998474	36.22892608	24.1768138
5	2020-09-10	0.433915	1.400001526	29.74779408	29.44420005
6	2020-09-11	0.404655556	0.900001526	20.50636388	42.71356956
8	2020-10-28	0.830731667	4.699996948	52.16362106	16.79139565
9	2020-10-29	3.003106944	7.900005341	24.2542309	36.11328694
10	2020-10-30	8.010838889	17.79999924	20.48674243	42.75447905
11	2020-10-31	3.968233889	7.200000763	16.72885442	52.35863604
12	2020-12-01	0.20358	0.399997711	18.1156248	48.35052666
13	2020-12-02	0.345658889	0.099998474	2.667328864	328.3809551
14	2021-02-20	3.024085278	7.399993896	22.56151446	38.82274842
15	2021-02-21	1.017998889	2.400001526	21.73677625	40.29576373
16	2021-02-23	0.404512778	2	45.58570461	19.21435694
17	2021-02-24	0.777819167	3.199996948	37.9316596	23.09152853

18	2021-02-25	1.372719444	3.600006104	24.17978153	36.22447948
19	2021-02-26	2.918251111	6.099998474	19.27249705	45.44818441
20	2021-02-27	0.458081944	2.200004578	44.2803792	19.78077008
21	2021-03-02	0.508961111	3.199996948	57.96901024	15.1097974
22	2021-03-03	0.818221667	1.400001526	15.7756933	55.52212401
23	2021-03-04	0.5665475	2.099998474	34.17539735	25.62954838
24	2021-03-08	0.356295833	1.000007629	25.87756993	33.84784593
25	2021-03-09	0.765644444	2.699996948	32.51374975	26.93937201
26	2021-03-15	0.576841389	0.399997711	6.393402013	137.0006138
27	2021-03-23	1.237411944	3.399997711	25.33350275	34.57476878
28	2021-03-24	0.14315	0.099998474	6.440698089	135.9945751
29	2021-03-25	0.746495833	2.5	30.87760034	28.36684167
30	2021-03-30	1.628809167	3.899993896	22.07621645	39.67618282
31	2021-03-31	4.183018333	13.90000153	30.63768883	28.58897108
32	2021-04-01	5.532750833	11.59999847	19.33070712	45.31132744
33	2021-04-02	7.29472	19.09999847	24.14102062	36.28264164
34	2021-04-03	4.686926944	7.599998474	14.95051806	58.58659857
35	2021-04-05	2.341406389	6.700000763	26.3832914	33.19904203
36	2021-04-06	3.986999722	11.40000153	26.36268407	33.22499324
37	2021-04-07	4.819006667	11.3999939	21.81112229	40.15841039
38	2021-04-08	5.972713333	15.60000229	24.08152092	36.3722874
39	2021-04-09	3.070623889	8.5	25.52250058	34.31873758

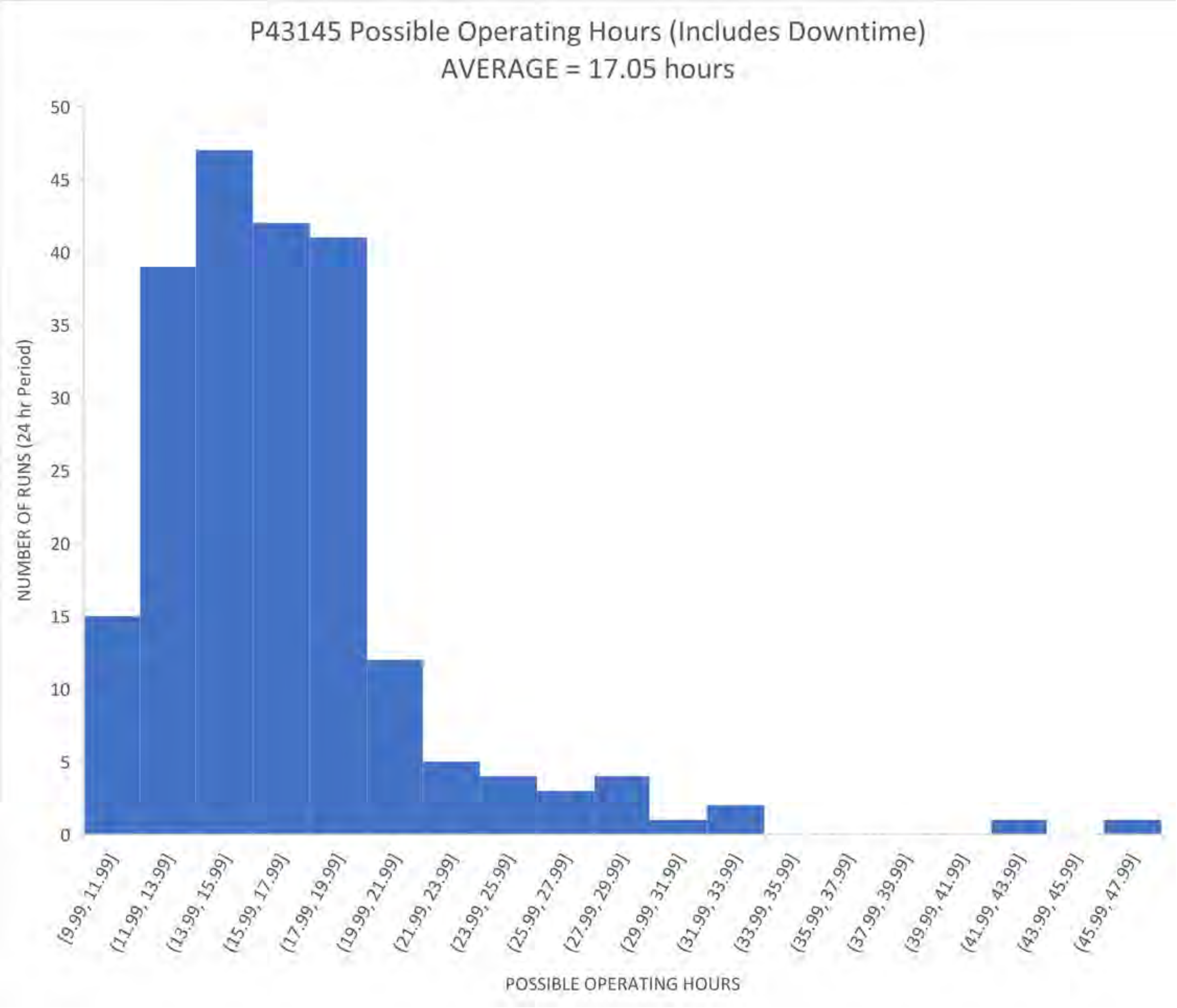
40	2021-04-10	4.258604167	15	32.47542964	26.97115972
41	2021-04-12	3.851399167	8.300003052	19.86966939	44.08226341
42	2021-04-13	4.589826389	12.89999771	25.91339385	33.80105305
43	2021-04-14	1.662633611	6.300003052	34.93615656	25.07144707
44	2021-04-23	0.067866389	0.199996948	27.17061999	32.23702662
45	2021-04-28	0.185034722	0.600006104	29.89739552	29.29686633
46	2021-04-29	5.387241667	15.90000153	27.21207311	32.18791882
47	2021-04-30	3.036322222	8.300003052	25.20352668	34.7530729
48	2021-05-01	3.110530278	9	26.67712338	32.83337515
49	2021-05-03	3.612905556	11.40000153	29.09237799	30.10754227
50	2021-05-04	4.156858056	11.5	25.50724576	34.3392622
51	2021-05-05	5.709065	15.8999939	25.67810031	34.11077882
52	2021-05-06	5.259360833	14.70000458	25.77005961	33.98905603
53	2021-05-07	2.544950833	6.5	23.54858853	37.19543526
54	2021-05-08	3.780481389	6.700000763	16.34024895	53.60383448
55	2021-05-10	2.586339722	10.79999924	38.50073991	22.75021213
56	2021-05-11	4.570208333	13	26.22637553	33.39767628
57	2021-05-12	6.510777778	15.70000076	22.23298229	39.39642413
58	2021-05-13	4.860395278	11.90000153	22.57388706	38.80146993
59	2021-05-14	6.529948889	10.09999847	14.26075265	61.42032061
60	2021-05-15	3.606959722	9	23.00552443	38.07346373
61	2021-05-16	3.053760833	3.099998474	9.359601976	93.58303934

62	2021-05-17	4.907745833	8.799999237	16.53223205	52.98135166
63	2021-05-18	3.131136389	9.299999237	27.38494346	31.98472918
64	2021-05-19	4.306966944	12.69999695	27.18710716	32.21747701
65	2021-05-22	0.587133056	3.199996948	50.25091261	17.43052921
66	2021-05-25	0.441136944	1.800003052	37.62103434	23.28218815
67	2021-06-03	0.016966944	0.099998474	54.34012791	16.11884318
68	2021-06-09	3.885363611	9.100006104	21.59438978	40.56146104
69	2021-06-10	4.292623611	11.19999695	24.05614403	36.41065662
70	2021-06-11	3.664976389	9.900001526	24.90548489	35.16895993
71	2021-06-12	3.359333056	9	24.70133167	35.4596267
72	2021-06-14	4.886503889	7.600002289	14.339909	61.08128022
73	2021-06-15	4.445670556	11.79999924	24.47234711	35.7914178
74	2021-06-29	2.476550833	7.099998474	26.43272452	33.13695489
75	2021-06-30	4.1395725	10.80000305	24.05466462	36.41289596
76	2021-07-01	4.580951111	14.5	29.18389582	30.01312797
77	2021-07-02	5.004996944	15.10000229	27.81660462	31.4883866
78	2021-07-03	3.393300833	9.299999237	25.26919869	34.66275329
79	2021-07-06	4.614867778	11.5	22.97573952	38.12282077
80	2021-07-07	7.244336111	28.89999914	36.78156121	23.81356232
81	2021-07-19	1.781228889	5.200004578	26.91627253	32.54165298
82	2021-07-20	3.681785833	10.80000305	27.0455786	32.38606994
83	2021-07-21	6.0398825	18.90000153	28.85122584	30.3591953

84	2021-07-24	3.715741944	9.700004578	24.06895945	36.39126991
85	2021-07-26	5.022089722	11.40000153	20.92913904	41.85074208
86	2021-07-27	4.173818611	9.400001526	20.76468149	42.18220252
87	2021-07-28	5.887608611	16.70000076	26.15221514	33.49238278
88	2021-07-29	5.259898333	13.5	23.66395548	37.01409938
89	2021-07-30	4.682747778	15.00000191	29.53394548	29.65739882
90	2021-07-31	2.900988889	8.400001526	26.69710814	32.80879695
91	2021-08-01	0.407198889	0.599998474	13.58546421	64.47332137
92	2021-08-02	3.834155	9.700004578	23.32561991	37.55098486
	Average:	3.039576954	8.063736502	26.79702568	40.83219988



9.2 ZLC-906 P-43145 SSA Marine


P43145 Possible Operating Hours (Includes Downtime)
AVERAGE = 17.05 hours
NUMBER OF RUNS (24 hr Period)
50
45
40
35
30
25
20
15
10
5
0
[9.99, 11.99]
(11.99, 13.99]
(13.99, 15.99]
(15.99, 17.99]
(17.99, 19.99]
(19.99, 21.99]
(21.99, 23.99]
(23.99, 25.99]
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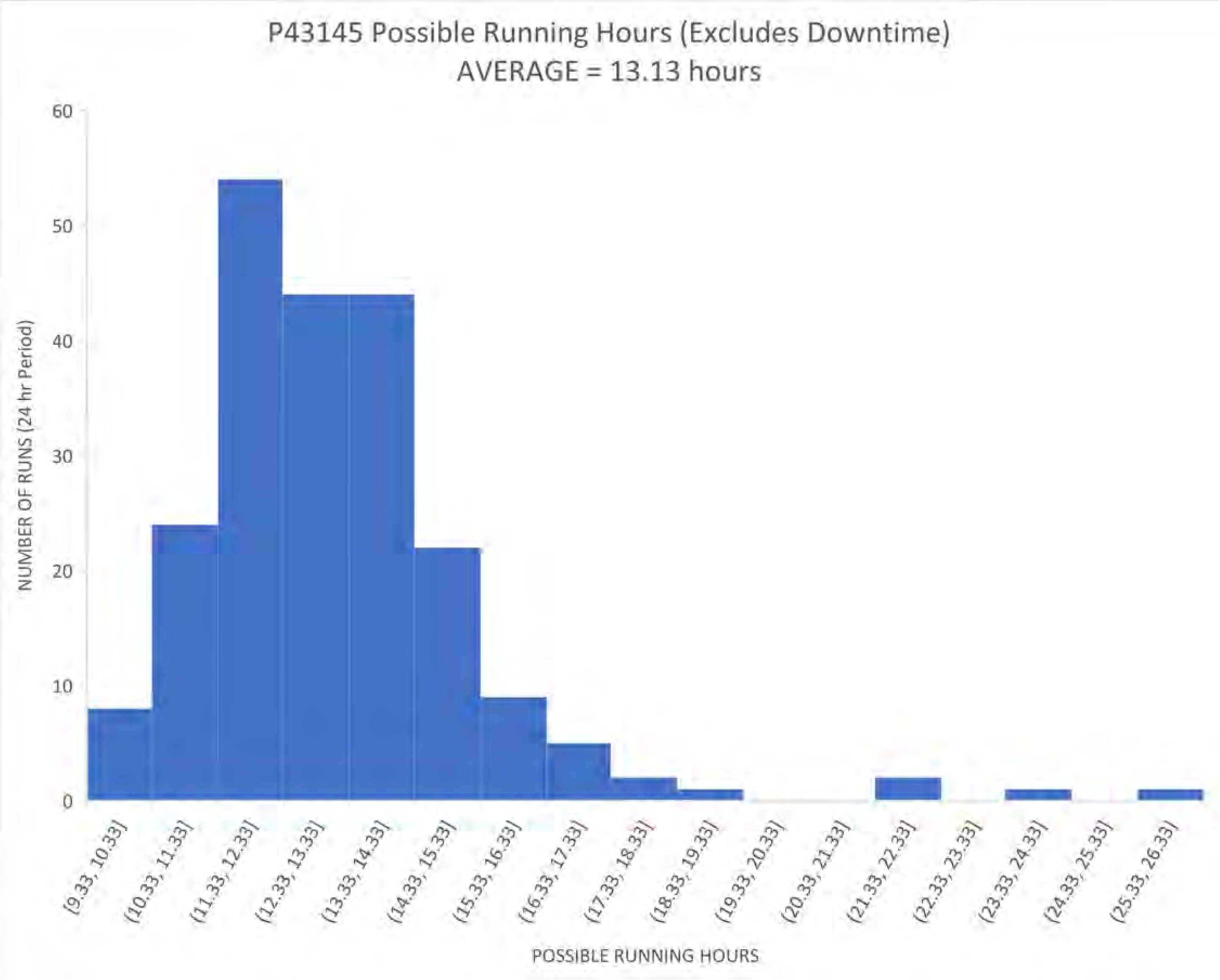
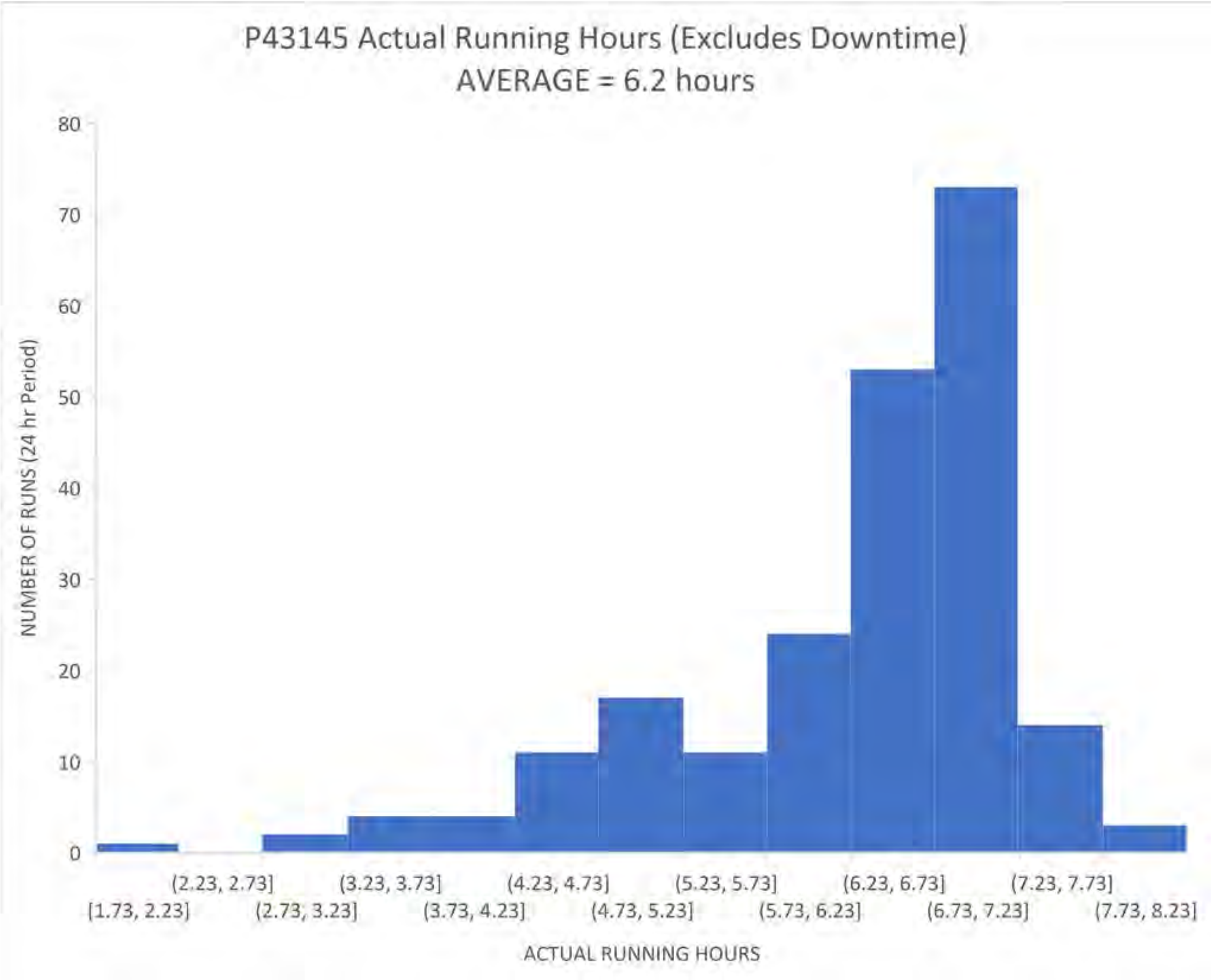
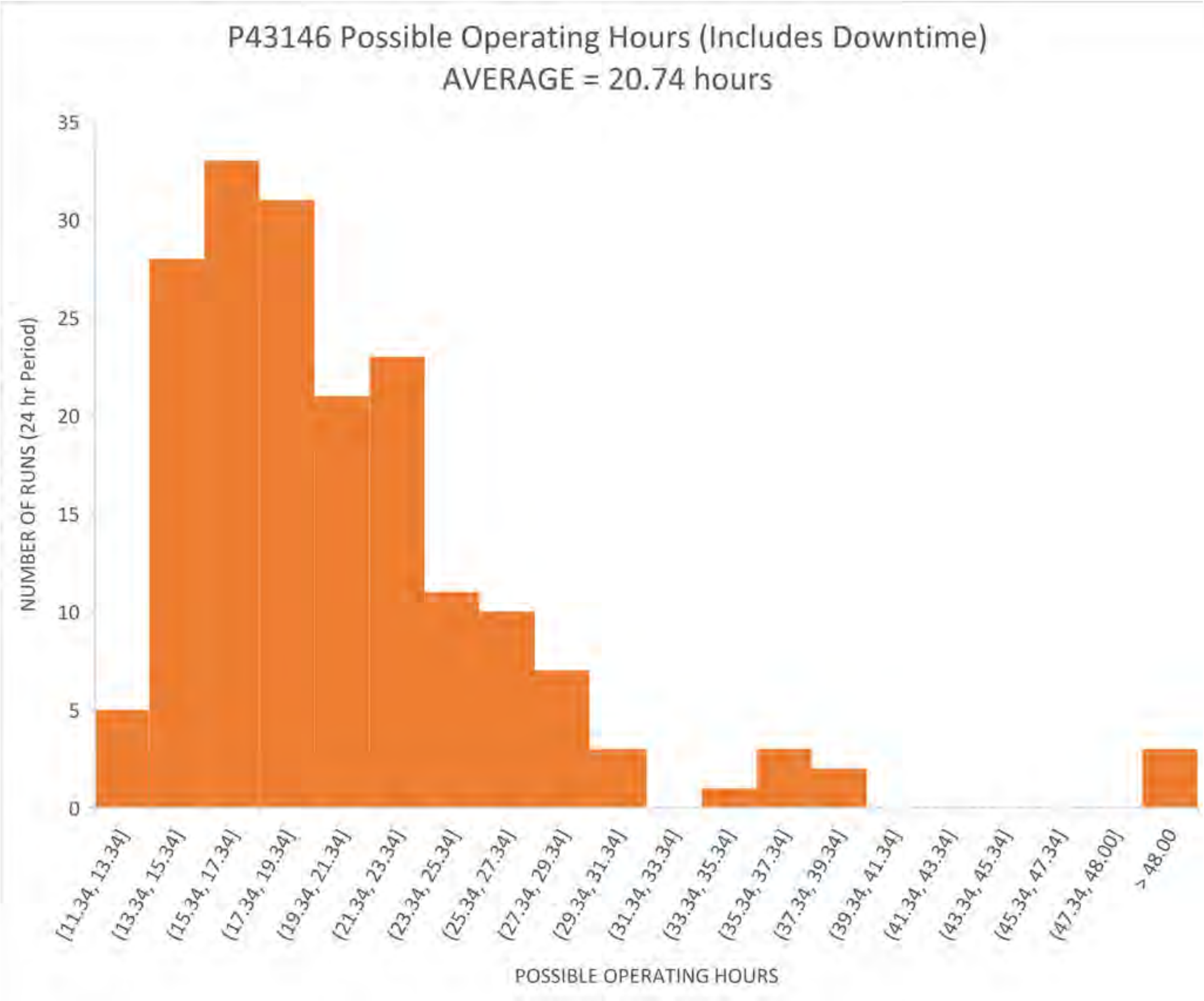
(37.99, 39.99]
(39.99, 41.99]
(41.99, 43.99]
(43.99, 45.99]
(45.99, 47.99]
POSSIBLE OPERATING HOURS

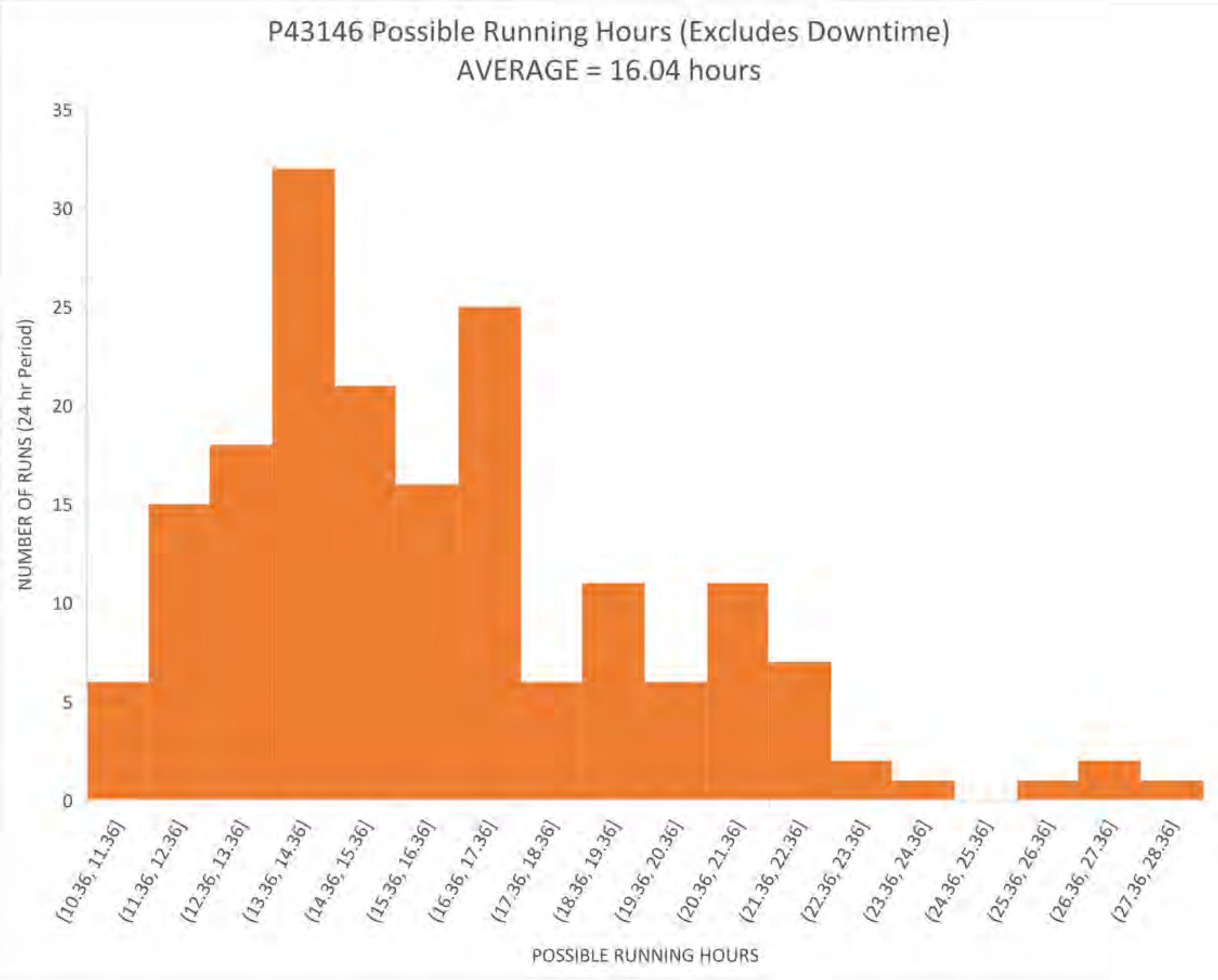

P43145 Possible Running Hours (Excludes Downtime)
AVERAGE = 13.13 hours
NUMBER OF RUNS (24 hr Period)
0
10
20
30
40
50
60
[9.33, 10.33]
(10.33, 11.33]
(11.33, 12.33]
(12.33, 13.33]
(13.33, 14.33]
(14.33, 15.33]
(15.33, 16.33]
(16.33, 17.33]
(17.33, 18.33]
(18.33, 19.33]
(19.33, 20.33]
(20.33, 21.33]
(21.33, 22.33]
(22.33, 23.33]
(23.33, 24.33]
(24.33, 25.33]
(25.33, 26.33]
POSSIBLE RUNNING HOURS


P43145 Actual Running Hours (Excludes Downtime)
AVERAGE = 6.2 hours
NUMBER OF RUNS (24 hr Period)
80
70
60
50
40
30
20
10
0
[1.73, 2.23]
(2.23, 2.73]
(2.73, 3.23]
(3.23, 3.73]
(3.73, 4.23]
(4.23, 4.73]
(4.73, 5.23]
(5.23, 5.73]
(5.73, 6.23]
(6.23, 6.73]
(6.73, 7.23]
(7.23, 7.73]
(7.73, 8.23]
ACTUAL RUNNING HOURS


P43145 Picks Per Hour
AVERAGE = 20.9 picks/hr
NUMBER OF RUNS (24 hr Period)
0
10
20
30
40
50
60
70
[5.51, 10.51]
(10.51, 15.51]
(15.51, 20.51]
(20.51, 25.51]
(25.51, 30.51]
(30.51, 35.51]
(35.51, 40.51]
(40.51, 45.51]
PICKS PER HOUR

9.3 ZLC-906 P-43146 SSA Marine




P43146 Possible Running Hours (Excludes Downtime)
AVERAGE = 16.04 hours
NUMBER OF RUNS (24 hr Period)
35
30
25
20
15
10
5
0
(10.36, 11.36]
(11.36, 12.36]
(12.36, 13.36]
(13.36, 14.36]
(14.36, 15.36]
(15.36, 16.36]
(16.36, 17.36]
(17.36, 18.36]
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(23.36, 24.36]
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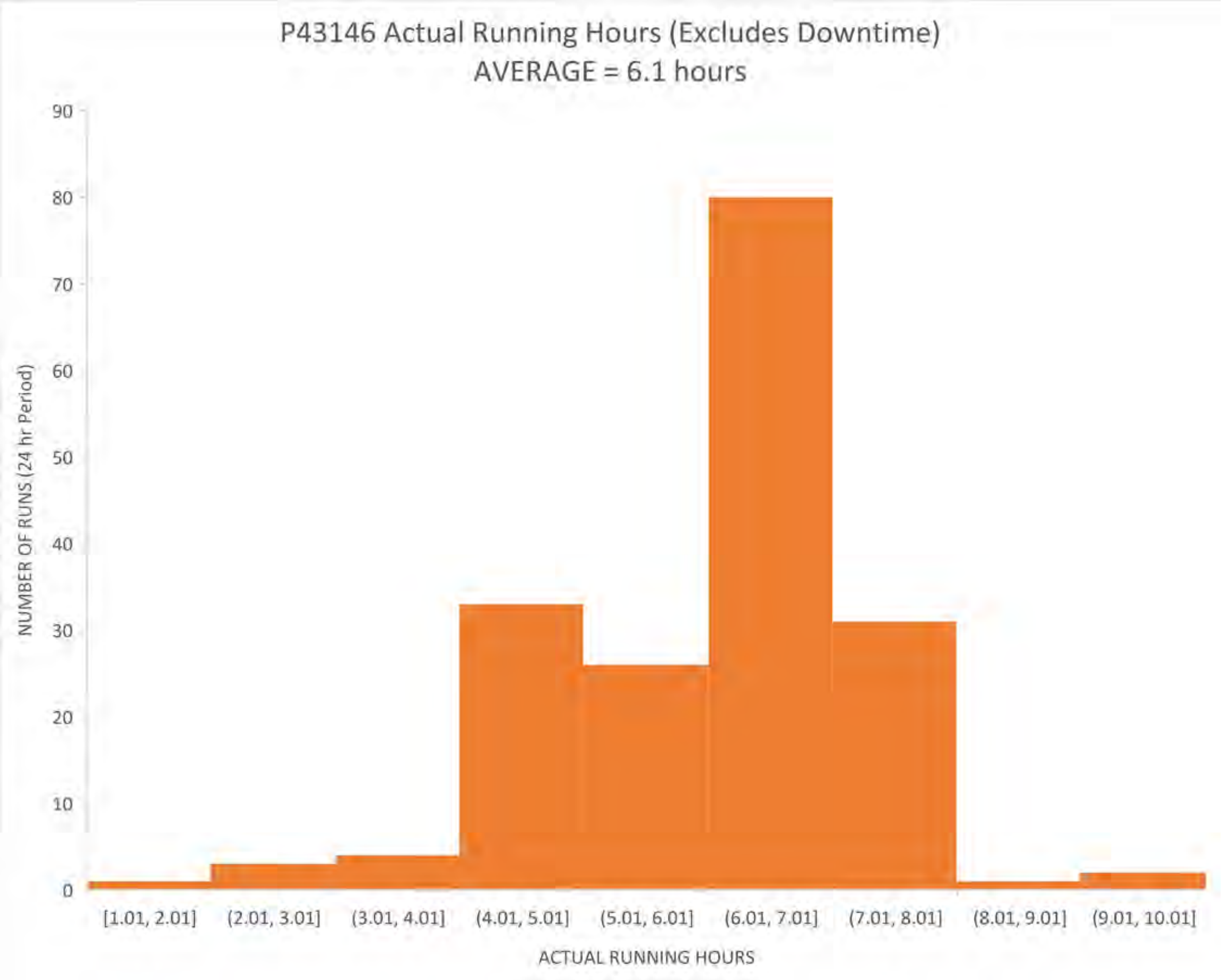
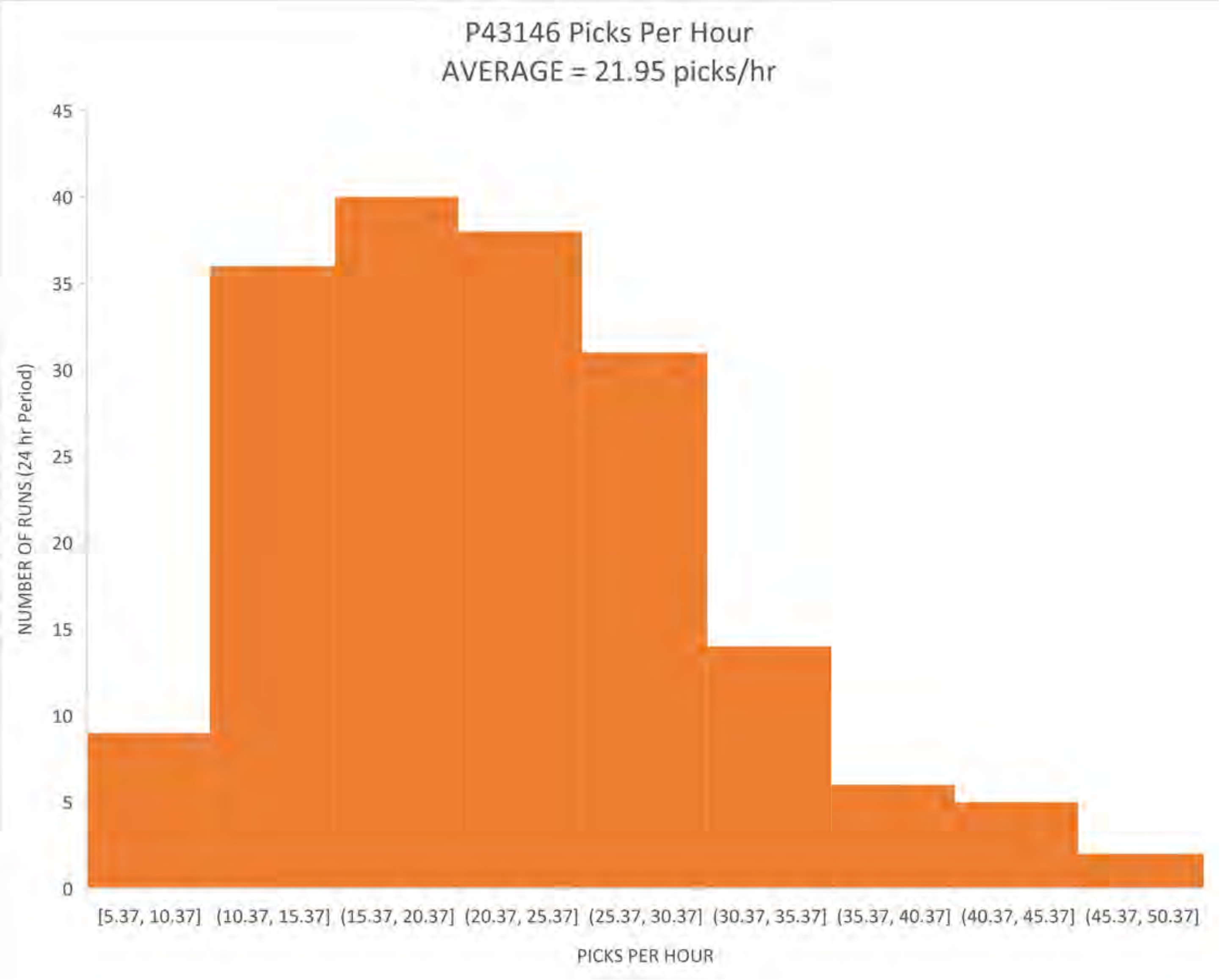
(27.36, 28.36]
POSSIBLE RUNNING HOURS



P43146 Actual Running Hours (Excludes Downtime)
AVERAGE = 6.1 hours
NUMBER OF RUNS (24 hr Period)
90
80
70
60
50
40
30
20
10
0
[1.01, 2.01]
(2.01, 3.01]
(3.01, 4.01]
(4.01, 5.01]
(5.01, 6.01]
(6.01, 7.01]
(7.01, 8.01]
(8.01, 9.01]
(9.01, 10.01]
ACTUAL RUNNING HOURS


P43146 Picks Per Hour
AVERAGE = 21.95 picks/hr
NUMBER OF RUNS (24 hr Period)
45
40
35
30
25
20
15
10
5
0
[5.37, 10.37]
(10.37, 15.37]
(15.37, 20.37]
(20.37, 25.37]
(25.37, 30.37]
(30.37, 35.37]
(35.37, 40.37]
(40.37, 45.37]
(45.37, 50.37]
PICKS PER HOUR

10.0 Operator Acceptance:

There were no issues with Operator Acceptance on the ZLC-906 Loaded Container Handlers. Taylor made a conscience decision to maintain all Operator Compartment Controls and Ergonomics from the XLC-976 IC Powered units that are operational on the Ports today. There are multiple hundreds of these baseline units currently being utilized across the Port of Long Beach and one of our priorities when designing these new ZLC-906 zero vehicle emission units was to make the transition from one unit to the other as seamless as possible.

The Operator compartment itself is the same as current production equipment and meets all safety standards (size, seat, doors, windows, controls, displays all remain the same as in the IC powered units). One noticeable difference is programming on the operator dash display that changed feedback to reflect battery charge levels instead of fuel levels. The operational performance of the ZLC's (Lift speeds, spreader functions and travel speeds) were also closely matched to the current production IC units so there would be very little difference in how the units "feel."

We have found that any operator who is trained and experienced on the current production model XLC-976 Container Handlers (IC power) can step into the ZLC-906 Zero Vehicle Emissions Unit and go straight to work. There is some training that is necessary on how to charge the units but the transition to operating the ZLC in normal port duty cycles (for existing trained operators) is almost immediate.

The main comment we have in the field is "This unit operates just like our other Taylor's…just quieter".

Note: There was operator pushback at LBCT due to the lack of Air Conditioning but not basic control of the machine. The unit was delivered as originally specified but after delivery, LBCT requested A/C be added to their machine based on this operator feedback.

11.0 Collaboration With Technology Providers:

The Taylor Design Engineering team is comprised of some of the longest tenured and most experienced large lift truck engineers in the industry. Development of the pre-commercial ZLC-906 and continuing through the soon to be released ZLC-996 still requires close collaboration with our technology partners to provide the quickest time to market with leading efficiency and technology. Technology partnerships exist in the areas of traction motor and motor controls, systems integration for high voltage components, battery supply and battery management, and vehicle control systems.

Taylor collaborated with our transmission supplier to provide traction gearing which meets the heavy demand of both low speed working torques and high travel speed power. While traditional powershift transmission hardware was incorporated, Taylor and its technology provider developed proprietary efficiency improvements in the torque converter controls.

Taylor also collaborated with our battery and battery management system provider to develop vehicle controls and systems integration. Taylor retains full vehicle control programming in-house and is capable of custom controls coding. This capability enabled a short development cycle. This work with battery systems seamlessly led to parallel development of charging hardware, charging controls and thermal management.

12.0 Lessons Learned:

The ZLC-906 demonstration project is the culmination of several years of development, validation, testing and adjustments. Each finite step of the development process provided Taylor, the Port, and the customer with valuable data and feedback regarding integration of BEV top handlers into an application dominated by diesel-powered mobile equipment.

Most significantly the project proved the concept of a two-full workshift capable machine. The average duty cycle exceeded the two-full workshift requirement, and further, the project revealed heavy duty cycles which require more energy. This additional energy requirement in the heaviest duty cycles will required extended run times provide through several options. The options include: 1.) higher system efficiencies to provide longer operating time using the same total stored energy; 2.) Higher efficiencies to provide more work with less total energy; and 3.) the consideration of modular stored energy to allow the matching of the appropriate stored energy to minimize cost.

Additionally, infrastructure remains as the consideration with the highest impact on operations. BEV equipment and the fundamental differences from liquid fuels in delivery, storage and refueling will require an iterative infrastructure development process. This is true due to the scale of both expense and total energy required. Taylor will continuously investigate and offer creative charging solutions using single point charging for flexibility, multi-point charging for cost effectiveness, and ESS (energy storage solutions). Logistics, labor considerations, maintenance, and installation permanents are all challenges which will require continuous development.

13.0 Future Application & Commercialization:

Electrification of off highway mobile equipment is a rapidly developing market. The technologies developed as part of this grant-funded demonstration will be quickly applied to a growing portfolio of zero and near-zero emissions models offered by Taylor machine works. The two soonest releases in this category are the “next generation” of EV top handlers and the first battery powered general-purpose forklift offered by Taylor. Taylor has chosen a new domestic supplier for their charging, battery, and battery controls partner moving forward into the commercialized products.

The ZLC-996 series of loaded container handlers will be a commercialized BEV unit which will feature technology directly evolved from the pre-commercial ZLC-906. This includes traction systems, battery and BMS systems, and hydraulic power system which feature state of the art hardware and software. The ZH-360L series of BEV forklifts will parallel the systems introduced in the ZLC models

C-PORT Final Report

Appendix C: Kalmar Yard Tractor Final Report

07.19.2021 **Draft Final Report**

Project Name
POLB/LBCT T2e

Client Name
POLB

Project Manager
Alan Wilson

Prepared By
Alan Wilson

Content

Statement of Work
- Task 3.2c – Battery-Electric Yard Tractor Design
- Task 3.2d – Battery-Electric Yard Tractor Component Ordering
- Task 3.2e – Battery-Electric Yard Tractor Build
- Task 3.2f – Provide Charging Infrastructure
- Task 3.2g – Battery-Electric Yard Tractor Delivery/Commission/Training
- Task 3.2h – Battery-Electric Yard Tractor Demonstration
    - Demonstration Summary
- Task 3.2i – Submit Draft & Final Reports/Attend Final Meeting

Service Summary
Safety Incident
Lessons Learned
Final Summary

Statement of Work

Task 3.2c – Battery-Electric Yard Tractor Design: Completed 1/16/19

Kalmar, in conjunction with TransPower, will review build specifications with LBCT and finalize the *Bill of Materials* for the battery-electric yard tractor for the design and build. Kalmar, with support from TransPower, will review and plan functional requirements, duty cycle and drive schedules, and power/energy calculations, and prepare a technical specification report for the proposed equipment. This report will confirm that the intended battery-electric yard tractor will meet LBCT duty cycle requirements before design is completed.

Kalmar/TransPower will design one (1) battery-electric yard tractor for LBCT.

Deliverables:

- Submit a technical specifications report with design plans to confirm battery-electric yard tractor will meet duty cycle requirements and drive schedules that will be demonstrated at LBCT.
    - PDF in this section represents the specifications agreed up with the customer based on the application of the machine along with the expected performance levels. As can be seen in this document, there were several revisions based on multiple discussions.

ORDER
ACKNOWLEDGEMEN

- Submit *Bill of Materials* allowing for reasonable necessary adjustments arising during the building process to City.
    - Once specifications were agreed upon, the engineering team began their design work ultimately resulting in the bill of material, which was used by the rest of the organization to secure components and develop the build process.

Z41023.pdf

Task 3.2d – Battery-Electric Yard Tractor Component Ordering: Completed 12/19/19

Kalmar, in conjunction with TransPower, will oversee the completion and approval of ordering the necessary components to build the battery-electric yard tractor. Kalmar/TransPower will order and/or fabricate vehicle components from local vendors.

Kalmar/TransPower will order and verify (when received) the necessary components to build one (1) battery-electric yard tractor.

Deliverables:

- Submit procurement order and paid invoices.
- Submit notification of delivery or any documentation to indicate completed delivery of components as proof of payment and delivery.
    - Once the bill of material was established, our procurement department then proceeded to secure supply through the defined suppliers. Represented in the PDF are the PO's and proof of payment for the new content for this product.

PO_Invoice_Proof of payment.pdf

Task 3.2e – Battery-Electric Yard Tractor Build: Completed 3/29/19

Kalmar, in conjunction with TransPower, will build one (1) battery-electric yard tractor, which will include assembly at TransPower's manufacturing facility where they will complete validation testing for the battery-electric yard tractor. This includes but is not limited to electronic testing such as to high- and low-voltage component functionality, charging, air conditioning, lighting, and dashboard configuration. Kalmar/TransPower will conduct drivability testing, including but not limited to ABS and regenerative braking, steering system, transmission, acceleration, gradability, range, and speed. Kalmar/TransPower will complete visual quality assurance, final road test, and pre-delivery test.

Deliverables:

- Submit to City results of validation testing for the battery-electric yard tractor.
    - To build the unit, we ran it on our current assembly line to test our manufacturing process for this product. The unit followed the normal production process and testing procedures for our current production. Certain operations were modified to support the electric product and our testing procedure was modified to align with electric vs diesel component requirements. In the documents below, you will find a number of points of inspection. We have Quality Gates located throughout our build process both on the assembly line as well as off the assembly line. Every unit is driven on

our test track for approximately 3 miles. In the Test Track phase, we connect the unit to our test trailer to ensure the 5th wheel is operating correctly. In addition to this testing, Transpower was onsite to commission the unit as reflected in the jpg file below.

351488 PACKET.pdf
351488 LINE CHECK.pdf
351488 SHORTS.pdf
351488 GIGS.pdf

351488 LST.pdf
TP Commission Report_LBCT.jpg

Task 3.2f – Provide Charging Infrastructure: Competed 5/14/19

TransPower will provide one (1) EVSE control console with charge cable (with the City to supply 208 VAC power) and one (1) transformer at LBCT. The City will manage all permits required for installation and electrical work. In addition, TransPower will work with City to conduct validation testing to ensure charging infrastructure is functional.

Deliverables:

- Provide charging infrastructure.
- Submit to City notification of delivery for the charging infrastructure. Please include photographs.
- Submit to City results of validation testing for the charging infrastructure.
  - Documents below provide evidence of the charging infrastructure for the electric terminal tractor installed and tested.

UL_Report_5-14-19_ POLB_12616183 FR.p
UL sticker.jpg

With requirements met in the SOW for tasks 3.2d, 3.2e, 3.2f, the invoice for these were submitted as referenced in document below.

1519033222 - 1116665 - POLB.pdf

Task 3.2g – Battery-Electric Yard Tractor Delivery/Commission/Training: Completed 5/1/19

Kalmar, in conjunction with TransPower, will deploy one (1) battery-electric yard tractor at LBCT. Prior to the start of demonstration, Kalmar/TransPower will commission the equipment and charging infrastructure to ensure the battery-electric yard tractor is operational, properly utilizes the charging infrastructure and is ready for revenue service. In addition, Kalmar/TransPower will provide operation and maintenance training to LBCT. Training on how to recharge will also be performed.

Deliverables:

- Deliver battery-electric yard tractor to LBCT.
- Submit to City notification of delivery for the battery-electric yard truck. Please include photographs.
- Submit to City a commission report summarizing that the battery-electric yard tractor and charging infrastructure are functional, that the battery-electric yard tractor is able to charge at the charging infrastructure, and that the battery-electric yard tractor is ready to operate in revenue service.
- Submit to City evidence of operations and maintenance training and recharge training including training materials and rosters.
    - PDF Documents referencing delivery via our local dealer. BOL reflects shipment to our local dealer, Cal-Lift. Upon arrival at the dealer, a PDI (pre-delivery inspection) was completed by the dealer.

351488 BOL.pdf

351488 PDI.pdf

351488 PDI Credit-CalLift.pdf

    - Commissioning event took place at the customer site. Training sign-off sheet along with training documents in files below.

T2e Technical Training Sheet.pdf

fwdlbcttrainingdocumentsandphotos.zip

Delivery_Commissioning_Training pics.do

    - Upon completion of the commissioning and training conducted at the customer site, invoice for task 3.2G has been submitted.

1519045483 - POLB - 1116665.pdf

<u>Task 3.2h – Battery-Electric Yard Tractor Demonstration: Completed 7/19/21</u>

LBCT will demonstrate battery-electric yard tractor in normal container operations for a <u>minimum</u> of 6 months to commence upon passing certifications described in Task 3.2e. The demonstration requires coordination between TransPower, LBCT and Tetra Tech to collect data per the test plan approved by City, which may include operational reporting, energy usage reports, and user experience surveys. Kalmar will own and hold title to the yard tractor during and following the demonstration.

Deliverables:

- Submit to City a Notice of Demonstration Commencement prior to the start of demonstration.
- Complete 6-month demonstration, provide information and data. Please include photographs during demonstration.
- Submit to City a Notice of Demonstration Completion at the conclusion of the demonstration.
  - Prior to beginning the demonstration phase, the customer requested changes to unit. These changes were to install FOPS and an intermediate cab step. It was also found that the telematics system was not installed. Kalmar sent the kits to Cal-Lift, our dealer, and the modifications were made to the unit in week 25.
  - Once the unit had the kits installed, the customer began to test the unit prior to actually putting it into demonstration mode. During this test, there were operational issues identified. Around the 21st , the original fault was described as: When backing hard into the trailer, the power steering would quit operating but the vehicle would still drive. Transpower worked with the LBCT team to reproduce the fault. After reproducing the fault, Transpower checked all harnesses and connections and found one connection at a fuse slightly loose. This was tightened. The unit was tested and the fault would not reproduce.LBCT put the vehicle into a validation period to ensure this resolved the issue. The unit operated almost 2 weeks without faulting. On July 8th, the fault appeared again. Transpower with the help of LBCT were then able to reproduce the fault consistently by maxing out both the 5th wheel and the steering. Transpower tested this scenario on the unit they have at Escondido and was able to reproduce on that unit as well. Transpower along with their inverter supplier determined the root cause on July 15th. They made changes to the inverter parameters and tested in Escondido. They tested with no load as well with lifting full load with both steering and 5th wheel maxed. Test was successful. On July 17th, Transpower installed fixed on the unit at LBCT.
  - LBCT sent notification via email that they were satisfied with the repair and would place the unit in service. Document below is signed confirmation of start of demonstration.

    In-Service
    Confirmation Letter.p

  - On July 31st, Kalmar/Transpower visited with LBCT. Good feedback was received concerning the operation of the electric terminal tractor. Jim Medina stated that they really liked the operation of the T2e and Don, the local technician, communicated that he had attempted to duplicate the fault and has not been able to. They are extremely happy with the overall operation of the tractor. Cindy, the operator of the unit, stated she likes the smooth operation and the quietness of the operation. She also stated she feels less fatigued while operating the T2e and that she feels much more relaxed when she goes home at the end of her shift. When asked about the pulling of loads with different weights, she replied heavier loads pull fine, just have to depress the accelerator a little more, similar to the diesel. She did state that she would like to have window on the right side that can be rolled down. Kalmar informed them that an optional wing window could be installed for any future T2e's for LBCT. Kalmar/Transpower inquired on how many containers are moved. Jim shared that 125 containers per shift with just the T2E. When asked if that was normal or more than a diesel, Jim's response was that the tractor is performing well. On the rail side, if it does not perform up to the level of the other tractors, it would be taken out of service and parked.

- Based on demonstration mode starting, requirement was met to submit additional invoice.

  1519045483 - POLB - 1116665.pdf

- Performance summary report submitted by Transpower

  LBCT Kalmar Ottawa Port Spec Tractor Perf

<u>Summary of Demonstration period</u>:

1/7/19: EVSE delivered to POLB in December 2018. EV Powertrain has notified Kalmar that the delivery of the components is delayed until 2/11/2019. Due to the part delay, production was also delayed to start on 2/21/2019 and expected to complete on 3/7/2019. The T2E Demo Truck will then ship to Kalmar's Authorized California dealer so that the Auto Coupler can be installed prior to delivery to the port on 3/15/2019. Invoicing needs to be completed and submitted in January 2019 for the submittal of design, material ordering and delivery of the EVSE to the PORT in December 2018.

2/1/19: EV Powertrain is scheduled to deliver 2/11/2019. Production will begin on 2/10/2019 and expected to complete on 3/7/2019. Arrangements have been made to have the truck shipped to Calift, a Kalmar Authorized dealer, for installation of the Auto Coupler. The T2E is scheduled to delivery to LBCT 3/15/2019. Invoicing is has not been completed for the submittal of design, material ordering and delivery of the EVSE to the PORT in December 2018, as the POLB is not currently set up as a customer and therefore we are unable to generate an invoice. Kalmar's Project manager is working to resolve this issue and will be in contact with the POLB to complete customer information. This issue should be resolved by the 2nd week of February 2019.

2/27/19: Invoicing is has not been completed for the submittal of design, material ordering and delivery of the EVSE to the PORT in December 2018, as the POLB is not currently set up as a customer and therefore we are unable to generate an invoice. Kalmar's Project manager is working to resolve this issue and will be in contact with the POLB to complete customer information. This issue should be resolved by the 2nd week of February 2019. Although work is complete, Invoicing is has not been completed for the following milestones: 1) submittal of design, 2) material ordering 3) delivery of the EVSE to the PORT in December 2018. Parties for Kalmar and POLB are working to complete the necessary paperwork so that invoicing can be completed as soon as possible. Kalmar is targeting March 31, 2019 to complete and submit late invoices.

3/31/19: Production is complete and truck has passed quality inspection. The unit will be shipped to Cal-lift so that auto coupler can be installed on April 9, 2019. Commissioning is scheduled for May 1, 2019. Although work is complete, Invoicing is has not been completed for the following milestones: 1) submittal of design, 2) material ordering 3) delivery of the EVSE to the PORT in December 2018. Parties for Kalmar and POLB are working to complete the necessary paperwork so that invoicing can be completed as soon as possible. Kalmar is targeting April 15, 2019 to complete and submit late invoices.

4/30/19: Production of the Kalmar Ottawa electric terminal tractor, T2E, completed in March and the unit was Gold Stickered which is the passing of Kalmar's Final Inspection. The T2E shipped to LBCT's dealer, Cal-lift, on 4/9/2019. The auto-coupler, required by LBCT, was installed on 4/11/2019 and the final acceptance was provided from the dealer at that time. Per agreement, the T2E was shipped Long Beach, CA and showcased at the ACT Expo the 3rd week of April. As the 1st OEM Production Terminal Tractor built in the USA market and destined for duty the Long Beach Container Terminal, the T2E was a huge success. There was a lot of excitement around the event. LBCT, POLB, Kalmar and Transpower received a multitude of great press throughout the expo. During the final day of the event, the T2E participated in "The Ride and Drive", which allowed participants to drive the truck in a closed course. Participation in the ACT Expo was a very positive experience and should go a long way to showing each of our company's commitment to reducing emissions. Due to the activities undertaken at the ACT Expo, the demonstration period at LBCT was pushed back to begin in early May. Commissioning of the T2E is scheduled for May 1, 2019 and entails two primary events. 1) UL certification of the charging station and 2) Safety and Operations Training for LBCT employees. Kalmar and Transpower will be in attendance and preform training as required. Invoicing for T2E has be a bit difficult and therefore delayed until May 2019. This is primarily due to Kalmar's core business as an OEM manufacturer direct sales. These issues have been resolved and invoicing is scheduled to be submitted during the 1st week of May.

6/14/19: With a joint group effort, Kalmar, TransPower and Cal-Lift commissioned the Kalmar T2E, completed the UL certification for the charging station, and provided the full safety and operations training to the LBCT employees on the first of May. In addition, LBCT performed the installation of their terminal operating system equipment. During this step, LBCT determined that additional requirements are required not requested in initial specification. The additional kits from Kalmar that needed are FOPS and an intermediate cab step. The kits are due to arrive at the customer the week of 6/17. A telematics system was not installed in the unit but was corrected by Transpower. Documentation submitted with this report is:

- 3.2c: Bill of Materials
- 3.2d: Purchase orders, Invoices, Proof of payment
- 3.2e: Validation testing data
- 3.2f: UL inspection report and picture
- 3.2g: Delivery/Commissioning/Training

6/30/19: The FOPS kit and intermediate cab step were installed on the unit according to schedule. Once completed, the customer initiated a test drive phase of the unit with their operators. During test drive, the operators noted "hard steering" and the unit stalled under a trailer. Transpower responded to LBCT concerning the two issues. For the stall, a loose pin was found in the connector of a harness. The defect was repaired. For the steering, the pressure was adjusted and the unit was released back to LBCT. LBCT tested the unit after the adjustment and asked for further improvements on the steering. Transpower is currently working on a solution. Demonstration phase will not begin till this is resolved. Documentation submitted with this report is:

- 3.2e: Validation testing data – Transpower Commissioning Summary report

7/31/19: First half of July, investigation on the reported power steering faults were underway. The original fault was reported around June 21st with the description as when backing hard into the trailer, the power steering would quit operating but the vehicle would still drive. Transpower was onsite working with LBCT to reproduce the fault. Once reproduced, all harnesses and connections were checked where one connection was found slightly loose at a fuse. Repair to the loose connection was completed and LBCT agreed to put the unit into a validation test for several weeks to ensure the issue was resolved. On July 8th, the fault appeared again. Upon investigation from Transpower, the fault was reproduced consistently by maxing out both the 5th wheel and the steering. Transpower then tested the scenario on a unit at their site in Escondido and was able to reproduce it. At this point, they scheduled a meeting with the inverter supplier and found a resolution. Changes to the inverter parameters were tested in Escondido both with no load and while lifting a full load with both steering and 5th wheel maxed. The fix was installed on the LBCT unit on July 17th. Notification was received on the afternoon of July 17th from LBCT that they were satisfied with the fix and were putting the unit into service. In-Service letter from LBCT attached in email with this report. Since the unit has been in service, general feedback from LBCT and the operator of the T2e have been positive. Documentation submitted with this report is:

- 3.2c: Battery-Electric Yard Tractor Design-Technical specifications report: LBCT Kalmar Ottawa Port Spec Tractor Performance Specification Summary
- 3.2h: Battery-Electric Yard Tractor Demonstration - In-Service Letter from LBCT

8/30/19: Unit has been operating as expected for the month August. Recent feedback from Jim Medina is “We love the truck you dropped off here! No issues, it just makes money all day and night and we couldn’t be happier.” As requested from the quarterly review, below is a more descriptive narrative concerning our progression in the project aligned with the requirements in the SOW. (Reference Task summaries above)

9/30/19: Unit continues to operate in the demonstration period with good feedback from the customer. Internally, we have experienced a connectivity issue with the telematics system. Transpower has ordered a replacement data logger. Expected arrival and replacement on the truck is expected to happen this week.

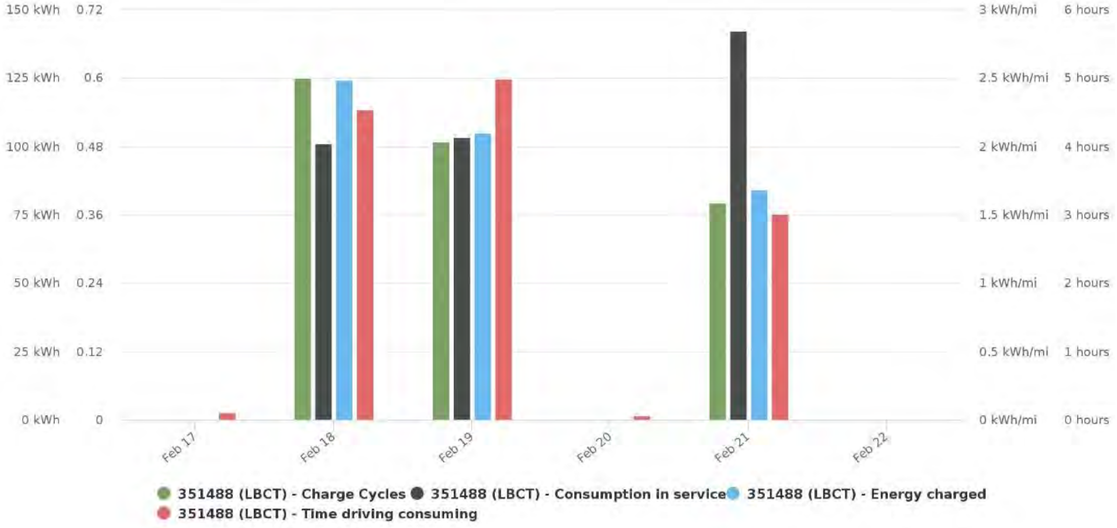
10/31/19: Unit was damaged in month of October. Customer stated damage from bom cart striking corner of battery box. Battery pack has been replaced. Simulation models are not able to create the contact so have requested our local dealer support in understanding specific situation causing the contact between the bom cart and the battery pack.

11/30/19: Although the battery pack was repaired, the unit has not been placed back in service due to the current configuration is still at risk for damage. Several simulations were ran but was unsuccessful in recreating the specific scenario. After further evaluation onsite, a final resolution has been agreed upon between Kalmar Engineering and the customer. The unit will be modified per the agreed plan and is expected to be back in service by end of the year.

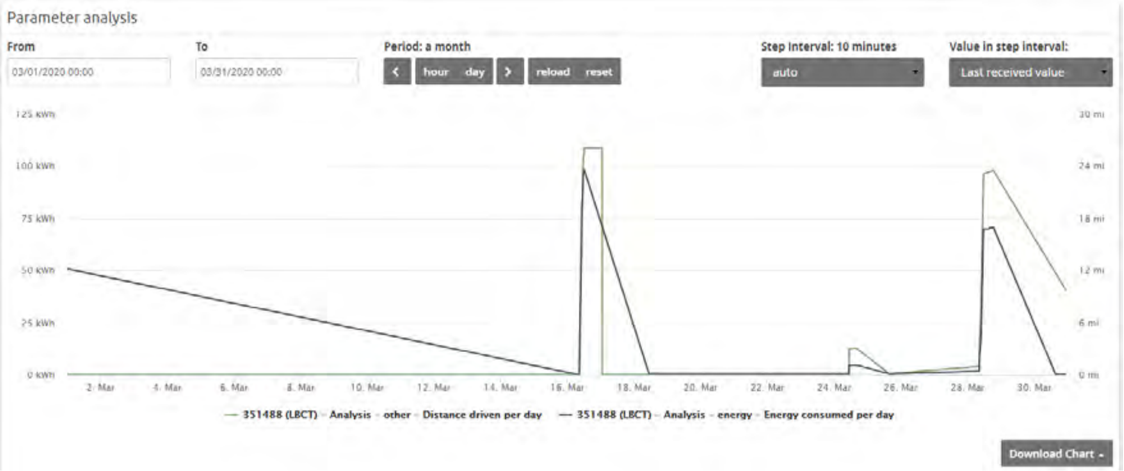
12/31/19: Final resolution concerning solution for unit was determined. It was agreed to remove the battery pack and operate the unit with 4 packs vs 5 packs. The customer will contain the operation of the unit on the railside only as the method of operation will not cause damage to the opposite side packs. To implement this solution, an additional bracket was needed to implement this solution. Bracket is being made and shipped to local dealer with expectation that unit will be available to be put back in service post holiday break. Kalmar has also agreed to the request to extend the demonstration period of this unit. Waiting on modified contract.

1/31/20: Unit repaired according to agreement and placed back into service week 2. HEM data logger installed on Feb. 4th.

2/28/20: Unit in service. Replaced telematics system to Viriciti in February.



3/31/20: Amendment to CARB C-Port signed/notarized and returned. Unit in service. Sample chart from Virciti.


Parameter analysis

From: 03/01/2020 00:00

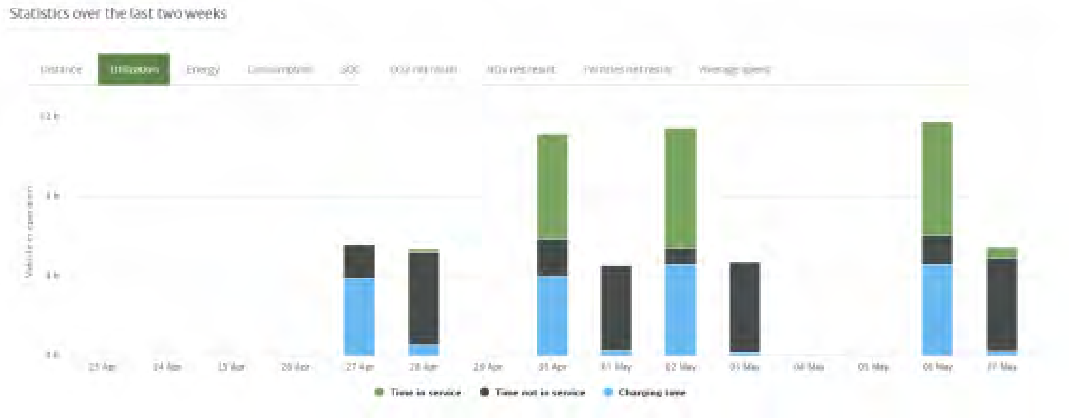
To: 03/31/2020 00:00

Period: a month

Step interval: 10 minutes: auto

Value in step interval: Last received value

4/30/20: Unit continues to be in use on site. Sample snapshot of utilization over last 2 weeks.



5/31/20: Usage in May: 810 miles driven


Parameter analysis

From: 05/01/2020 00:00

To: 05/31/2020 00:00

Period: a month

Step interval: 10 minutes: auto

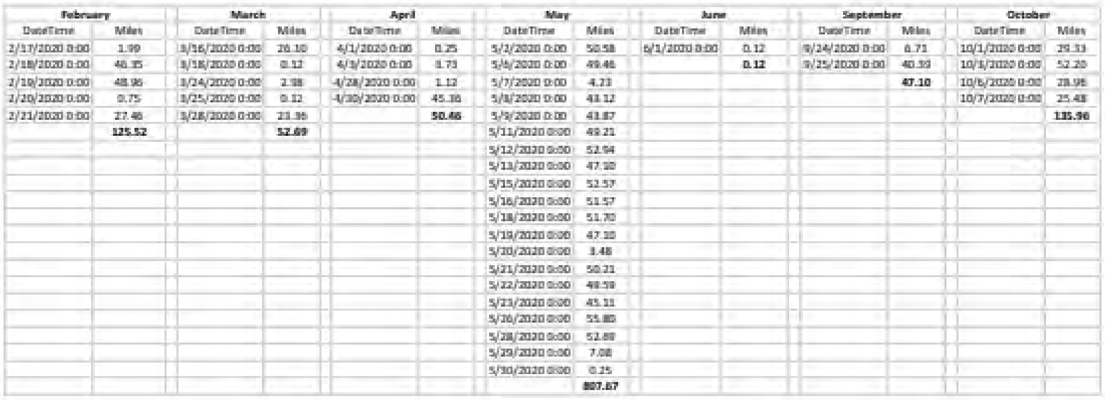
Value in step interval: Last received value

6/30/20: Unit was to local dealer for service on the transmission. Transmission was replaced. Unit returned to service. Near the end the month, a ESS string was damaged with all bolts stripped from the cover. The string will need replaced before it can go back in service. Expected replacement to occur in July.

7/31/20: A miss communication occurred between Kalmar's Dealer and LBCT M&R Power Shop Senior Manager concerning who would bear the cost for repairing the damage caused by a LBCT operator. Based on the communication provided by Kalmar's dealer, LBCT requested to have the unit removed from site and not returned. Once Kalmar was informed of this development, steps were taken with both LBCT and the dealer to resolve the issue with Kalmar bearing the cost to repair the damage. The unit was picked up from LBCT on July 28th and moved to the local dealer to have the ESS replaced. This work is scheduled for first week of August.

8/31/20: Unit was returned to LBCT on Monday, August 10th. Unit has been in service since operating according to expectations.

9/30/20: Unit was in operation but due to blown fuse for the data logger, the unit was not able to transmit data. Fuse was replaced end of September.



February		March		April		May		June		September		October	
DateTime	Miles	DateTime	Miles	DateTime	Miles	DateTime	Miles	DateTime	Miles	DateTime	Miles	DateTime	Miles
2/17/2020 0:00	1.99	3/16/2020 0:00	26.10	4/1/2020 0:00	0.25	5/2/2020 0:00	50.58	6/1/2020 0:00	0.12	9/24/2020 0:00	6.71	10/1/2020 0:00	29.33
2/18/2020 0:00	46.35	3/18/2020 0:00	0.12	4/3/2020 0:00	3.73	5/6/2020 0:00	49.46		**0.12**	9/25/2020 0:00	40.39	10/3/2020 0:00	52.20
2/19/2020 0:00	48.96	3/24/2020 0:00	2.98	4/28/2020 0:00	1.12	5/7/2020 0:00	4.23				**47.10**	10/6/2020 0:00	28.95
2/20/2020 0:00	0.75	3/25/2020 0:00	0.12	4/30/2020 0:00	45.36	5/8/2020 0:00	43.12					10/7/2020 0:00	25.48
2/21/2020 0:00	27.46	3/28/2020 0:00	23.36		**50.46**	5/9/2020 0:00	43.87						**135.96**
	125.52		**52.69**			5/11/2020 0:00	49.21						
						5/12/2020 0:00	52.94						
						5/13/2020 0:00	47.30						
						5/15/2020 0:00	52.57						
						5/16/2020 0:00	51.57						
						5/18/2020 0:00	51.70						
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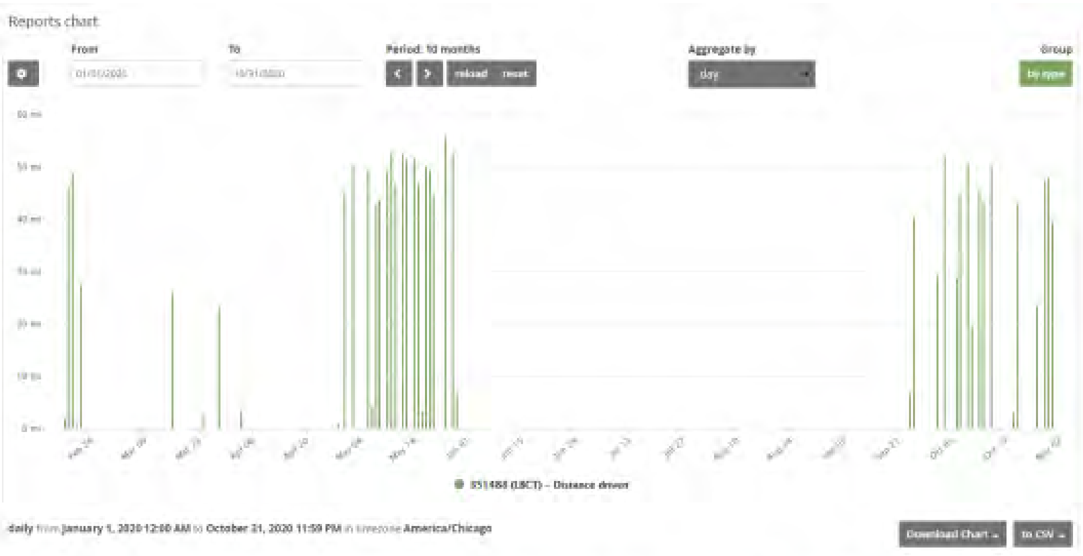
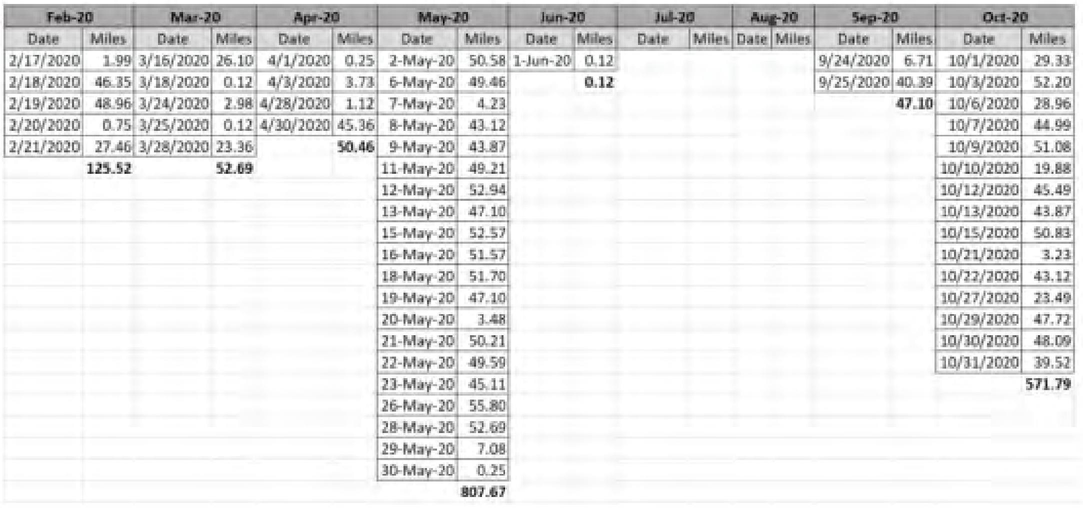
						5/22/2020 0:00	48.59						
						5/23/2020 0:00	45.11						
						5/26/2020 0:00	55.80						
						5/28/2020 0:00	52.69						
						5/29/2020 0:00	7.08						
						5/30/2020 0:00	0.25						
							807.67						

10/31/20: Unit in operation during month of October.



daily from January 1, 2020 12:00 AM to October 31, 2020 11:59 PM in timezone America/Chicago



Feb-20		Mar-20		Apr-20		May-20		Jun-20		Jul-20		Aug-20		Sep-20		Oct-20	
Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles
2/17/2020	1.99	3/16/2020	26.10	4/1/2020	0.25	2-May-20	50.58	1-Jun-20	0.12					9/24/2020	6.71	10/1/2020	29.33
2/18/2020	46.35	3/18/2020	0.12	4/3/2020	3.73	6-May-20	49.46		**0.12**					9/25/2020	40.39	10/3/2020	52.20
2/19/2020	48.96	3/24/2020	2.98	4/28/2020	1.12	7-May-20	4.23								**47.10**	10/6/2020	28.96
2/20/2020	0.75	3/25/2020	0.12	4/30/2020	45.36	8-May-20	43.12									10/7/2020	44.99
2/21/2020	27.46	3/28/2020	23.36		**50.46**	9-May-20	43.87									10/9/2020	51.08
	125.52		**52.69**			11-May-20	49.21									10/10/2020	19.88
						12-May-20	52.94									10/12/2020	45.49
						13-May-20	47.10									10/13/2020	43.87
						15-May-20	52.57									10/15/2020	50.83
						16-May-20	51.57									10/21/2020	3.23
						18-May-20	51.70									10/22/2020	43.12
						19-May-20	47.10									10/27/2020	23.49
						20-May-20	3.48									10/29/2020	47.72
						21-May-20	50.21									10/30/2020	48.09
						22-May-20	49.59									10/31/2020	39.52
						23-May-20	45.11										**571.79**
						26-May-20	55.80										
						28-May-20	52.69										
						29-May-20	7.08										
						30-May-20	0.25										
							807.67										

11/30/20: Unit in operation during month of November. Experiencing communication issues with Viriciti. Investigation still on going between supplier, Transpower, and Kalmar.

20-Feb		20-Mar		20-Apr		20-May		20-Jun		20-Jul		20-Aug		20-Sep		20-Oct		20-Nov	
Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles	Date	Miles
2/17/2020	1.99	3/16/2020	26.1	4/1/2020	0.25	2-May-20	50.58	1-Jun-20	0.12					9/24/2020	6.71	10/1/2020	29.33	11/2/2020	49.96
2/18/2020	46.35	3/18/2020	0.12	4/3/2020	3.73	6-May-20	49.46		0.12					9/25/2020	40.39	10/3/2020	52.2	11/4/2020	44.37
2/19/2020	48.96	3/24/2020	2.98	4/28/2020	1.12	7-May-20	4.23								47.1	10/6/2020	28.96	11/11/2020	0.37
2/20/2020	0.75	3/25/2020	0.12	4/30/2020	45.36	8-May-20	43.12									10/7/2020	44.99		94.7
2/21/2020	27.46	3/28/2020	23.36		50.46	9-May-20	43.87									10/9/2020	51.08		
	125.52		52.69			11-May-20	49.21									10/10/2020	19.88		
						12-May-20	52.94									10/12/2020	45.49		
						13-May-20	47.1									10/13/2020	43.87		
						15-May-20	52.57									10/15/2020	50.83		
						16-May-20	51.57									10/21/2020	3.23		
						18-May-20	51.7									10/22/2020	43.12		
						19-May-20	47.1									10/27/2020	23.49		
						20-May-20	3.48									10/29/2020	47.72		
						21-May-20	50.21									10/30/2020	48.09		
						22-May-20	49.59									10/31/2020	39.52		
						23-May-20	45.11										571.79		
						26-May-20	55.8												
						28-May-20	52.69												
						29-May-20	7.08												
						30-May-20	0.25												
							807.67												

12/31/20: Transmission replaced and unit returned on Dec 23rd. Unit was put back in service, however, electrical issues were identified. Troubleshooting identified PCM fault is causing ICU to lose its 24v supply. In addition, the X-Y shifter needed replaced also. Replacement parts ordered, with expected delivery the week of Jan 11th.

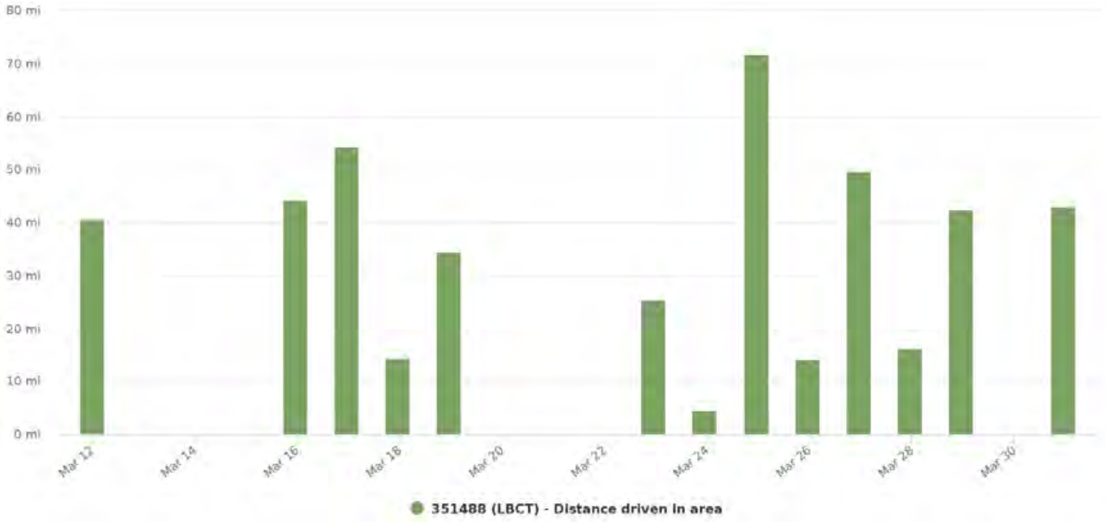
1/31/21: Unit was returned to LBCT during January, however, the operator continued to hear a noise. Unit was shipped back to dealer for further analysis. Steps being taken is to change the transmission, change bonding and grounding scheme and install VR sensor with slight wiring change based on testing completed by Transpower to eliminate the grounding and shifting issues. Unit is slated to return to LBCT in week 6.

2/28/21: Actions taken on the unit prior to returning to LBCT on February 10th were as follows:

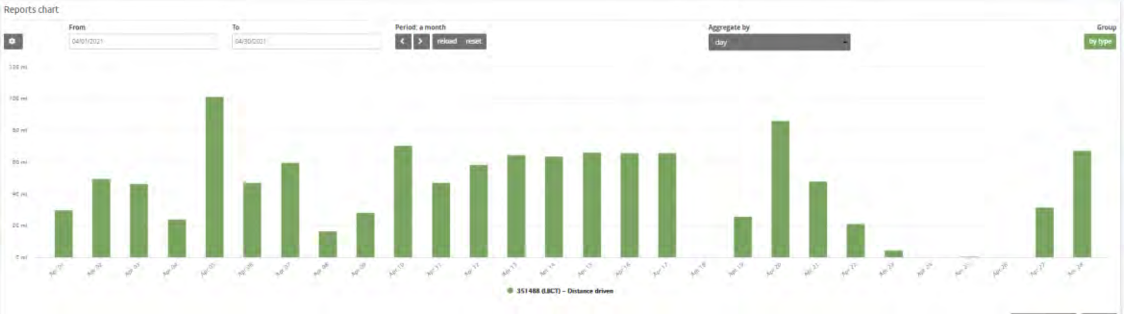
- Changes made to the bonding and wiring scheme
- VR sensor is being installed with wiring changes
- Transmission replaced.

Testing completed at Transpower shown positive results in eliminating the grinding and shifting issue. Feedback received on 3/2 from Jeff at LBCT concerning how the unit has been running since returned on Feb 10th: “The machine was only not working for one shift, the use has been intermittent the last few days due to the operator of choice taking some days off, everything on your side is in good working order.”

3/31/21: Unit in operation. Viriciti logger replaced March 11th. Unit reflects over 750 miles driven between 3/12 and 3/31.



4/30/21: Unit in operation. Unit reporting driven 1190.44 miles for the month.


Reports chart

From 04/01/2021

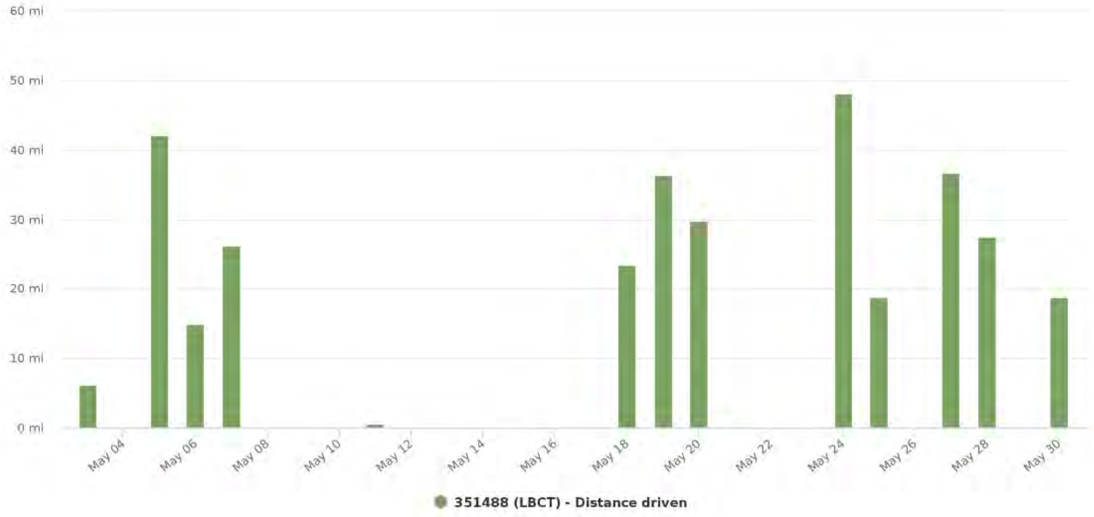
To 04/30/2021

Period: a month

Aggregate by day

Group by type

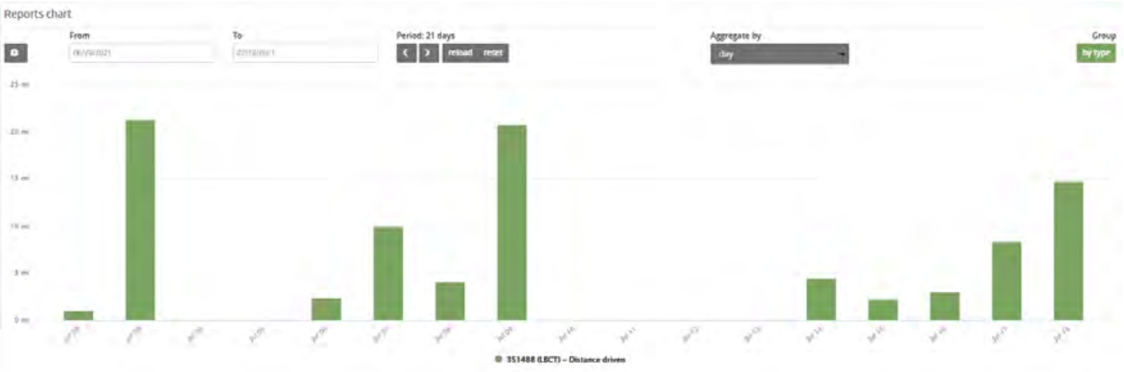
5/31/21: Unit in operation. Unit reported driven 329.83 miles for the month.



6/30/21: On June 14th, Kalmar/Transpower was notified that the unit has been taken out of service due to noise being reported from the transmission. Unit was transported to our dealer Cal-lift on June 15th and replacement parts were ordered. Transmission was replaced on June

22nd however, the unit is still losing PSI due to the air dryer continuing to purge. During this time period, it was found that the unit had actually been taken out of service on June 3rd but communication did not occur.

7/19/21: Unit was returned to LBCT the afternoon of July 2nd. Confirmed with Jacqueline that July 19, 2021 will be the official end to the demonstration period. Usage during this period reflected below:



LBCT Project Overview_Final

POLB LBCT-Kalmar Schedule_Final

Task 3.2i – Submit Draft & Final Reports/Attend Final Meeting: Completed 7/19/21

When the demonstration is complete, Kalmar/TransPower will submit a draft report to City for review no later than June 30, 2021 and then submit a final report no later than July 16, 2021. Final invoice requests must be submitted no later than July 16, 2021.

Kalmar, TransPower, and City will attend a final meeting with CARB on a date to be determined.

Deliverables:

- Submit to City a draft report.
- Attend final meeting.
- Submit to City a final report.
- Submit invoice request to City by the 5th of every third month (beginning three months after the kick-off meeting) with a letter demonstrating completion of each task (and referencing appropriate task number) and the total amount requested.
  - Due to a multiple factors, which have outlined in the previous sections, the demonstration period was extended through July 19, 2021.
    - Closeout Meeting conducted on 6/28/21 at 12:00 pm CST. Participates were as follows:
      - Kalmar: Alan Wilson, Dean Newton
      - Transpower/Meritor: Harold Meyer
      - Build Momentum: Matt, Melody, Andrea Swanson

    - POLB: Jacqueline Moore
    - Grant Farm: James
- Rough Draft of Final Report submitted 6/29/2021
- Notice of Demonstration period confirmed with Jacqueline via email on July 7,2021.

7/19/2021 Cargotec Oyj Mail - RE: Kalmar unit

CARGOTEC **Wilson, Alan <alan.wilson@kalmarglobal.com>**

RE: Kalmar unit

1 message

Moore, Jacqueline <jacqueline.moore@polb.com> **Wed, Jul 7, 2021 at 12:10 PM**
To: "Wilson, Alan" <alan.wilson@kalmarglobal.com>

Hi Alan, confirmed the unit was back in operation today, so your demo will officially end Monday July 19th.

From: Wilson, Alan <alan.wilson@kalmarglobal.com>
Sent: Friday, July 2, 2021 1:27M
To: Moore, Jacqueline <jacqueline.moore@polb.com>
Subject: Kalmar unit

Hi Jacqueline. Just received notice that unit has been repaired and is being returned to LBCT today. –

Best regards,
Alan Wilson

https://mail.google.com/mail/u/0?ik=b36e71d4f2&view=pt&search=all&permthid=thread-a%3Ar6422199204333278744%7Cmsg-f%3A1704646742879… 1/1

- Invoice for 3.2h demonstration period sent on 6/30/21.

PDF

Inv
1521045436_3.2h

- Invoice for 3.2i Draft and Final Reports/Attend Final Meeting sent on 6/30/21

Inv 1521045438_3.2i

Service/Maintenance Summary

Over the period of this project, replacement of parts were 74,086.25 with labor at 13,750. Breakdown of maintenance (without specific prices) are below:

- July 2019: Power steering fault – fuse and inverter parameters changed
- September 2019: Replaced data logger
- October 2019: Battery box damaged by customer.
- December 2019: Reconfigure battery pack solution to support operation with required trailer. Additional bracket added to support solution
- February 2020: Replaced telematics system to Viriciti
- June 2020: Transmission replaced then towards the end of the month, the ESS string damaged with all bolts stripped from the cover.
- August 2020: ESS string replaced and returned to LBCT
- September 2020: Blown fuse for data logger
- November 2020: Communication issue with Viriciti
- December 2020: Replaced transmission. PCM fault causing ICU to lose its 24v supply. In addition, the X-Y shifter needed replaced.
- January 2021: Reported noise from transmission again. Transmission changed along with change bonding and grounding scheme and install VR sensor with slight wiring changed based on testing completed by Transpower to eliminate the grounding and shifting issues
- March 2021: Viriciti logger replaced
- June 2021: Replaced transmission due to reported noise from operator.

Safety

FOPS: As highlighted in previous sections, the initial design did not include FOPS. Prior to the unit being put into service, FOPS was added.

Charging Plug: Concern was brought forth from LBCT concerning the size and weight of the charging plug/cable. Solution was to install a balancer at the charging station to minimize the ergonomic impact to the operator.

Battery Pack: Unit was damaged in month of October 2019. Customer stated damage from bom cart striking corner of battery box. Simulation models were ran but were not able to recreate constraint. After onsite evaluation, it was determined that the bom cart in use did not match initial models in simulation model. Solution was agreed upon between Kalmar Engineering and LBCT. Final resolution concerning solution for unit was determined. It was agreed to remove the battery pack and operate the unit with 4 packs vs 5 packs. The customer will contain the operation of the unit on the railside only as the method of operation will not cause damage to the opposite side packs. To implement this solution, an additional bracket was needed to implement this solution.

Lessons Learned

Specification of unit:

FOPS: At the beginning of the project, there was a disconnect between the agreed specifications of the unit and what was acceptable in the operations at specific location in regards to FOPS causing a delay to the start of the demonstration period. Key lesson learned here is to ensure all parties are engaged in the specification discussion when participating in similar projects in the future.

BOM Cart: As described previous section, the bom cart in use was not the trailer used in the simulation model. Key lesson learned when participating in similar projects in the future is to ensure that an updated model for current equipment in use at the site is provided to ensure the simulation model is using accurate information.

Telematics:

Coordination between all required data sets for the project created a challenge in ensuring the project could be completed on time.

Communication

Throughout the project, there were numerous times where there was a breakdown in communication on the status of the unit in regards to an operational issue that impacted the ability to have a quick response to minimize downtime of the unit. Key lesson learned is to ensure that the proper chain of communication is established between all parties to ensure clear channels of communication.

Summary

During this project, there were a number of “wins” experienced.

- Operator feedback during this project has been positive with satisfaction in operator comfort, noise level, and ride ability.
- Collaboration between Kalmar and Transpower (technology provider) has been good during this project. Clear focus from both parties to ensure the project completed successfully and to continue to improve the overall design.
- Several months of expected performance of the machine.
- Field testing in live environment to prove out design of equipment in this specific application.

As with any project, there were also a number of lessons learned as identified in previous section requiring the overall timeline to be extended.

Overall, we felt this was a successful project. We were able to test the functionality of our EV product in a Port application. From this test, we feel confident that we have a viable and tested solution to take to our customer base for future grown in the EV market.

C-PORT Final Report

Appendix D: Baseline Emissions Testing Plan

Baseline Emissions Test Plan
UPDATED

Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program

CARB Off-Road Advanced Technology Demonstration Projects

Prepared for:
Ms. Jacqueline Moore
Port of Long Beach
4801 Airport Plaza Drive
Long Beach, CA 90815

January 2019
April 2020

Submitted by:

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Tetra Tech Inc.
3475 East Foothill Blvd.
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Riverside, CA 92521

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5. Test Set-up and Procedures 5

Appendix A – List of ECM Parameters Requested

1. Background

The Tetra Tech team will provide support for data logging and portable emissions measurement systems (PEMS) testing of zero-emissions off-road equipment as part of the Baseline Emissions Test Plan efforts. This will be conducted in support of the Port of Long Beach's (POLB) C-PORT project for the California Air Resources Board (CARB) Off-Road Advanced Technology Demonstration Projects solicitation. There will be ~~five (5)~~ four (4) total pieces of zero-emissions equipment demonstrated. There are three (3) total battery-electric top handlers (Taylor/BYD Motors): two (2) at Pier J SSA and one (1) at Pier E LBCT. There ~~are two (2)~~ is ~~one total yard tractors:~~ one (1) battery-electric yard tractor (Kalmar/TransPower) at Pier E LBCT ~~and one (1) fuel cell yard tractor (UQM/CNHTC/LOOP energy) also at Pier E LBCT~~.

2. Objective

The purpose of this study is to better understand emissions and performance benefits of the zero-emissions equipment. For this Baseline Emissions Test Plan, PEMS testing will be conducted on the ~~three (3)~~ two (2) pieces of baseline diesel equipment (one top handler at Pier J SSA~~, one top handler at Pier E LBCT,~~ and one yard tractor at Pier E LBCT). The PEMS testing, as discussed in this plan, will provide information on the baseline emissions and fuel consumption for the diesel equipment, which in turn will provide a basis for comparison that the zero-emissions equipment can be compared with. The baseline PEMS measurements will include emissions for oxides of nitrogen (NO_x), particulate matter (PM), carbon monoxide (CO), carbon dioxide (CO_2), and total hydrocarbon (THC). Fuel consumption will be determined from the emissions measurements based on the carbon balance method.

3. PEMS Testing

Tetra Tech team member, University of California at Riverside (UCR), will install and make PEMS measurements on the three pieces of baseline diesel equipment. PEMS will make measurements for a typical day of operation for each piece of equipment during it typical operation. For pieces of equipment operated for multiple shifts in a single day or on a 24-hour basis, testing would be conducted over one of the shifts. The PEMS testing will require two days at the test site for each piece of equipment. The PEMS will be installed the day prior to the testing day, such that a full day or shift of actual operation can be captured, and the PEMS will be removed at the end of the day of operation. UCR will work with the terminal operators to ensure that the PEMS can be installed and removed such that a full day of operation can be captured.

The main PEMS to be used for this study will be SEMTECH gas-phase analyzers that UCR obtains from the EPA via a Cooperative Research and Development Agreement (CRADA) with UCR. UCR utilizes a SEMTECH-DS that is obtained through the EPA CRADA. This system is 1065 compliance and measures carbon monoxide (CO), carbon dioxide (CO_2), total hydrocarbon (THC), and total NOx emissions. These systems measure NO_x using a non-dispersive ultraviolet (NDUV) analyzer, THC using a heated flame ionization detector (HFID), and CO and CO_2 using a non-dispersive infrared (NDIR) analyzer. THC emissions are collected through a line heated to 190°C consistent with the conditions for regulatory measurements. The analyzer provides measurements of the concentration levels in the raw exhaust. Figure 1 shows the SEMTECH-DS unit. UCR also has access to several different SEMTECH-DS units from the EPA CRADA as well as SEMTECH-DS units that are owned internally by UCR.

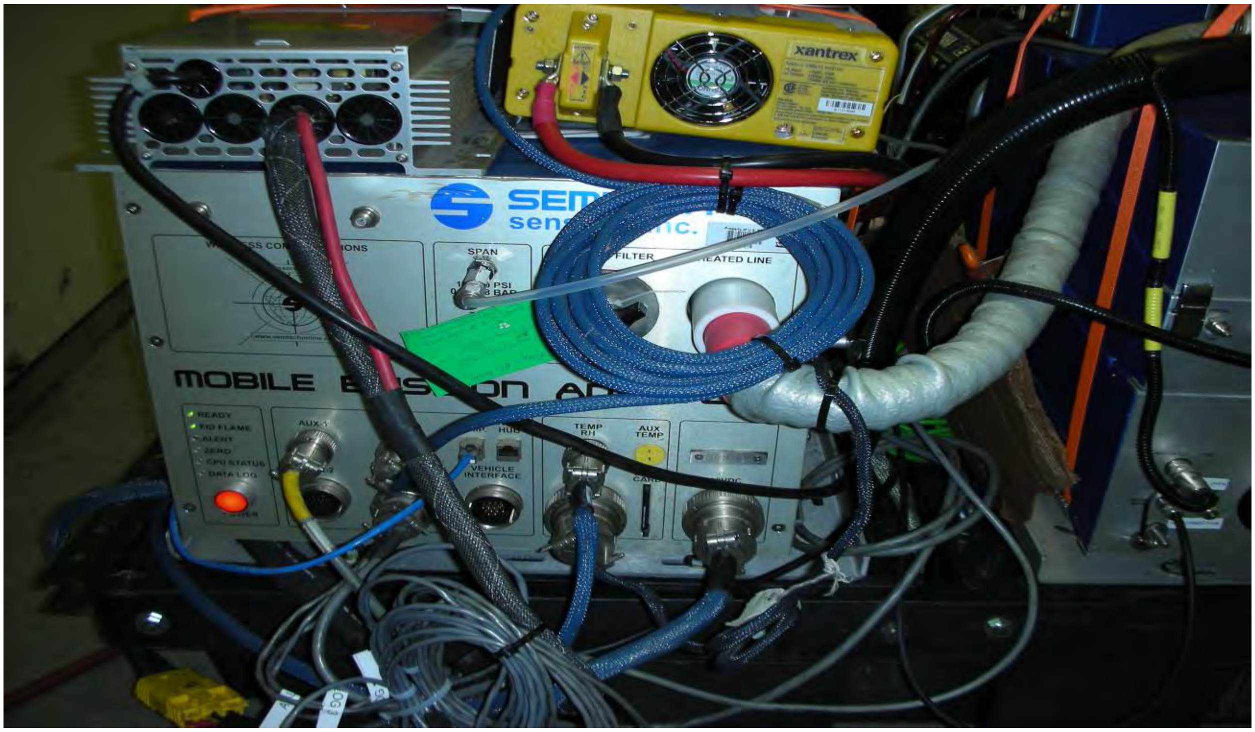

Figure 1: Picture of Semtech DS PEMS

The PM PEMS measurement system to be used is the AVL 494 PM system, which was released in mid-2010, combines AVL's 483 micro soot sensor (MSS) with a gravimetric filter module (GFM) option. The AVL 483 MSS measures the modulated laser light absorbed by particles from an acoustical microphone. The measurement principle is directly related to elemental carbon (EC) mass (also called soot), and is robust and found to have good agreement with the reference gravimetric method for EC dominated PM. The GFM is then utilized in conjunction with a post processor that utilizes the filter to estimate (or calibrate) the total PM from the soot and gravimetric filter measurements. One gravimetric filter can be sampled per day or depending on loading for per vehicle and continuous PM concentration is recorded at 1 Hz with an option of 10 Hz data. The combined MSS+GFM system recently received type approval by EPA as a total PM measurement solution for in-use testing, thus making it one of the few 1065 compliant PM PEMS systems.

Figure 2: Picture of PM PEMS

When exhaust flow is to be measured, a 40 CFR 1065 capable flow meter manufactured by Sensors, Inc. will be used. This flow meter is compatible with a wide range of different PEMS systems. The flow meter uses an averaging pitot tube and temperature to measure exhaust velocity via the Bernouli principle. The flow meter is housed in a 3", 4", or 5" diameter pipe that is placed in line with the engine tailpipe exhaust for the equipment being tested. Combining the known cross-sectional area of the tube with the measured exhaust velocity gives the volumetric flow rate, which is converted to mass flow rate using the Ideal Gas Law, known fuel properties and measured properties/constituents of the exhaust. Figure 3 is a picture of the exhaust flow meter. The exhaust flow rates are multiplied by the concentration levels for the various emission components to provide emission rates in grams per second.

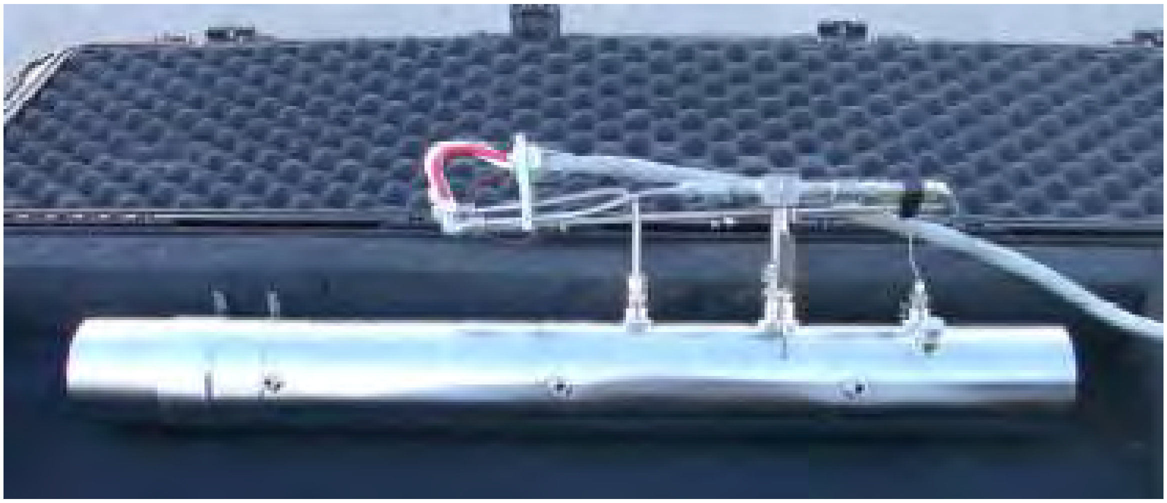

Figure 3: Picture of Sensors Exhaust Flow Meter

4. Engine Control Module Measurements

In conjunction with the PEMS measurements, a full range of information from the engine control module (ECM) will also be conducted. The data loggers to be utilized for this study are HEM Data Corporation data loggers capable of collecting information from the engine control module (ECM). These HEM data loggers are provided for and maintained through the EPA CRADA, such that they meet the highest standards for data measurement quality. The data loggers are configured to collect more than 170 ECM parameters at a frequency of 1 Hz. A subset of the type of data that can be collected is provided in Table 1. A more detailed list of potentially available ECM parameters is provided in Attachment A. It should be noted that list of actual ECM parameters that can be collected could be limited by the information that is broadcast publically by the ECM. Additional information may be available to the extent that UCR is provided access and assistance to obtain any manufacturer proprietary signals. The data loggers are also equipped to collect filtered Global Positioning System (GPS) data on a second-by-second basis. The data loggers communicate with the engine's ECM/OBD through industry standard communication protocols. The GPS is capable of measuring the vehicle's location (latitude and longitude) and altitude, from which speed and road grade are derived. The HEM data loggers are a small unit that can be attached quickly to the engine ECM connector in the cab on the driver's side (as shown below). The HEM data loggers are self-triggering to start automatically when a test vehicle is started and stop automatically when the test vehicle is stopped and can store data for up to 6 months, see Figure 4. The data will be downloaded to a server maintained by UCR following testing on each vehicle. For redundancy and data security, these data will also be maintained at an EPA/HEM Data Dashboard site that is also part of the EPA CRADA. The HEM data loggers are further described in the Activity Data Collection and Analysis Plan.

Table 1. A subset of data to be collected from each heavy duty vehicle [1]

Vehicle and Engine Information	ECU Data	GPS Data
Vocational use	Vehicle speed	Speed
Vehicle type	Engine horsepower	Latitude
Axle configuration	Engine RPM	Longitude
Vehicle model year	Fuel rate	Altitude
VIN number	Exhaust and SCR Temperatures	Date & time
Vehicle weight	Engine percent load	No. of satellites fixed
Engine make	Engine percent torque	Fix quality
Engine size	Reference engine torque	Position dilution of precision
Engine model	Engine intake manifold temperature	Engine on/off
Engine model year	Engine turbo boost pressure	
	Engine coolant temperature	

[1] Note GPS data can be sanitized to prevent identifying locations and routes taken. GPS data is utilized to know regions and impacts areas for the study not to study route behavior.

Figure 4. HEM data logger utilized for the J1939 activity monitoring program

5. Test Set-up and Procedures

For the testing set up, the equipment will all be housed in a rack that is designed to hold all of the PEMS equipment as well as the associated auxiliary equipment required to power the PEMS. The PEMS rack will be mounted to the equipment at a convenient location that provides access to the equipment's tailpipe for the exhaust connection, while at the same time not impeding the visibility of the driver. A picture of the PEMS rack is provided in Figure 5. A typical set up is shown in Figure 6.

With the Port's introduction, Tetra Tech/UCR will coordinate with SSA and LBCT directly. It is expected that assistance from the terminal operator with a forklift or crane will be needed to install the PEMS rack in an appropriate location. It should be noted that UCR has extensive experience with the mounting and installation of the PEMS rack, which has been installed on over 20 pieces of off-road equipment.

Figure 5. Picture of PEMS Rack Mount

Figure 6. Picture of PEMS Rack Mounted to Construction Bulldozer

Preliminary discussions with LBCT have indicated that there may be an issue with the amount of available space to mount the full 1065 compliant PEMS system on their yard tractor, as there are significant limitations with putting the PEMS on the railing behind the cab. For such applications, a mini-PEMS system shall be used for the emissions measurements. The NTK Compact Emissions Meter (NCEM) utilizes sensor based measurements to characterize NOx, PM mass, and particle number (PN). The NCEM unit requires considerably less space, as shown in Figure 7, and could be utilized in applications where the full 1065 PEMS system could not be realistically mounted. UCR studies has shown correlations between the NCEM and a 1065 compliant PEMS are within 10% for NOx. For PM and PN measurements, the NCEM will utilize the latest technology that has been implemented into the NCEM system as of approximately November 2018.

Figure 7. Picture of NCEM unit installed in a passenger car

The NCEM will provide concentration measurements that will be correlated with exhaust flow measurements to obtain tailpipe emissions on a grams basis. The exhaust flow can be determined from engine parameters and fuel flow, if such information is available through the ECM. Such information would more readily be available on a later model diesel engine. In the case where the engine ECM does not provide the information needed for the exhaust flow calculation, an exhaust flow meter would also be required, which would in turn require additional support instrumentation that would need to be positioned at an appropriate position on the yard tractor.

The operation of the PEMS includes daily and pre- and post-test calibration checks. These include zero and span checks for all pollutants. In addition, the system performs internal leak checks and purging during every power cycle of the instrument to help assure the system is functioning properly. The system does a functional check for each of the analyzers and to ensure that the analyzers and sampling lines have gotten up to the appropriate temperatures. UCR works in conjunction with the EPA to maintain the calibration of the system, including bi-annual, and monthly checks per the CFR 1065 subpart J. This includes semiannual checks of the EFM calibration, which is done at the Sensors Inc. facility in Michigan, as well as linearity checks for each of the analyzers, which are performed every 35 days per the CFR 1065.

Attachment A. List of Potentially Available ECM Parameters

1. PGN (Dec)	2. PGN (Hex)	3. SPN	4. SPN Name
5. 61443	6. F003	7. 91	8. Accelerator Pedal Position 1
9. 61443	10. F003	11. 92	12. Engine Percent Load At Current Speed
13. 61444	14. F004	15. 513	16. Actual Engine - Percent Torque
17. 61444	18. F004	19. 190	20. Engine Speed
21. 61445	22. F005	23. 524	24. Transmission Selected Gear
25. 61445	26. F005	27. 526	28. Transmission Actual Gear Ratio
29. 61445	30. F005	31. 523	32. Transmission Current Gear
33. 61450	34. F00A	35. 2659	36. Engine Exhaust Gas Recirculation 1 Mass Flow Rate
37. 61450	38. F00A	39. 132	40. Engine Intake Air Mass Flow Rate
41. 61450	42. F00A	43. 5257	44. Engine Exhaust Gas Recirculation 2 Mass Flow Rate
45. 61452	46. F00C	47. 3030	48. Transmission Torque Converter Ratio
49. 61454	50. F00E	51. 3216	52. Aftertreatment 1 Selective Catalytic Reduction Intake Nox
53. 61454	54. F00E	55. 3220	56. Aftertreatment 1 Selective Catalytic Reduction Intake NOx Reading Stable
57. 61454	58. F00E	59. 3224	60. Aftertreatment 1 Selective Catalytic Reduction Intake NOx Sensor Preliminary FMI
61. 61455	62. F00F	63. 3226	64. Aftertreatment 1 Outlet Nox
65. 61455	66. F00F	67. 3230	68. Aftertreatment 1 Outlet NOx Reading Stable
69. 61455	70. F00F	71. 3234	72. Aftertreatment 1 Outlet NOx Sensor Preliminary FMI
73. 61475	74. F023	75. 4332	76. Aftertreatment 1 SCR System State
77. 61477	78. F025	79. 4377	80. Aftertreatment 1 Outlet NH3
81. 61491	82. F033	83. 5848	84. Aftertreatment 1 SCR Intermediate NH3
85. 61491	86. F033	87. 5850	88. Aftertreatment 1 SCR Intermediate NH3 Reading Stable
89. 61497	90. F039	91. 6392	92. Engine Desired Air Fuel Ratio
93. 64585	94. FC49	95. 6935	96. Aftertreatment 1 SCR System Total Cleaning Time
97. 64585	98. FC49	99. 6936	100. Aftertreatment 1 SCR System Total Number of System Cleaning Events
101. 64585	102. FC49	103. 6937	104. Aftertreatment 1 SCR System Total Number of System Cleaning Inhibit Requests
105. 64585	106. FC49	107. 6938	108. Aftertreatment 1 SCR System Total Number of System Cleaning Manual Requests
109. 64585	110. FC49	111. 6939	112. Aftertreatment 1 SCR System Average Time Between System Cleaning Events
113. 64585	114. FC49	115. 6940	116. Aftertreatment 1 SCR System Average Distance Between System Cleaning Events
117. 64598	118. FC56	119. 6819	120. Aftertreatment SCR Malfunction Time
121. 64657	122. FC91	123. 6579	124. Engine Exhaust NOx
125. 64697	126. FCB9	127. 5978	128. Aftertreatment 1 Diesel Particulate Filter Time to Next Active Regeneration

129. 64697	130. FCB9	131. 6941	132. Aftertreatment 1 SCR System Time Since Last System Cleaning Event
133. 64709	134. FCC5	135. 5862	136. Aftertreatment 1 SCR Intermediate Temperature
137. 64709	138. FCC5	139. 5863	140. Aftertreatment 1 SCR Intermediate Temperature Preliminary FMI
141. 64713	142. FCC9	143. 5785	144. Engine Fuel Valve 1 Temperature
145. 64713	146. FCC9	147. 5786	148. Engine Fuel Valve 2 Temperature
149. 64735	150. FCDF	151. 5578	152. Engine Fuel Delivery Absolute Pressure
153. 64736	154. FCE0	155. 5503	156. Aftertreatment 1 Fuel Mass Rate
157. 64739	158. FCE3	159. 5541	160. Engine Turbocharger 1 Turbine Outlet Pressure
161. 64739	162. FCE3	163. 5544	164. Engine Turbocharger 2 Turbine Outlet Pressure
165. 64740	166. FCE4	167. 5540	168. Engine Fuel Temperature (High Resolution)
169. 64748	170. FCEC	171. 5459	172. Aftertreatment 1 NOx Adsorber Regeneration Status
173. 64752	174. FCF0	175. 5417	176. Engine Fuel Filter (Suction Side) Intake Absolute Pressure
177. 64828	178. FD3C	179. 4374	180. Aftertreatment 1 Diesel Exhaust Fluid Pump Motor Speed
181. PGN (Dec)	**182. PGN (Hex)**	**183. SPN**	**184. SPN Name**
185. 64828	186. FD3C	187. 5435	188. Aftertreatment 1 Diesel Exhaust Fluid Pump State
189. 64830	190. FD3E	191. 4360	192. Aftertreatment 1 SCR Inlet Temperature
193. 64830	194. FD3E	195. 4363	196. Aftertreatment 1 SCR Outlet Temperature
197. 64831	198. FD3F	199. 4358	200. Aftertreatment 1 SCR Differential Pressure
201. 64870	202. FD66	203. 5020	204. Engine Exhaust Gas Recirculation 1 Mixer Intake Temperature
205. 64878	206. FD6E	207. 3826	208. Aftertreatment 1 Diesel Exhaust Fluid Average Consumption
209. 64878	210. FD6E	211. 3828	212. Aftertreatment 1 SCR Commanded Diesel Exhaust Fluid Consumption
213. 64878	214. FD6E	215. 5463	216. Aftertreatment SCR Operator Inducement Active Traveled Distance
217. 64879	218. FD6F	219. 4750	220. Engine Exhaust Gas Recirculation 1 Cooler Intake Temperature
221. 64879	222. FD6F	223. 4751	224. Engine Exhaust Gas Recirculation 1 Cooler Intake Absolute Pressure
225. 64891	226. FD7B	227. 3721	228. Aftertreatment 1 Diesel Particulate Filter Time Since Last Active Regeneration
229. 64891	230. FD7B	231. 5466	232. Aftertreatment 1 Diesel Particulate Filter Soot Load Regeneration Threshold
233. 64892	234. FD7C	235. 3699	236. Aftertreatment Diesel Particulate Filter Passive Regeneration Status
237. 64892	238. FD7C	239. 3700	240. Aftertreatment Diesel Particulate Filter Active Regeneration Status
241. 64892	242. FD7C	243. 3701	244. Aftertreatment Diesel Particulate Filter Status

245. 64897	246. FD81	247. 3672	248. Engine Exhaust Gas Recirculation 1 Cooler Bypass Actuator Postion
249. 64920	250. FD98	251. 3522	252. Aftertreatment 1 Total Fuel Used
253. 64920	254. FD98	255. 3523	256. Aftertreatment 1 Total Regeneration Time
257. 64920	258. FD98	259. 3524	260. Aftertreatment 1 Total Disabled Time
261. 64920	262. FD98	263. 3525	264. Aftertreatment 1 Total Number of Active Regenerations
265. 64920	266. FD98	267. 3725	268. Aftertreatment 1 Diesel Particulate Filter Total Passive Regeneration Time
269. 64929	270. FDA1	271. 3480	272. Aftertreatment 1 Fuel Pressure 1
273. 64929	274. FDA1	275. 3481	276. Aftertreatment 1 Fuel Rate
277. 64931	278. FDA3	279. 3675	280. Engine Turbocharger Compressor Bypass Actuator 1 Position
281. 64932	282. FDA4	283. 3941	284. Engagement Status - PTO Engine Flywheel
285. 64932	286. FDA4	287. 3944	288. Engagement Status - PTO Engine Accessory Drive 1
289. 64932	290. FDA4	291. 3947	292. Engagement Status - PTO Engine Accessory Drive 2
293. 64932	294. FDA4	295. 3948	296. At least one PTO engaged
297. 64946	298. FDB2	299. 3250	300. Aftertreatment 1 Diesel Particulate Filter Intermediate Temperature
301. 64946	302. FDB2	303. 3251	304. Aftertreatment 1 Diesel Particulate Filter Differential Pressure
305. 64947	306. FDB3	307. 3246	308. Aftertreatment 1 Diesel Particulate Filter Outlet Temperature
309. 64948	310. FDB4	311. 3241	312. Aftertreatment 1 Exhaust Temperature 1
313. 64948	314. FDB4	315. 3242	316. Aftertreatment 1 Diesel Particulate Filter Intake Temperature
317. 64976	318. FDD0	319. 3562	320. Engine Intake Manifold #2 Pressure
321. 64976	322. FDD0	323. 3563	324. Engine Intake Manifold #1 Absolute Pressure
325. 64981	326. FDD5	327. 2791	328. Engine Exhaust Gas Recirculation 1 Valve 1 Control 1
329. 65110	330. FE56	331. 1761	332. Aftertreatment 1 Diesel Exhaust Fluid Tank Level
333. 65110	334. FE56	335. 3031	336. Aftertreatment 1 Diesel Exhaust Fluid Tank Temperature
337. 65110	338. FE56	339. 5245	340. Aftertreatment Selective Catalytic Reduction Operator Inducement Active
341. 65153	342. FE81	343. 1440	344. Engine Fuel Flow Rate 1
345. 65153	346. FE81	347. 1442	348. Engine Fuel Valve 1 Position
349. 65174	350. FE96	351. 1188	352. Engine Turbocharger Wastegate Actuator 1 Position
353. PGN (Dec)	**354. PGN (Hex)**	**355. SPN**	**356. SPN Name**
357. 65188	358. FEA4	359. 411	360. Engine Exhaust Gas Recirculation 1 Differential Pressure
361. 65190	362. FEA6	363. 1127	364. Engine Turbocharger 1 Boost Pressure
365. 65203	366. FEB3	367. 1028	368. Total Engine PTO Governor Fuel Used
369. 65203	370. FEB3	371. 1029	372. Trip Average Fuel Rate
373. 65208	374. FEB8	375. 1007	376. Trip Drive Fuel Used (Gaseous)

377.	65208	378.	FEB8	379.	1008	380.	Trip PTO Governor Moving Fuel Used (Gaseous)
381.	65208	382.	FEB8	383.	1009	384.	Trip PTO Governor Non-moving Fuel Used (Gaseous)
385.	65208	386.	FEB8	387.	1010	388.	Trip Vehicle Idle Fuel Used (Gaseous)
389.	65209	390.	FEB9	391.	1001	392.	Trip Drive Fuel Used
393.	65209	394.	FEB9	395.	1002	396.	Trip PTO Governor Moving Fuel Used
397.	65209	398.	FEB9	399.	1003	400.	Trip PTO Governor Non-moving Fuel Used
401.	65209	402.	FEB9	403.	1004	404.	Trip Vehicle Idle Fuel Used
405.	65213	406.	FEBD	407.	977	408.	Fan Drive State
409.	65213	410.	FEBD	411.	975	412.	Estimated Percent Fan Speed
413.	65217	414.	FEC1	415.	917	416.	Total Vehicle Distance (High Resolution)
417.	65217	418.	FEC1	419.	918	420.	Trip Distance (High Resolution)
421.	65226	422.	FECA	423.	987	424.	DM1 - Flash Engine Amber Warning Lamp (AWL)
425.	65226	426.	FECA	427.	624	428.	DM1 - Flash Engine Protect Lamp
429.	65226	430.	FECA	431.	623	432.	DM1 - Flash Engine Red Stop Lamp (RSL)
433.	65226	434.	FECA	435.	1213	436.	DM1 - Protect Lamp
437.	65226	438.	FECA	439.	3041	440.	DM1 - Amber Warning Lamp
441.	65226	442.	FECA	443.	3040	444.	DM1 - Red Stop Lamp
445.	65226	446.	FECA	447.	3039	448.	DM1 - Malfunction Indicator Lamp
449.	65226	450.	FECA	451.	3038	452.	DM1 - Failure Mode Identifier
453.	65226	454.	FECA	455.	1214	456.	DM1 - Ocurrence Count
457.	65226	458.	FECA	459.	1215	460.	DM1 - SPN Conversion Method
461.	65226	462.	FECA	463.	1216	464.	DM1 - Suspect Parameter Number
465.	65226	466.	FECA	467.	1706	468.	DM1 - Flash Malfunction Indicator Lamp
469.	65236	470.	FED4	471.	987	472.	DM12 - Protect Lamp
473.	65236	474.	FED4	475.	624	476.	DM12 - Amber Warning Lamp
477.	65236	478.	FED4	479.	623	480.	DM12 - Red Stop Lamp
481.	65236	482.	FED4	483.	1213	484.	DM12 - Malfunction Indicator Lamp
485.	65236	486.	FED4	487.	3041	488.	DM12 - Flash Protect Lamp
489.	65236	490.	FED4	491.	3040	492.	DM12 - Flash Amber Warning Lamp (AWL)
493.	65236	494.	FED4	495.	3039	496.	DM12 - Flash Red Stop Lamp (RSL)
497.	65236	498.	FED4	499.	3038	500.	DM12 - Flash Malfunction Indicator Lamp
501.	65236	502.	FED4	503.	1214	504.	DM12 - Suspect Parameter Number
505.	65236	506.	FED4	507.	1215	508.	DM12 - Failure Mode Identifier
509.	65236	510.	FED4	511.	1216	512.	DM12- Ocurrence Count
513.	65236	514.	FED4	515.	1706	516.	DM12 - SPN Conversion Method
517.	65244	518.	FEDC	519.	236	520.	Engine Total Idle Fuel Used
521.	65244	522.	FEDC	523.	235	524.	Engine Total Idle Hours
525.	65245	526.	FEDD	527.	103	528.	Engine Turbocharger 1 Speed
529.	65247	530.	FEDF	531.	514	532.	Nominal Friction - Percent Torque
533.	65247	534.	FEDF	535.	515	536.	Engine's Desired Operating Speed
537.	65247	538.	FEDF	539.	519	540.	Engine's Desired Operating Speed Asymmetry Adjustment
541.	65247	542.	FEDF	543.	2978	544.	Estimated Engine Parasitic Losses - Percent Torque

545. 65247	546. FEDF	547. 3236	548. Aftertreatment 1 Exhaust Gas Mass Flow Rate
549. 65248	550. FEE0	551. 244	552. Trip Distance
553. 65248	554. FEE0	555. 245	556. Total Vehicle Distance
557. 65251	558. FEE3	559. 188	560. Engine Speed At Idle, Point 1
561. 65251	562. FEE3	563. 539	564. Engine Percent Torque At Idle, Point 1
565. PGN (Dec)	**566. PGN (Hex)**	**567. SPN**	**568. SPN Name**
569. 65251	570. FEE3	571. 528	572. Engine Speed At Point 2
573. 65251	574. FEE3	575. 540	576. Engine Percent Torque At Point 2
577. 65251	578. FEE3	579. 529	580. Engine Speed At Point 3
581. 65251	582. FEE3	583. 541	584. Engine Percent Torque At Point 3
585. 65251	586. FEE3	587. 530	588. Engine Speed At Point 4
589. 65251	590. FEE3	591. 542	592. Engine Percent Torque At Point 4
593. 65251	594. FEE3	595. 531	596. Engine Speed At Point 5
597. 65251	598. FEE3	599. 543	600. Engine Percent Torque At Point 5
601. 65251	602. FEE3	603. 532	604. Engine Speed At High Idle, Point 6
605. 65251	606. FEE3	607. 544	608. Engine Reference Torque
609. 65251	610. FEE3	611. 533	612. Engine Maximum Momentary Override Speed, Point 7
613. 65251	614. FEE3	615. 535	616. Engine Requested Speed Control Range Lower Limit
617. 65251	618. FEE3	619. 536	620. Engine Requested Speed Control Range Upper Limit
621. 65251	622. FEE3	623. 537	624. Engine Requested Torque Control Range Lower Limit
625. 65251	626. FEE3	627. 538	628. Engine Requested Torque Control Range Upper Limit
629. 65251	630. FEE3	631. 1712	632. Engine Requested Speed Control Range Upper Limit (Extended Range)
633. 65251	634. FEE3	635. 1794	636. Engine Moment of Inertia
637. 65251	638. FEE3	639. 1846	640. Engine Default Torque Limit
641. 65253	642. FEE5	643. 247	644. Engine Total Hours of Operation
645. 65255	646. FEE7	647. 246	648. Total Vehicle Hours
649. 65257	650. FEE9	651. 182	652. Engine Trip Fuel
653. 65257	654. FEE9	655. 250	656. Engine Total Fuel Used
657. 65262	658. FEEE	659. 110	660. Engine Coolant Temperature
661. 65262	662. FEEE	663. 174	664. Engine Fuel Temperature 1
665. 65262	666. FEEE	667. 175	668. Engine Oil Temperature 1
669. 65265	670. FEF1	671. 84	672. Wheel-Based Vehicle Speed
673. 65266	674. FEF2	675. 183	676. Engine Fuel Rate
677. 65266	678. FEF2	679. 184	680. Engine Instantaneous Fuel Economy
681. 65266	682. FEF2	683. 51	684. Engine Throttle Valve 1 Position 1
685. 65269	686. FEF5	687. 108	688. Barometric Pressure
689. 65269	690. FEF5	691. 105	692. Engine Intake Air Temperature
693. 65270	694. FEF6	695. 105	696. Engine Intake Manifold 1 Temperature
697. 65270	698. FEF6	699. 106	700. Engine Intake Air Pressure
701. 65270	702. FEF6	703. 173	704. Engine Exhaust Temperature

C-PORT Final Report

Appendix E: Baseline Emissions Testing Report

Baseline Emissions Testing Report

Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program

CARB Off-Road Advanced Technology Demonstration Projects

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1. Background

The Tetra Tech team is providing support for data logging and portable emissions measurement systems (PEMS) testing of zero-emissions off-road equipment as part of the Baseline Emissions Test Plan efforts. This is being conducted in support of the Port of Long Beach's (POLB) C-PORT project for the California Air Resources Board (CARB) Off-Road Advanced Technology Demonstration Projects solicitation. There are four (4) total pieces of zero-emissions equipment demonstrated. There are three (3) total battery-electric top handlers (Taylor/BYD Motors): two (2) at Pier J SSA and one (1) at Pier E LBCT. There is one (1) battery-electric yard tractor (Kalmar/TransPower) at Pier E LBCT.

2. Objective

The purpose of this project is to better understand emissions and performance benefits of the zero-emissions equipment. This report covers the baseline emissions testing that was conducted on two (2) pieces of baseline diesel equipment (one top handler at Pier J SSA and one yard tractor at Pier E LBCT). The PEMS testing, as discussed in this report, provides information on the baseline emissions and fuel consumption for the diesel equipment, which in turn provides a basis for comparison that the zero-emissions equipment can be compared with. The baseline PEMS measurements included emissions for oxides of nitrogen (NO_x), particulate matter (PM), carbon monoxide (CO), carbon dioxide (CO_2), and total hydrocarbon (THC) for the diesel top handler. Fuel consumption was determined from the emissions measurements based on the carbon balance method.

3. Experimental Set-up

3.1 PEMS Testing

Tetra Tech team member, University of California at Riverside (UCR), installed and made PEMS measurements on the three pieces of baseline diesel equipment. PEMS measurements were for a typical day of operation for each piece of equipment over a single shift. The PEMS were installed the day prior to the testing day, such that a full day or shift of actual operation can be captured, and the PEMS were removed at the end of the day or shift of operation.

The main PEMS to be used for this study was a SEMTECH gas-phase analyzer. This system is 1065 compliance and measures carbon monoxide (CO), carbon dioxide (CO_2), total hydrocarbon (THC), and total NOx emissions. The SEMTECH measure NO_x using a non-dispersive ultraviolet (NDUV) analyzer, THC using a heated flame ionization detector (HFID), and CO and CO_2 using a non-dispersive infrared (NDIR) analyzer. THC emissions are collected through a line heated to 190°C consistent with the conditions for regulatory measurements. The analyzer provides measurements of the concentration levels in the raw exhaust. Figure 1 shows the SEMTECH-DS unit. UCR also has access to several different SEMTECH-DS units from the United States (U.S.) Environmental Protection Agency (EPA) via a Cooperative Research and Development Agreement (CRADA) with UCR as well as SEMTECH-DS units that are owned internally by UCR. These units are also maintained and calibration through the EPA CRADA.

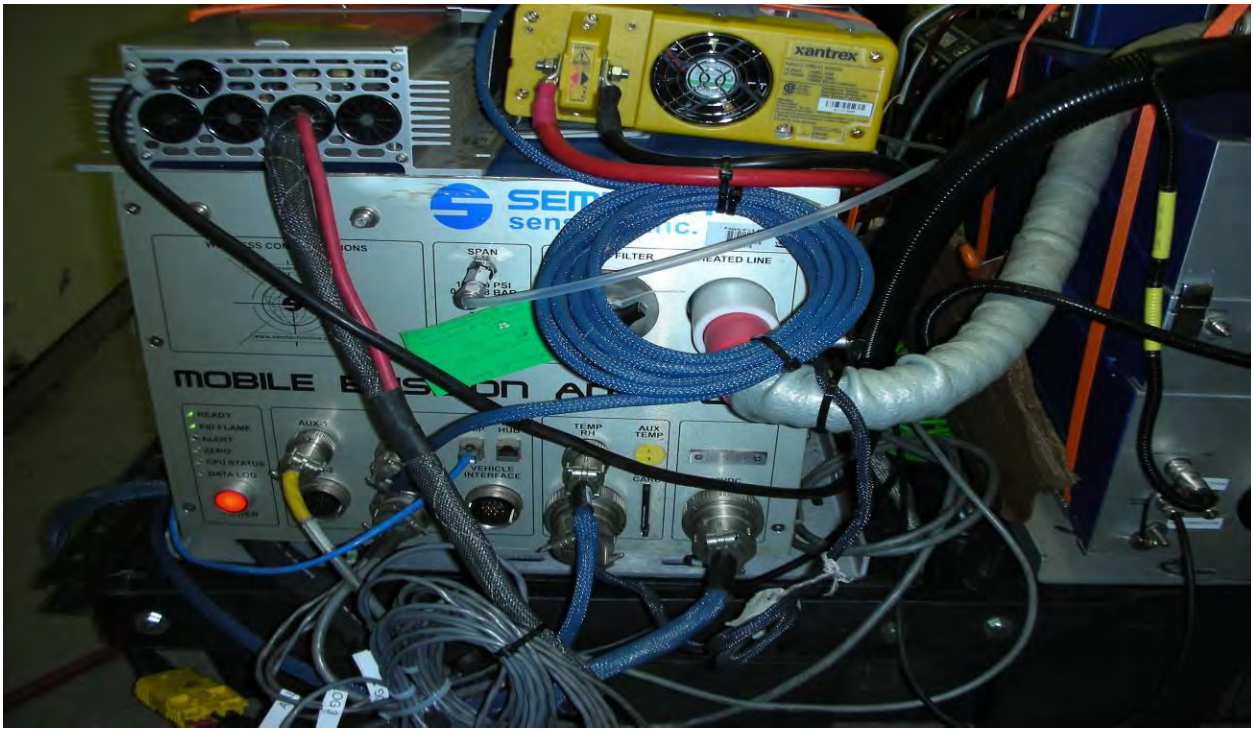

Figure 1: Picture of Semtech DS PEMS

The main PM PEMS measurement system used was the AVL 494 PM system, which combines AVL's 483 micro soot sensor (MSS) with a gravimetric filter module (GFM) option. The AVL 483 MSS measures the modulated laser light absorbed by particles from an acoustical microphone. The measurement principle is directly related to elemental carbon (EC) mass (also called soot), and is robust and found to have good agreement with the reference gravimetric method for EC dominated PM. The GFM is then utilized in conjunction with a post processor that utilizes the filter to estimate (or calibrate) the total PM from the soot and gravimetric filter measurements. One gravimetric filter can be sampled per day or depending on loading for per vehicle and continuous PM concentration is recorded at 1 Hz with an option of 10 Hz data. The combined MSS+GFM system is approved by EPA as a total PM measurement solution for in-use testing, thus making it one of the few 1065 compliant PM PEMS systems.

Figure 2: Picture of PM PEMS

A 40 CFR 1065 capable flow meter manufactured by Sensors, Inc. was used for exhaust flow measurements. This flow meter is compatible with a wide range of different PEMS systems. The flow meter uses an averaging pitot tube and temperature to measure exhaust velocity via the Bernouli principle. The flow meter is housed in a 3”, 4”, or 5” diameter pipe that is placed in line with the engine tailpipe exhaust for the equipment being tested. Combining the known cross-sectional area of the tube with the measured exhaust velocity gives the volumetric flow rate, which is converted to mass flow rate using the Ideal Gas Law, known fuel properties and measured properties/constituents of the exhaust. Figure 3 is a picture of the exhaust flow meter. The exhaust flow rates are multiplied by the concentration levels for the various emission components to provide emission rates in grams per second.

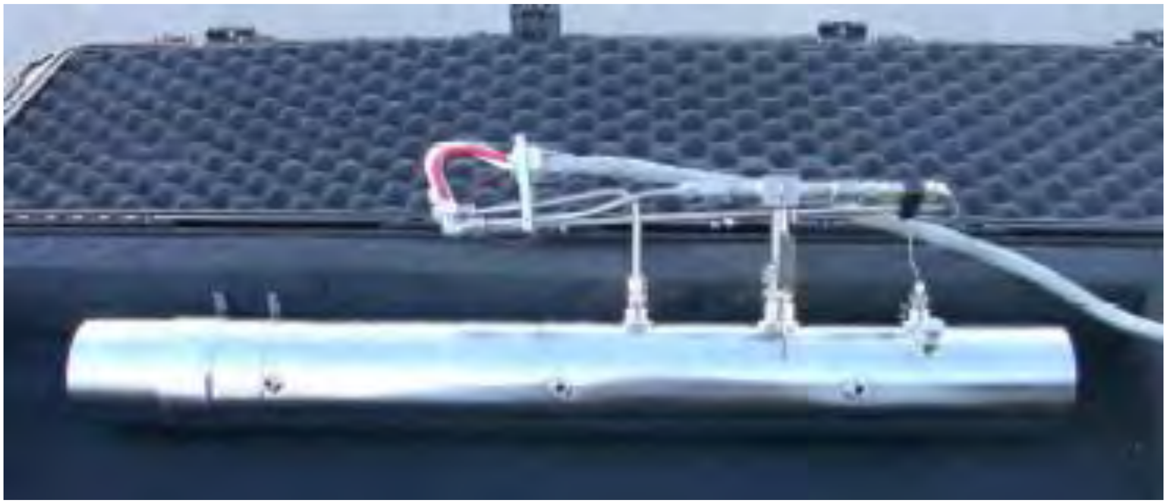

Figure 3: Picture of Sensors Exhaust Flow Meter

For the PEMS testing on the diesel yard tractor at LBCT, a second mini-PEMS system was used. This system was utilized due to spatial constraints on the LBCT diesel yard tractor that prohibited the installation of the full Semtech and AVL 494 PM system. The mini-PEMS utilized for the baseline diesel yard tractor testing was a parSYNC system. The parSYNC utilizes electro chemical sensor-based modules to characterize CO, CO_2, NO, NO_2 and PM mass, and PN. The modules have a shelf life of 1 year and require routine maintenance to manage their accuracy. The quality of the sensors can be managed with standard linearity practices so the system is safe to use until the linearity starts to decline. The parSYNC unit requires very little space, as shown in Figure 4, and can be utilized in applications where the full regulatory PEMS system could not be realistically mounted, such as a diesel yard tractor. UCR studies have shown correlations between the parSYNC and regulatory compliant PEMS are within 10% for CO_2 and NOx. PM does not correlate as well at the low levels expected for DPF equipped yard tractors, although PM levels near the detection threshold of the instrument inherently indicate good PM control. The fuel flow measurement from the engine control module (ECM) was used to determine the corresponding exhaust flow rates in conjunction with the parSNYC mini-PEMS.

Figure 4: Picture of parSYNC mini-PEMS

3.2 Engine Control Module Measurements

In conjunction with the PEMS measurements, a full range of information from the engine control module (ECM) was also collected. The data loggers utilized for this study were HEM Data Corporation data loggers capable of collecting information from the ECM. These HEM data loggers are provided for and maintained through the EPA CRADA, such that they meet the highest standards for data measurement quality. The data loggers are configured to collect more than 200 ECM parameters at a frequency of 1 Hz. A subset of the type of data that can be collected is provided in Table 1. It should be noted that the actual ECM parameters that can be collected is limited by the information that is broadcast publically by the ECM. The data loggers are also equipped to collect filtered Global Positioning System (GPS) data on a second-by-second basis. The data loggers communicate with the engine's ECM/OBD through industry standard communication protocols. The GPS is capable of measuring the vehicle's location (latitude and longitude) and altitude, from which speed and road grade are derived. The HEM data loggers are a small unit that can be attached quickly to the engine ECM connector in the cab on the driver's side, see Figure 5. The HEM data loggers are self-triggering to start automatically when a test vehicle is started and stop automatically when the test vehicle is stopped and can store data for up to 6 months. The data was downloaded to a server maintained by UCR following testing on each piece of equipment.

Table 1. A subset of data to be collected from the diesel equipment[1]

Engine and Equipment Information	ECU Data	GPS Data
Axle Configuration	Odometer	Velocity
Engine Make	Engine Load Percentage	Latitude
Engine Model	Engine Torque Percentage	Longitude
Engine Size	Engine RPM	Altitude
Engine Model Year	Fuel Rate	Date and Time
Equipment Model Year	Exhaust Temperature	Number of Satellites Fixed
Equipment Type	Aftertreatment Temperatures	Fix Quality
Equipment Weight	Equipment Speed	Position Dilution of Precision
VIN		
Vocational Use		

[1] Note GPS data can be sanitized to prevent identifying locations and routes taken. GPS data is utilized to know regions and impacts areas for the study not to study route behavior.

Figure 5. HEM data logger utilized for the J1939 activity monitoring program

3.3 Test Set-Up and Procedures

The PEMS were mounted and secured to the equipment in a spot that allowed the equipment to be operated typically without any visual impairment. A picture of the PEMS installation on the top handler is provided in Figure 6. A picture of the mini-PEMS installation on the top handler is provided in Figure 6.

Figure 6. Picture of PEMS Mounted on the Top Handler

Figure 7. Picture of the mini-PEMS mounted on the Yard Tractor

The operation of the Semtech PEMS and the mini-PEMS includes daily and pre- and post-test calibration checks. These include zero and span checks for all pollutants. In addition, the Semtech PEMS performs internal leak checks and purging during every power cycle of the instrument to help assure the system is functioning properly. The Semtech PEMS also does a functional check for each of the analyzers and to ensure that the analyzers and sampling lines have gotten up to the appropriate temperatures. UCR works in conjunction with the EPA to maintain the calibration of the Semtech PEMS, including bi-annual, and monthly checks per the CFR 1065 subpart J. This includes semiannual checks of the EFM calibration, which is done at the Sensors Inc. facility in Michigan, as well as linearity checks for each of the analyzers, which are performed every 35 days per the CFR 1065. A linearity check was also done on the parSYNC system before the testing was conducted on the diesel yard tractor.

4. Results

4.1 Diesel Top Handler

Figure 8 shows the NOx emissions for the SSA diesel top handler for the PEMS testing. The daily average NOx emissions for the diesel top handler were 22.9 g/mi, 2.87 g/bhp-hr, 57.6 g/gal., 355 g/hour, and 1803 g/day.

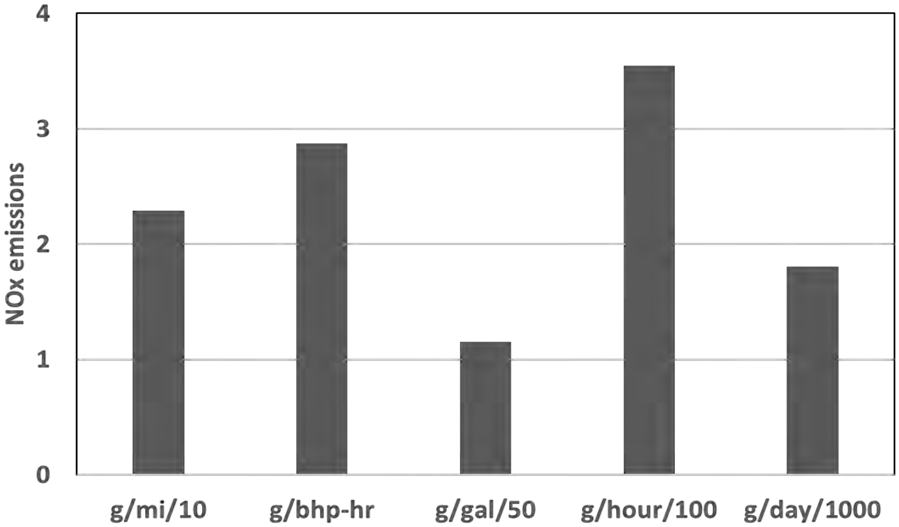

Figure 8. NOx Emissions for SSA Diesel Top Handler

Figure 9 shows the PM emissions for the SSA diesel top handler for the PEMS testing. The daily average PM emissions for the diesel top handler were 0.73 mg/mi, 0.09 mg/bhp-hr, 1.83 mg/gal., 11.3 mg/hour, and 57.3 mg/day.

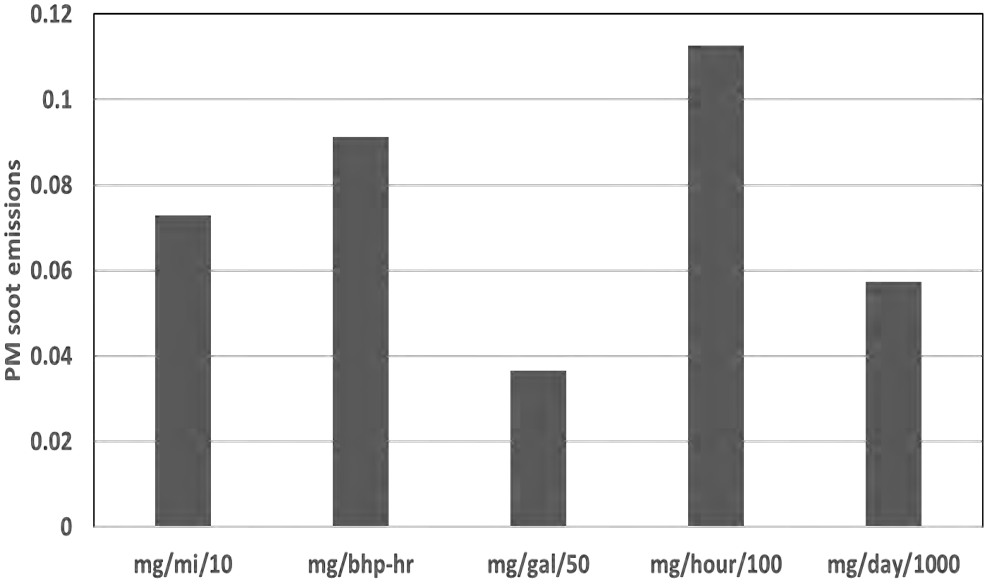

Figure 9. PM Emissions for SSA Diesel Top Handler

Figure 10 shows the THC emissions for the SSA diesel top handler for the PEMS testing. The daily average THC emissions for the diesel top handler were 0.03 g/mi, 0.004 g/bhp-hr, 0.09 g/gal., 0.53 g/hour, and 2.69 g/day.

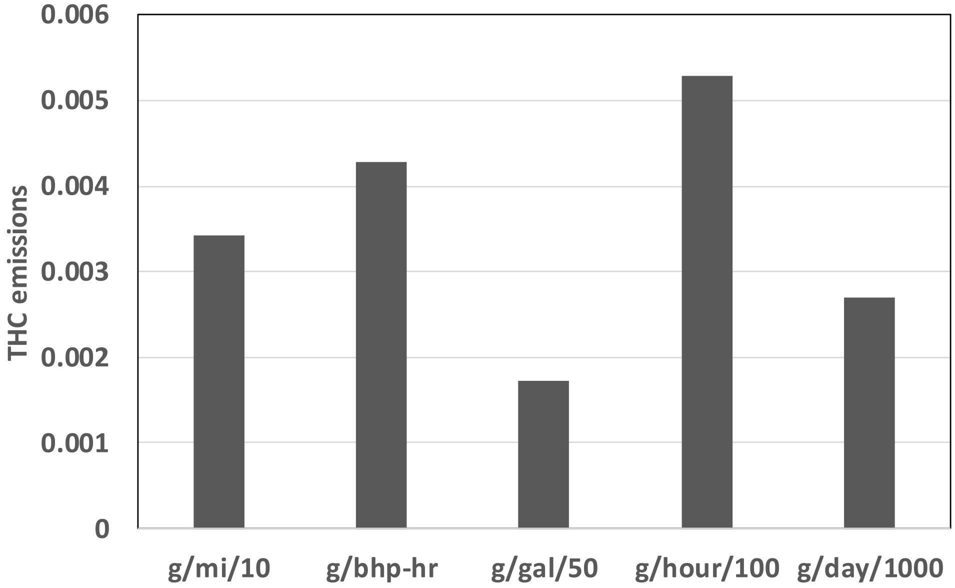

Figure 10. THC Emissions for SSA Diesel Top Handler

Figure 11 shows the CO emissions for the SSA diesel top handler for the PEMS testing. The daily average CO emissions for the diesel top handler were 4.25 g/mi, 0.53 g/bhp-hr, 10.7 g/gal., 65.8 g/hour, and 334 g/day.

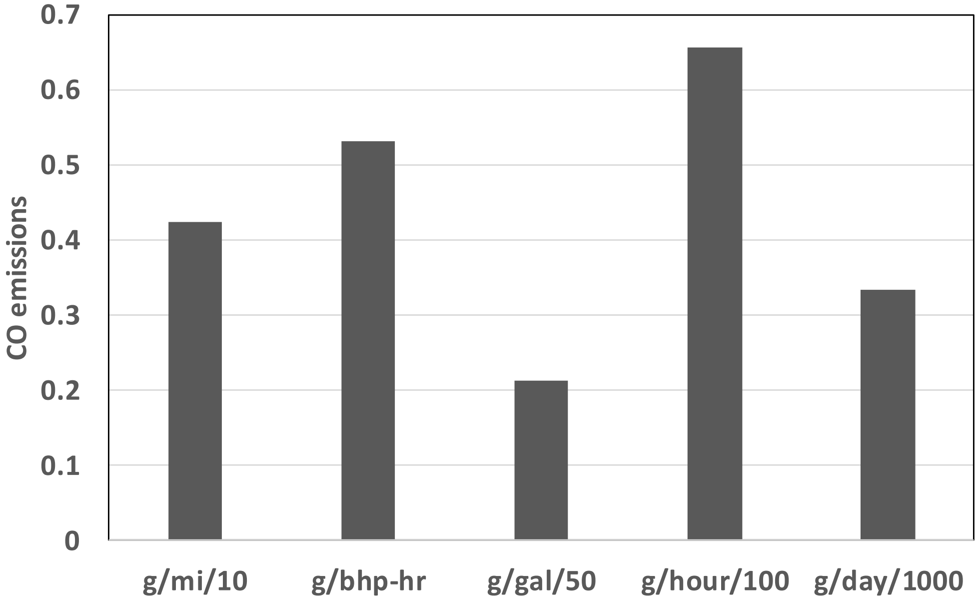

Figure 11. CO Emissions for SSA Diesel Top Handler

Figure 12 shows the CO_2 emissions for the SSA diesel top handler for the PEMS testing. The daily average CO_2 emissions for the diesel top handler were 4,025 g/mi, 505 g/bhp-hr, 10,124 g/gal., 62,330 g/hour, and 316,948 g/day.

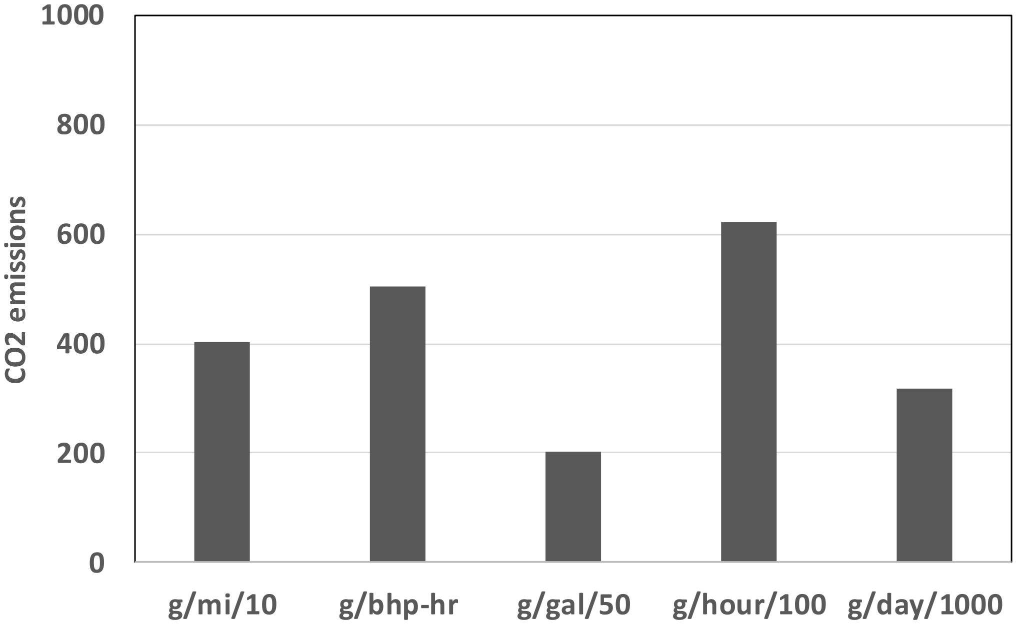

Figure 12. CO_2 Emissions for SSA Diesel Top Handler

Figure 13 shows the fuel consumption for the SSA diesel top handler for the PEMS testing. The fuel consumption for the diesel top handler was 31.3 gal/day, 6.2 gal/hr, and 0.05 gal/bhp-hr.

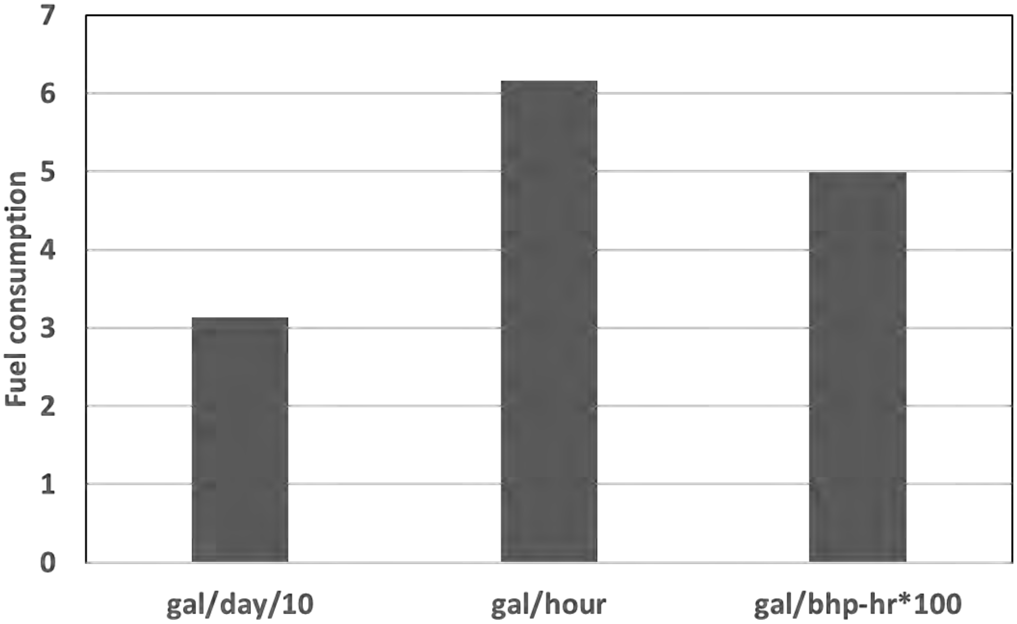

Figure 13. Fuel consumption for SSA Diesel Top Handler

4.2 Diesel Yard Tractor

Figure 14 shows the NOx emissions for the LBCT diesel yard tractor for the PEMS testing. The daily average NOx emissions for the diesel yard tractor were 7.56 g/mi, 1.91 g/bhp-hr, 30.25 g/gal., 61.16 g/hour, and 1768.57 g/day.

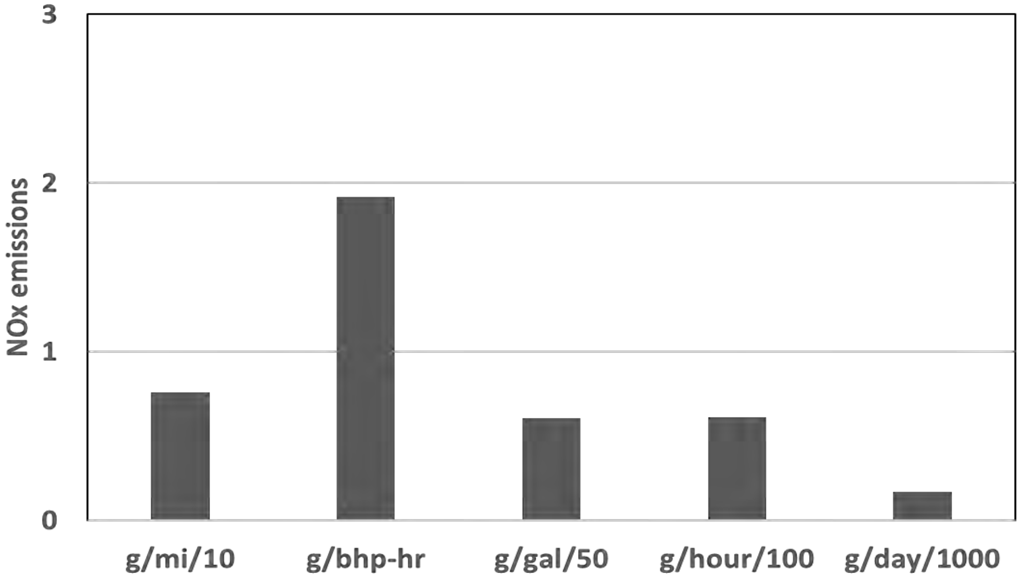

Figure 14. NOx Emissions for LBCT Diesel Yard Tractor

Figure 15 shows the PM emissions for the LBCT diesel yard tractor for the PEMS testing. The daily average PM emissions for the diesel yard tractor were 0.015 mg/mi, 0.004 mg/bhp-hr, 0.061 mg/gal., 0.124 mg/hour, and 0.344 mg/day.

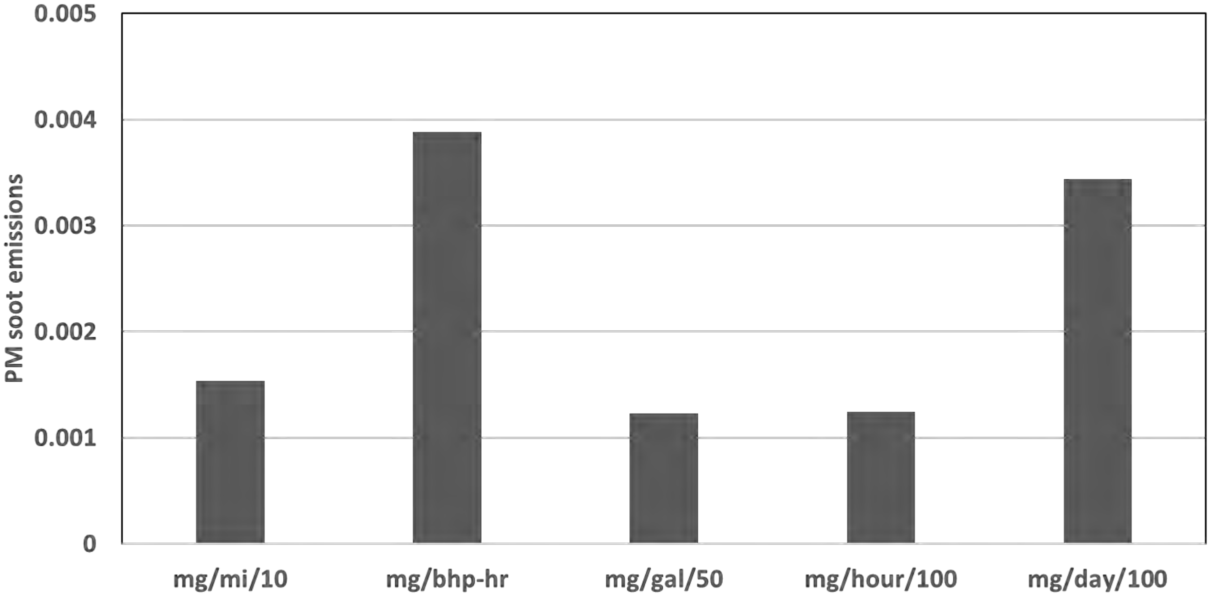

Figure 15. PM Emissions for LBCT Diesel Yard Tractor

Figure 16 shows the CO emissions for the LBCT diesel yard tractor for the PEMS testing. The daily average CO emissions for the diesel yard tractor were 3.43 g/mi, 0.87 g/bhp-hr, 13.72 g/gal., 27.74 g/hour, and 76.83 g/day.

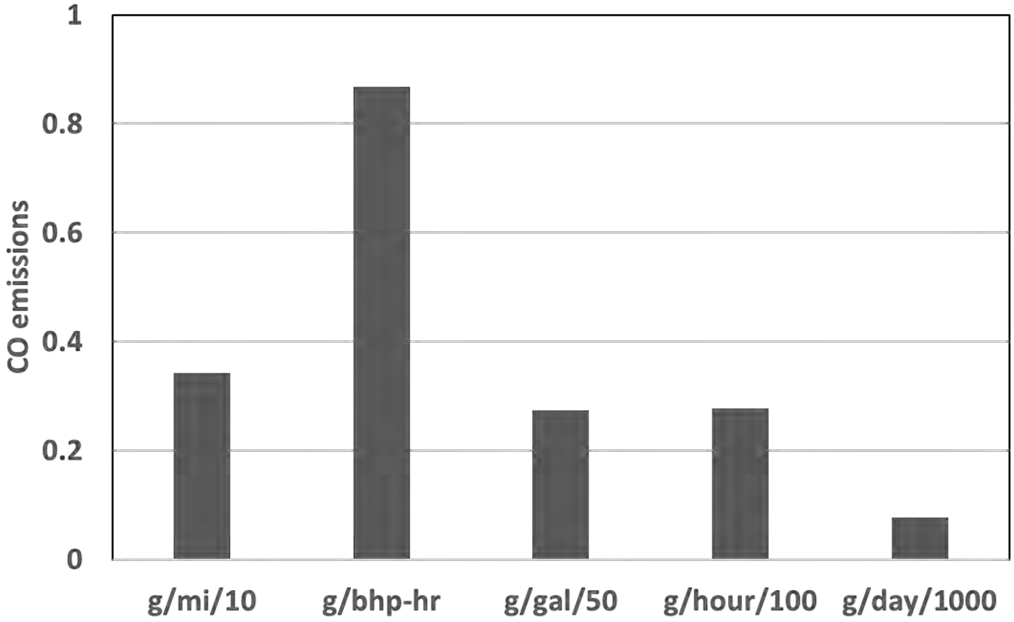

Figure 16. CO Emissions for LBCT Diesel Yard Tractor

Figure 17 shows the CO_2 emissions for the LBCT diesel yard tractor for the PEMS testing. The daily average CO_2 emissions for the diesel yard tractor were 2,062 g/mi, 522 g/bhp-hr, 8,252 g/gal., 16,684 g/hour, and 46,216 g/day.

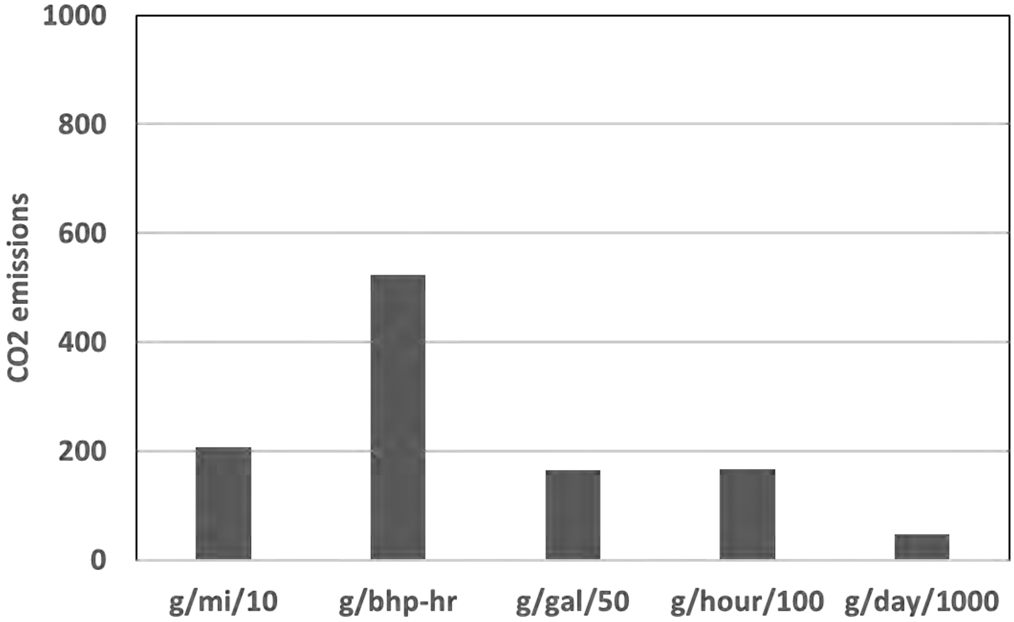

Figure 17. CO_2 Emissions for LBCT Diesel Yard Tractor

Figure 18 shows the fuel consumption for the LBCT diesel yard tractor for the PEMS testing. The daily basis fuel consumption for the diesel yard tractor was 5.6 gal/day, 2.8 gal/hr, and 0.06 gal/bhp-hr.

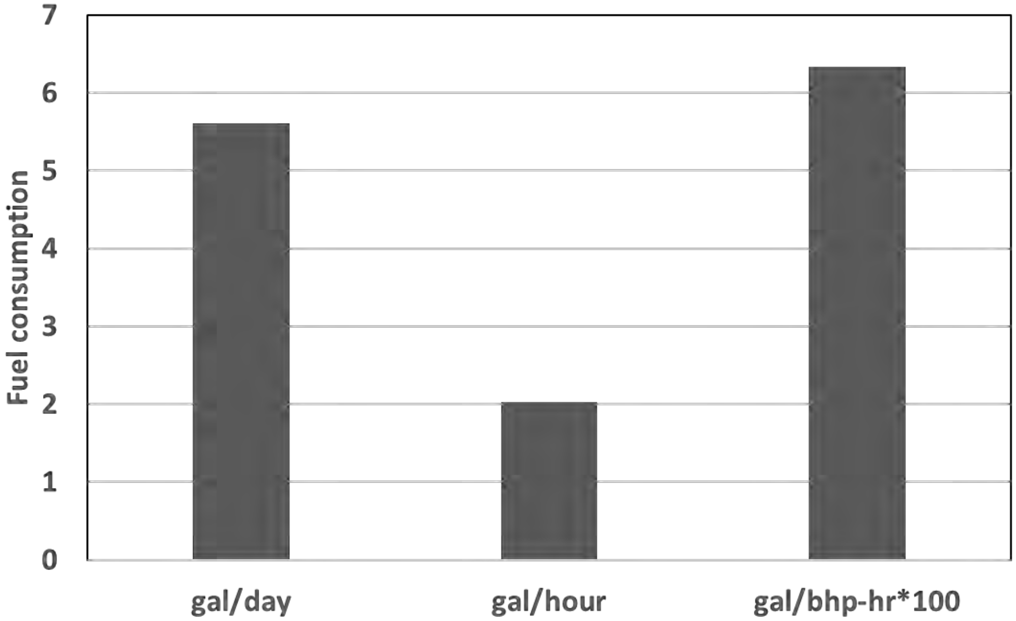

Figure 18. Fuel consumption for LBCT Diesel Yard Tractor

5. Summary

The purpose of this project is to better understand emissions and performance benefits of the zero-emissions equipment. This report covers the baseline emissions testing that was conducted on two (2) pieces of baseline diesel equipment (one top handler at Pier J SSA and one yard tractor at Pier E LBCT). PEMS testing was conducted for one operational shift for each piece of equipment. The baseline PEMS measurements included emissions for NO_x, PM, CO, CO_2, and THC for the diesel top handler. Fuel consumption was determined from the emissions measurements based on the carbon balance method. The information from these baseline emissions and fuel consumption PEMS measurements provides a basis for comparison to better understand the emissions benefits of the zero-emissions equipment.

A summary of the PEMS data results is provided below.

- NOx emissions for the diesel top handler averaged 22.9 g/mi, 2.87 g/bhp-hr, 57.6 g/gal., 355 g/hour, and 1803 g/day. NOx emissions for the diesel yard tractor averaged 7.56 g/mi, 1.91 g/bhp-hr, 30.25 g/gal., 61.16 g/hour, and 1768.57 g/day.
- PM emissions for the diesel top handler averaged 0.73 mg/mi, 0.09 mg/bhp-hr, 1.83 mg/gal., 11.3 mg/hour, and 57.3 mg/day. PM emissions for the diesel yard tractor averaged 0.015 mg/mi, 0.004 mg/bhp-hr, 0.061 mg/gal., 0.124 mg/hour, and 0.344 mg/day.
- THC emissions for the diesel top handler averaged 0.03 g/mi, 0.004 g/bhp-hr, 0.09 g/gal., 0.53 g/hour, and 2.69 g/day.
- CO emissions for the diesel top handler averaged 4.25 g/mi, 0.53 g/bhp-hr, 10.7 g/gal., 65.8 g/hour, and 334 g/day. CO emissions for the diesel yard tractor averaged 3.43 g/mi, 0.87 g/bhp-hr, 13.72 g/gal., 27.74 g/hour, and 76.83 g/day.
- CO_2 emissions for the diesel top handler averaged 4,025 g/mi, 505 g/bhp-hr, 10,124 g/gal., 62,330 g/hour, and 316,948 g/day. CO_2 emissions for the diesel yard tractor averaged 2,062 g/mi, 522 g/bhp-hr, 8,252 g/gal., 16,684 g/hour, and 46,216 g/day.
- Fuel consumption values for the diesel top handler averaged 31.3 gal/day, 6.2 gal/hr, and 0.05 gal/bhp-hr. Fuel consumption values for the diesel yard tractor averaged 5.6 gal/day, 2.8 gal/hr, and 0.06 gal/bhp-hr.

C-PORT Final Report

Appendix F: Data Collection and Analysis Test Plan

Activity Data Collection and Analysis Plan

Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program

CARB Off-Road Advanced Technology Demonstration Projects

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1. Background

The Tetra Tech team will provide support for data logging and Portable Activity Measurement System (PAMS) Measurements testing of diesel and zero-emissions off-road equipment as part of the Activity Data Collection and Analysis efforts. This will be conducted in support of the Port of Long Beach's (POLB) C-PORT project for the California Air Resources Board (CARB) Off-Road Advanced Technology Demonstration Projects solicitation. There will be five (5) total pieces of zero-emissions equipment demonstrated. There are three (3) total battery-electric top handlers (Taylor/BYD Motors): two (2) at Pier J SSA and one (1) at Pier E LBCT. There are two (2) total yard tractors: one (1) battery-electric yard tractor (Kalmar/TransPower) at Pier E LBCT and one (1) fuel cell yard tractor (UQM/CNHTC/LOOP energy) also at Pier E LBCT.

2. Objective

The purpose of this Activity Data Collection and Analysis Planis to better understand the activity and performance benefits of zero-emissions equipment. For this study, the demonstration will focus on measuring the activity data for the equipment and a portable activity measurement system (PAMS) data logging collection will be conducted on the five (5) pieces of zero-emissions equipment and the three (3) baseline diesel equipment (one top handler at Pier J SSA, one top handler at Pier E LBCT, and one yard tractor at Pier E LBCT). Based on the information collected by the data loggers from the engine control module (ECM), University of California at Riverside (UCR) will process and analyze the collected data to determine activity patterns including hours of operation, days of operation per year, average miles traveled per day, average value and distribution of speed and acceleration, and idling time.

3. Portable Activity Measurement System (PAMS) Measurements

For this testing, UCR, will install data loggers and make PAMS measurements on the five pieces of zero-emissions equipment and the three pieces of baseline diesel equipment at POLB, for a total of 8 pieces of equipment. There will be three (3) total battery-electric top handlers (Taylor/BYD Motors): two (2) at Pier J SSA and one (1) at Pier E LBCT. There are two (2) total yard tractors: one (1) battery-electric yard tractor (Kalmar/TransPower) at Pier E LBCT and one (1) fuel cell yard tractor (UQM/CNHTC/LOOP energy) also at Pier E LBCT. UCR will coordinate with the terminal operators to ensure that the PAMS can be installed and removed such that a full day of operation can be captured.

The PAMS data loggers to be utilized for this study are HEM Data Corporation data loggers capable of collecting a full range of information from the engine control module (ECM). These HEM data loggers are provided for and maintained through the EPA CRADA, such that they meet the highest standards for data measurement quality. The data loggers are configured to collect more than 170 ECM parameters at a frequency of 1 Hz. A subset of the type of data that can be collected is provided in Table 1. It should be noted that list of actual ECM parameters that can be collected could be limited by the information that is broadcast publically by the ECM. Additional information may be available to the extent that Tetra Tech team is provided access and assistance to obtain any manufacturer proprietary signals. In some cases, data such as aftertreatment temperatures and state of charge (SOC) and other metrics for electric vehicles may require information to be collected from manufacturer proprietary signals. The data loggers are also equipped to collect filtered Global Positioning System (GPS) data on a second-by-second basis. The data loggers communicate with the engine's ECM/OBD through industry standard communication protocols. The GPS is capable of measuring the vehicle's location (latitude and longitude) and altitude, from which speed and road grade are derived. The HEM data loggers are a small unit that can be attached quickly to the engine ECM connector in the cab on the driver's side (as shown below - see Figure 1). The HEM data loggers are self-triggering to start automatically when a test vehicle is started and stop automatically when the test vehicle is stopped and can store data for up to 6 months. For this program, we are planning to transmit the data remotely via cellular data. The data is also stored physically on the data logger, in case there is a problem with the cellular transmission. The data will be downloaded to a server maintained by UCR following testing on each vehicle. For redundancy and data security, these data will also be maintained at an EPA/HEM Data Dashboard site that is also part of the EPA CRADA. The HEM data loggers are further described in the Baseline Emissions Test Plan.

Table 1. A subset of data to be collected from each heavy duty vehicle [1]

Vehicle and Engine Information	ECU Data	GPS Data
Vocational use	Vehicle speed	Speed
Vehicle type	Engine horsepower	Latitude
Axle configuration	Engine RPM	Longitude
Vehicle model year	Fuel rate	Altitude
VIN number	Exhaust and SCR Temperatures	Date & time
Vehicle weight	Engine percent load	No. of satellites fixed
Engine make	Engine percent torque	Fix quality
Engine size	Reference engine torque	Position dilution of precision
Engine model	Engine intake manifold temperature	Engine on/off
Engine model year	Engine turbo boost pressure	
	Engine coolant temperature	

[1] Note GPS data can be sanitized to prevent identifying locations and routes taken. GPS data is utilized to know regions and impacts areas for the study not to study route behavior.

Figure 1. Outlet and HEM data logger to be utilized for the activity monitoring program

We will collect information on the specifications of each vehicles/equipment being data logged, including manufacturer, model, model year, gross vehicle weight, fuel capacity, propulsion system specification, etc. This information will be collected with photographs if possible. We will also visually monitor the operation of the equipment at each of the terminals, to determine and qualitatively document the typical use patterns of the equipment at the terminal.

4. Terminal and OEM Coordination

Tetra Tech team will coordinate with the two terminals in advance and request as much information as needed from the OEM or other sources, including any information about the data transmission protocols, configurations for the data connectors, etc. To the extent that SOC or other important parameters are not publically broadcast, such information would need to be acquired through the proprietary signals provided by the OEM manufacturer with an appropriate data collection device. Tetra Tech and UCR in particular have worked with OEM manufacturers to obtain proprietary signals as part of previous projects, including chassis dynamometer testing and other programs. Hybrid electric usage will be reported using the metrics of miles per kWh and hours per kWh.

Tetra Tech team will coordinate with the terminal operators to collect additional information related to the normal activities, use and performance of the equipment (both baseline and zero-emission equipment). This would include compiling information about the amount of fuel/electricity obtained, date and fuel price during refueling, as well as off-peak and/or renewable energy load shifting potential (e.g., battery recharging optimization with smart meter). This would also include information on the average weight per load/lift or load of container being moved, and the number of pallets moved per day or containers per day.

5. Data Analysis Procedures

Tetra Tech team will process and analyze the collected data to determine activity patterns including hours of operation, days of operation per year, average miles traveled per day, average value and distribution of speed and acceleration, and idling time. Most of this can be obtained from the GPS data (which can be used to get speed as well as location) as well as speed from the ECM itself. UCR has developed methods to reconcile these two speeds to determine which speed most accuracy represents the speed at any given time. Idling time can be determined by setting a limit on the speed (for example, 1 mph), and then counting the amount of seconds that meet that criteria. GPS data can also be analyzed to determine the number of trips between specific locations that are related to loading and unloading cargo, and refueling. This information will be used to assess the performance and duty cycles of the equipment (zero-emissions technology versus the baseline diesel equipment) as a function of time, including the number of trips and loading and unloading times. These parameters can be evaluated over the data logging period.

Tetra Tech team will analyze the performance of the equipment in terms of the state of charge (SOC) at the beginning and end of the work day, fuel/energy consumption rate on a daily basis, and fuel/energy consumption rate while idling. It is assumed that the SOC, energy consumption, and other battery performance parameters can be obtained directly from the ECU as part of the normal data logging connection, or that such information would be made available through proprietary manufacturer broadcast data. It is anticipated that one to two weeks of engineering time will be needed to develop the appropriate configuration files to gather this information for the different vehicles, providing that it is either publically broadcast or can be obtained with assistance from the OEM.

The data from each test run will be read into Matlab where it will be reviewed, QA/QC, and corrected as needed. The procedures for the data scrubbing and QA/QC have been developed under the EPA CRADA to ensure that the final data sets will be of the quality level expected for application in emissions models and other uses for agencies such as the EPA and CARB. These procedures are described in greater detail in Attachment A. This includes procedures for the review/correction of GPS and ECM data. Additionally, some companies require Tetra Tech to scrub the first and last mile of latitude and longitude to ensure that confidential information about their business activities is not compromised. Field ranges, character types, variable lengths, etc. will be formatted and verified against SAE J1939, and a database schema diagram and data dictionary will be provided. The entire dataset for each vehicle (all parameters) will be provided in Matlab file format, one file for each piece of equipment. These files can subsequently be formatted into other data formats as requested by the POLB. Additionally, the data files will be consistent with our on-going data collection efforts with EPA and the ARB. The data can also be made available to the POLB through a secured FTP site that will allow the data to be downloaded.

Attachment A. Data logger post processing and data quality assurance procedures

There are multiple steps of processing the collected data. The steps are described below.

1. ***Data Conversion***: The Mini Logger™ creates two binary files for each trip—a .GSP file that logs the GPS data and a .IOS file that logs the ECU data. DawnEdit software is used to convert the two data files into a comma-separated values (CSV) file before the following processing and analysis steps. During the conversion, the software time-aligned the GPS and ECU data streams and created a single CSV file.

2. ***Map Matching***: In this research, it is of interest to understand vehicle activity patterns on different road types. In order to identify the road type for each data point, map matching is performed on a GIS analysis platform with the collected data. Using latitude, longitude, and heading information, the map matching algorithm assigned each data point to a road link in the digital road network based on its proximity (a data point usually belongs to the closest road link), orientation (a data point heads into the same direction as the road link), and history (a data point is more likely to be on the same road type as the few previous data points than not). The map matching resulted in each data point being assigned to one of the three broad categories of road type: 1) freeway, 2) non-freeway, and 3) ramp. A "Road Type" data field is added to the CSV file to store the road type of each data point.

3. ***Data Quality Assurance***: The vocation master data files went through several data quality assurance procedures with the primary focus on timestamp and vehicle speed data fields. There are two sources of timestamp data: 1) GPS and 2) internal clock of the data logger. The data logger's internal clock only reports timestamp down to minutes. While the GPS reports timestamp down to seconds, there are parts in the data where the GPS timestamp is obviously incorrect or missing. For those parts in the data, the timestamp from the data logger's internal clock is used to estimate the timestamps for the data records.

   In terms of vehicle speed data, there are two sources: GPS-based speed and ECU-based speed. The speed reported by GPS is based on a distance the vehicle travels in a given time (one second in this case) that is determined from the satellite signals. The accuracy of the speed depends on the number of satellites and the quality of satellite signal. The speed reported by ECU is based on rotational speed of the wheels, which could be affected by general wear and tear of the wheels. The ECU-based speed data could also be incorrect if the wheel size is changed without a proper calibration of the wheel speed calculation. Figure B-1 shows an example of questionable ECU-based speed data where the values are unreasonably high for long periods. The linear interpolation applied to correct the unreasonably high values results in unrealistic vehicle speed profile, such as around the seconds 170-300. Figure B-2 shows another example of questionable ECU-based speed data. In this case, there are sporadic offsets of ECU-based speed from the GPS-based speed that cannot be explained. In general, the GPS-based speed data is more accurate, and therefore, is used as the primary source of vehicle speed in this research. The ECU-based speed data is used to supplement or replace the GPS-based speed data as needed, for example, when the GPS-based speed is not available or unrealistic. A "Composite Speed" data field is added to the master data files to store the vehicle speed data that had gone through the data quality assurance described above.

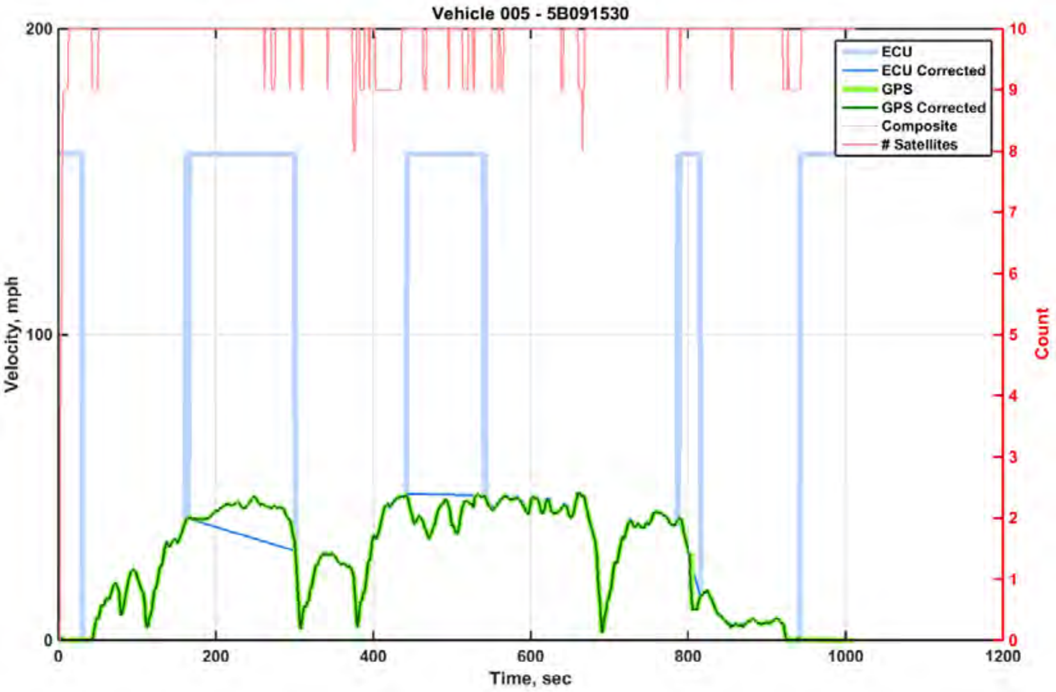

Figure B-1. Example of questionable ECU-based speed data with periods of unreasonably high values

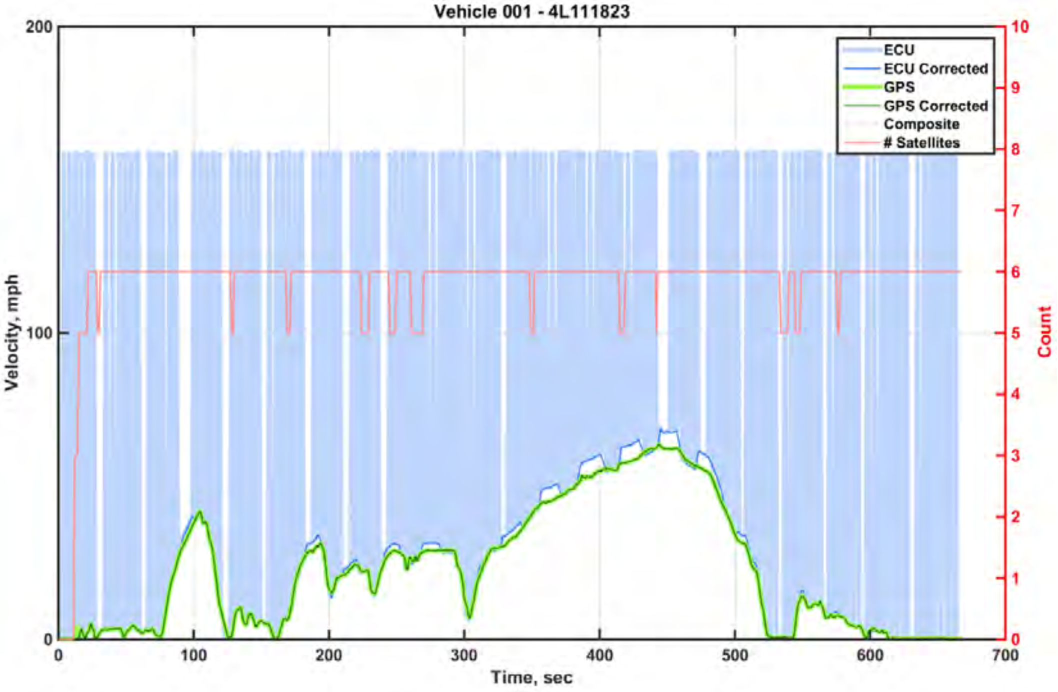

Figure B-2. Example of questionable ECU-based speed data with sporadic offsets

Figure B-3 shows an example of vehicle speed data where there is a good match between GPS-based speed and ECU-based speed. Figure B-4 shows an example where the GPS-based speed data from the seconds 1-18 are questionable due to having no satellite, and thus, are replaced by the corrected ECU-based speed data.

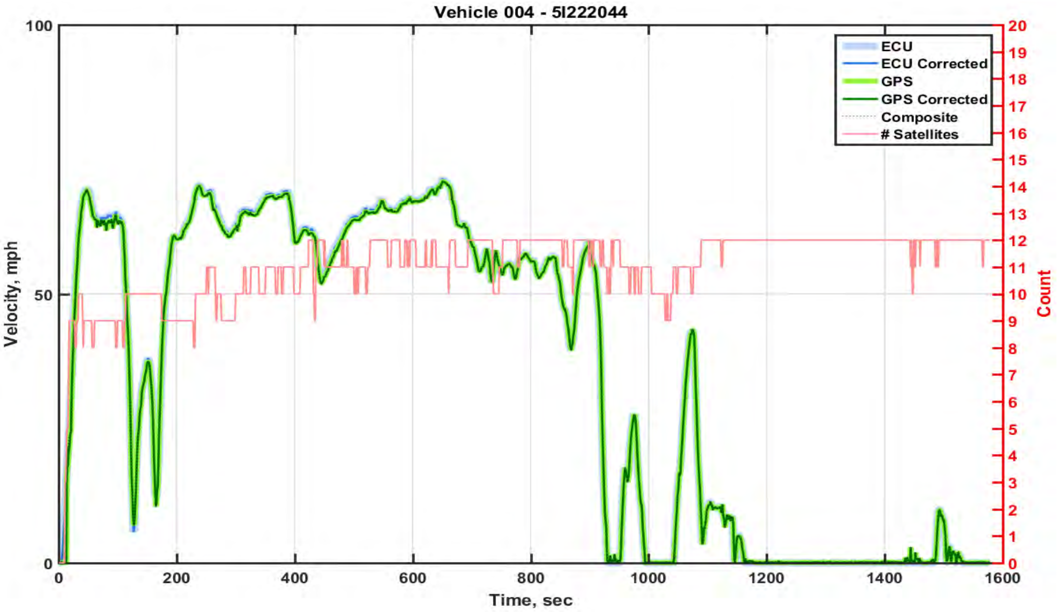

Figure B-3. Example of a good match between GPS-based speed and ECU-based speed data

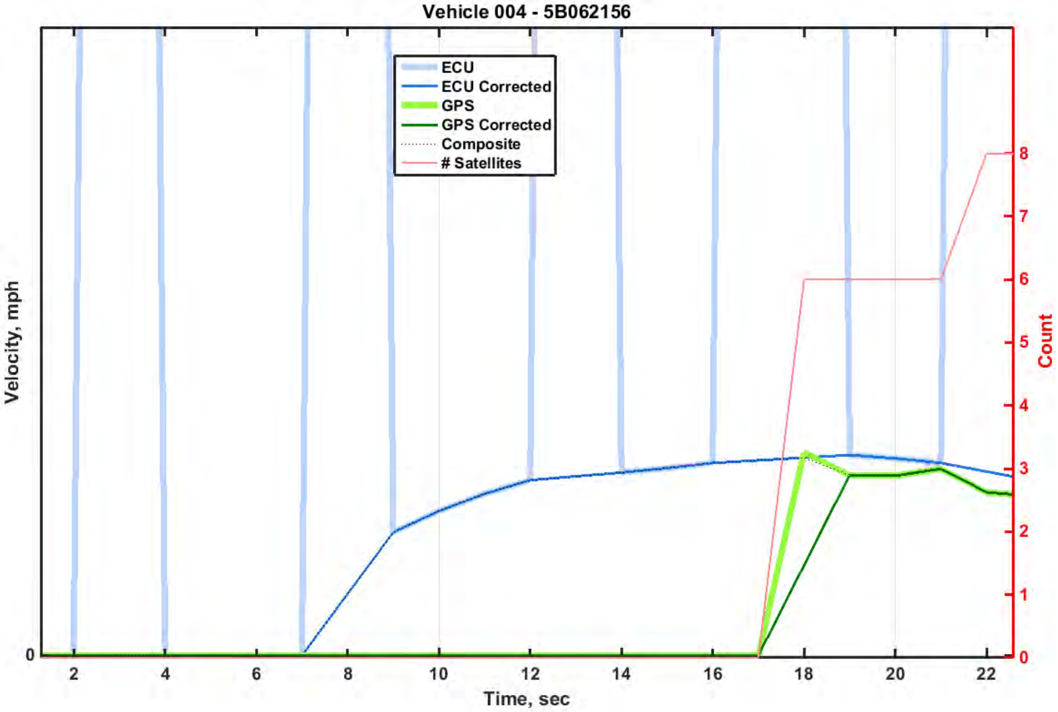

Figure B-4. Example of replacing questionable GPS-based speed with ECU-based speed

4. ***Trip Identification***: A trip in the context of this research is from an engine-on event to an engine-off event. Therefore, trips needed to be identified and indexed in the master data

files before they could be used for analyses. Engine speed is used to identify engine-on and engine-off events. An engine off event is defined as having engine speed below 300 rpm. This threshold value is selected based on our observation that there is some noise in the engine speed data. A "Trip ID" data field is added to identify each unique trip in the master data files. Sometimes, a key-on event is followed by a key-off event, resulting in a data file being created by the J1939 Mini Logger^{TM} although it is not a trip. In this case, a Trip ID is not assigned to this portion of the data. In other times, an engine-off event is followed by an engine-on event without key-off, resulting in the data file containing more than one trip. In this case, each trip is assigned a unique Trip ID.

Occasionally, the data loggers can experience issues with interruption of data connection with the ECU. Typically, the J1939 Mini Logger^{TM} takes less than one second after the ignition key has been switched on to create a data file and start recording data. When the ignition key is switched off, the data messages on the ECU stop being transmitted. The data logger stops recoding data when there are no more messages. Thus, an interruption to data connection during vehicle operation would cause the data logger to misunderstand that the ignition key has been switched off, and so it would stop recording and close the data file. A reconnection of data stream would then cause the data logger to misunderstand that the ignition key has been switched on, and so it would create a new data file and start recording data. An example is given in Figure B-5, which shows vehicle speed and engine speed data in two consecutive data files. It can be seen that the first data file ended when the vehicle speed was around 10 mph and the engine speed was around 1,100 rpm. The following data file started when the vehicle speed was around 10 mph and the engine speed was around 1,100 rpm. The time gap between the two files was less than 30 seconds. Under these conditions, it is reasonable to assume that the vehicle had been moving and the two files should be merged into a single file.

Therefore, a data file merging step is performed prior to trip identification. First, the starting and ending values of vehicle speed, engine speed, latitude, longitude, and timestamp in each data files are compiled. Then, the lapsed time and distance between the end of one file to the start of the next file in chronological order are calculated. Next, two consecutive trips are merged if all of the following are true: a) ending engine speed of the first file > 300 rpm; b) starting engine speed of the second file > 300 rpm; and c) lapsed time < 60 seconds. The remaining cases can be manually examined to determine whether the trips should be merged or not.

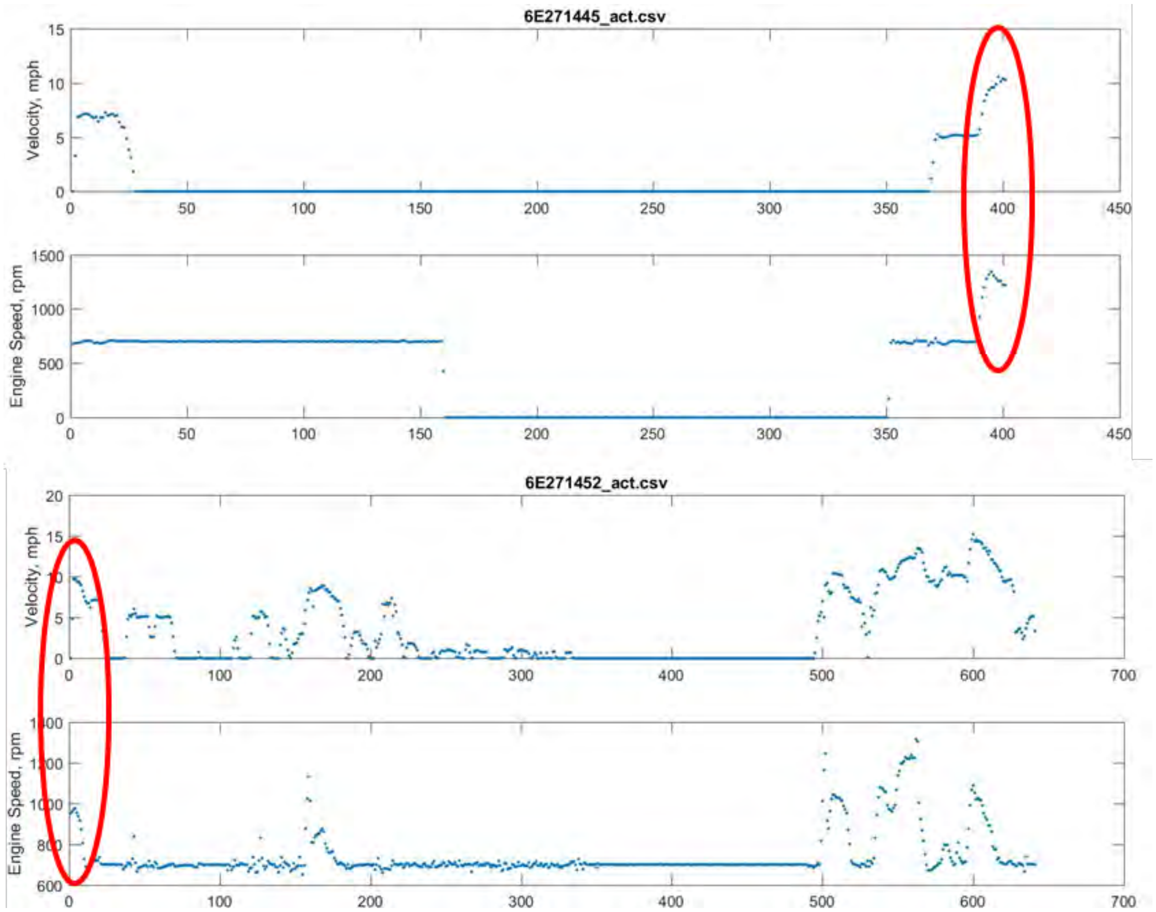

Figure B-5. Vehicle and engine speed of two consecutive data files showing data interruption

5. ***Trip Origin and Destination Cloaking*****:** To protect the identity of the participating fleets, the latitude and longitude information are removed for the first and last miles of each trip in the data files. Other GPS data fields such as timestamp and speed and all ECU data fields are retained.

6. ***Data Aggregation*****:** As data for a vehicle consists of many data files, these individual data files are concatenated in chronological order into a single data file. Then, data files of all the vehicles in a data logging group are aggregated into a master data file for the group. A "Vehicle ID" field is added to this master data file to identify which data records belong to which vehicle. Due to the large amount of data that are collected, the size of a group's master data file ranges from 0.7 gigabytes (GB) to 12.1 GB. Each master data file is essentially a very large data table where the columns include all the data fields in the GPS and ECU data plus additional data fields that are added such as Vehicle ID. Some columns are empty as the data for those data fields are not available. Each row in the data table represents one second of data. Every second of data can be uniquely identified by a combination of Vehicle ID and timestamp. Vehicle ID can also be used to associate vehicle activity data in these master data files with the vehicle and engine information that are stored in a different data table.

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Appendix G: Final Data Collection and Analysis Report

Final Data Collection and Analysis Report
C-PORT

Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program
CARB Off-Road Advanced Technology Demonstration Projects

Activity and Emissions Data Collection and Analysis

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August 2021

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1. Introduction and Objective

The Tetra Tech team provided support for data logging and portable emissions measurement systems (PEMS) testing of the off-road equipment for the Off-Road Technology Demonstration (C-PORT) Project. This was conducted in support of the Port of Long Beach's (POLB) prime contract effort with the California Air Resources Board (CARB) Off-Road Advanced Technology Demonstration Projects solicitation. The equipment was demonstrated at two fleets: SSA Marine (SSA), and Long Beach Container Terminal (LBCT), which both operate at the POLB. This included three (3) zero-emission (ZE) battery-electric top handlers (Taylor/BYD Motors) [two (2) at Pier J SSA and one (1) at Pier E LBCT], and one (1) battery-electric yard tractor (Kalmar/TransPower) at Pier E LBCT.

1.1 Project objective

The purpose of this study was to better understand the activity, performance, and emissions benefits of the advanced technology equipment. As part of this study, activity data were being measured for the advanced equipment using portable activity measurement system (PAMS) data loggers. The data loggers were put on four (4) pieces of zero-emissions equipment and two (2) baseline diesel equipment. Based on the information collected by the data loggers from the equipment Controller Area Network (CAN) system, the data was analyzed to characterize the activity patterns of the equipment, including hours of operation, days of operation per year, average miles traveled per day, and average value and distribution of speed and acceleration. Baseline emissions testing was also conducted on one diesel top handler at SSA, and the one diesel yard truck at LBCT. This provided information on the baseline emissions and fuel consumption for the diesel equipment, which, in turn, provided a basis for comparison with advanced technology equipment. An overview of the project deliverables and the completion dates for the C-PORT project is provided in Table 1. Note that the task numbers are according to the Tetra Tech and POLB contract, and may slightly vary from the overarching CARB tasks.

Table 1. Overview of Project Tasks and Deliverables

Task number	Task	Date(s)
Sub-task 4.1c:	Notice Commencement of Demonstration	July 2020
Sub-task 4.2a:	Submit Baseline Emissions Test Plan	January 2019
Sub-task 4.2b:	Perform Baseline Emissions Testing	July and December 2020
Sub-task 4.2c:	Submit Baseline Emissions Test Final Report	January 2021
Sub-task 4.3a-1:	Submit Data Collection and Analysis Plan	January 2019
Sub-task 4.3a-2:	Install Data Collection Equipment	February 2020
Sub-task 4.3a-3:	Perform Data Collection	February 2020 – July 2021
Sub-task 4.1c-2	Notice of Demonstration of Completion	July 2021
Sub-task 4.3a-4	Final Data Collection and Analysis Report	August 2021

Note that this Final Data Collection and Analysis Report is intended to be comprehensive of the activity and emissions data collection efforts for C-PORT. Some information and analyses presented here are also included in the Baseline Emissions Test Final Report, which provides additional inclusive data. Note, that a second version of the Baseline Emissions Test Plan was submitted to CARB in January of 2021, and any references are in adherence to the second version of the Plan. Similarly, this Final Data Collection and Analysis Report adheres to the Activity Data Collection and Analysis Plan, approved by CARB in January of 2019.

2. Experimental Procedures

2.1 Activity Data Collection and Analysis

PAMS data loggers were installed on four pieces of zero-emissions equipment and the two pieces of baseline diesel equipment at POLB, for a total of 6 pieces of equipment. This included: three (3) total ZE battery-electric top handlers (Taylor/BYD Motors) [two (2) at Pier J SSA and one (1) at Pier E LBCT], and one (1) ZE battery-electric yard tractor (Kalmar/TransPower) at Pier E LBCT. A picture of the electric top handler and yard tractor are provided in Figure 1 and Figure 2, respectively.

The baseline diesel equipment included (1) diesel top handler at Pier J SSA and (1) diesel yard tractor at Pier E LBCT. It should be noted that initially it was also initially planned to data log a diesel top handler at Pier E LBCT. However, discussions with LBCT indicated that top handlers are only sporadically used in their typical operations. So, it was expected that as the ZE battery-electric top handler was incorporated into the operations at LBCT that the diesel top handler would have limited to no use, such that any data collected from this unit during the demonstration would not have been representative of typical operation. As such, it was decided not to PAMS data log the diesel top handler at LBCT. This was approved by CARB.

Figure 1. Picture of Taylor-BYD Top Handler at POLB SSA Terminal

Figure 2. Picture of TransPower eHustler Yard Tractor at POLB

2.1.1 Portable Activity Measurement System (PAMS) Measurements

The primary PAMS data loggers to be utilized for this study were HEM Data Corporation data loggers capable of collecting a full range of information from the equipment/vehicle CAN bus or the engine control module (ECM). This data logger was used for the electric and diesel top handlers and the diesel yard tractor. The electric yard tractors came equipped with a ViriCiti data logger, which were used for the data collection. The HEM data loggers were provided for and maintained through a Cooperative Research and Development Agreement with the United States Environmental Protection Agency (U.S. EPA), such that they met the highest standards for data measurement quality. The data loggers are shown in Figure 3. Picture of a typical set up for the data loggers on a top handler are provided in Figure 4. The data loggers were set up to collect CAN parameters at a frequency of 1 Hz. and are also equipped to collect filtered Global Positioning System (GPS) data at the same frequency. A subset of parameters collected for the electric equipment is provided in Table 2. More detailed lists of CAN parameters that were collected for the yard tractor and top handler are provided in Attachments A and B, respectively.

The HEM data loggers are self-triggering to start automatically when a test equipment is started and stop automatically when the test equipment is stopped and can store data for up to 6 months. For this program, data were collected via a remote cellular transmission. The data were also stored physically on the data logger in case there is a problem with the cellular transmission. For the ViriCiti data loggers for the yard tractors, the Tetra Tech team was given access to the data collection portal where the data is collected and maintained by Kalmar/Transpower. The data was downloaded to a server maintained by UCR.

Table 2. A subset of data collected from each piece of electric equipment.[1]

Vehicle Information	ECU Data	GPS Data
Vocational Use	Equipment Speed	Latitude
Equipment Type	Odometer	Longitude
Equipment Model Year	Charge Motor AC Current	Altitude
VIN	Charge Motor AC Voltage	Velocity
Equipment Weight	State of Charge (SOC)	Heading
	Energy storage/drive motor Current	Date
	Energy storage/drive motor Voltage	Time
	Accelerator pedal position	Fix Quality
		No. of Satellites Fixed
		Position of Dilution of Precision

Figure 3. HEM data logger utilized for the activity monitoring program

Figure 4. HEM data logger installation for a Top Handler

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[1] Note that that GPS system is incorporated into the data logger, as opposed to being acquired through the CAN bus.

2.1.2 Deployment

Data loggers were installed on the Taylor/BYD top handlers on 2/12/2020 at SSA and LBCT. A data logger was installed on the Kalmar/TransPower yard tractor on 3/20/2020, which was taken off the electric yard tractor on 9/21/2020. As a reliable connection to the ECM could not be established with the HEM data logger, data collection was switched to a ViriCiti data logger system for the Kalmar unit only, which had already been installed by TransPower in the development of the equipment. CARB approved this alteration.

Data loggers were installed on the baseline diesel yard tractor on 3/20/2020 at LBCT and on the first baseline diesel top handler (ID 80290) on 6/24/2020 at SSA. Due to a logger malfunction, caused by excessive heat from the engine, a data logger was installed on a second diesel top handler (ID 80361) at SSA to extend the data logging of the equipment.

2.1.3 Activity Data Analysis

Based on the PAMS collected, analyses were conducted to obtain daily hours of operation, days of operation, average energy use per day, average SOC used per day, and average miles traveled per day. For the diesel equipment, the data were analyzed to determine averaged engine load, average engine torque, average hours of use per day, average speed, average miles traveled per day, and average fuel used per day. Information was also collected on the specifications of each piece of equipment being data logged, including manufacturer, model, model year, gross vehicle weight, fuel capacity, propulsion system specification, etc.

2.2 Emissions Testing

Baseline emissions testing was also conducted on one diesel top handler at the SSA terminal, and the one diesel yard truck at LBCT. The PEMS testing period, as described in the submitted Baseline Emissions Test Plan, is one day per unit. PEMS tests were conducted on a baseline diesel top handler on 7/2/2020 at SSA and on a baseline diesel yard tractor on 12/2/2020 at LBCT. The PEMS test for the top handler included gaseous and particulate emission measurements using the Senor's SEMTECH DS and the AVL MSS MOVE, respectively. The PEMS test for the yard tractor included gaseous and particulate emission measurement using a 3DATX parSYNC.

2.2.1 Portable Emissions Measurement System (PEMS)

The main PEMS used for this study was a SEMTECH gas-phase analyzer that UCR obtained from the U.S. EPA via a Cooperative Research and Development Agreement (CRADA) with UCR. This system is 1065 compliance and measures carbon monoxide (CO), carbon dioxide (CO_2), total hydrocarbon (THC), and total NOx emissions. These systems measure NO_x using a non-dispersive ultraviolet (NDUV) analyzer, THC using a heated flame ionization detector (HFID), and CO and CO_2 using a non-dispersive infrared (NDIR) analyzer. THC emissions are collected through a line heated to 190°C consistent with the conditions for regulatory measurements. The analyzer provides measurements of the concentration levels in the raw exhaust. Figure 5 shows the SEMTECH-DS unit.

Figure 5. Picture of Semtech DS PEMS installed on the top handler.

The particulate matter (PM) PEMS measurement system that was used is the AVL 494 PM system, which was released in mid-2010, combines AVL's 483 micro soot sensor (MSS) with a gravimetric filter module (GFM) option.[2] The AVL 483 MSS measures the modulated laser light absorbed by particles from an acoustical microphone. The measurement principle is directly related to elemental carbon (EC) mass (also called soot), and is robust and found to have good agreement with the reference gravimetric method for EC-dominated PM. The GFM is then utilized in conjunction with a post processor that utilizes the filter to estimate (or calibrate) the total PM from the soot and gravimetric filter measurements. One gravimetric filter can be sampled per day and continuous PM concentration is recorded at 1 Hz with an option of 10 Hz data. The combined MSS+GFM system is approved by the U.S. EPA as a total PM measurement solution for in-use testing, thus making it one of the few 1065 compliant PM PEMS systems. A picture of this system is provided in Figure 6. It should be noted that currently there are no approved methodologies for in-use emissions measurements of PM10 and PM2.5 from vehicles, as the as the gravimetric filter methods utilized to make these measurements for ambient air cannot be utilized for vehicles where the operation is transient. Additionally, more than 90% of PM from diesel engines is below PM1.0 in size,[3] so nearly all of the total PM emissions from diesel vehicles is also below both and PM10 and PM2.5. Neither PM10 nor PM2.5 was planned to be analyzed, as can be seen in the Baseline Emissions Test Plan.

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[2] https://www.avl.com/documents/10138/885965/AVL+M.O.V.E+PM+PEMS+Portable+soot+and+particulate+(PM)+measurement+device

[3] https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health

Figure 6. Picture of PM PEMS installed on the top handler.

A 40 CFR 1065 capable flow meter, manufactured by Sensors, Inc., was used to measure exhaust flow. This flow meter is compatible with a wide range of different PEMS systems. The flow meter uses an averaging pitot tube and temperature to measure exhaust velocity via the Bernoulli principle. The flow meter is housed in a 3”, 4”, or 5” diameter pipe that is placed in line with the engine tailpipe exhaust for the equipment being tested. Combining the known cross-sectional area of the tube with the measured exhaust velocity gives the volumetric flow rate, which is converted to mass flow rate using the Ideal Gas Law, known fuel properties and measured properties/constituents of the exhaust. Figure 7 is a picture of the exhaust flow meter. The exhaust flow rates are multiplied by the concentration levels for the various emission components to provide emission rates in grams per second.

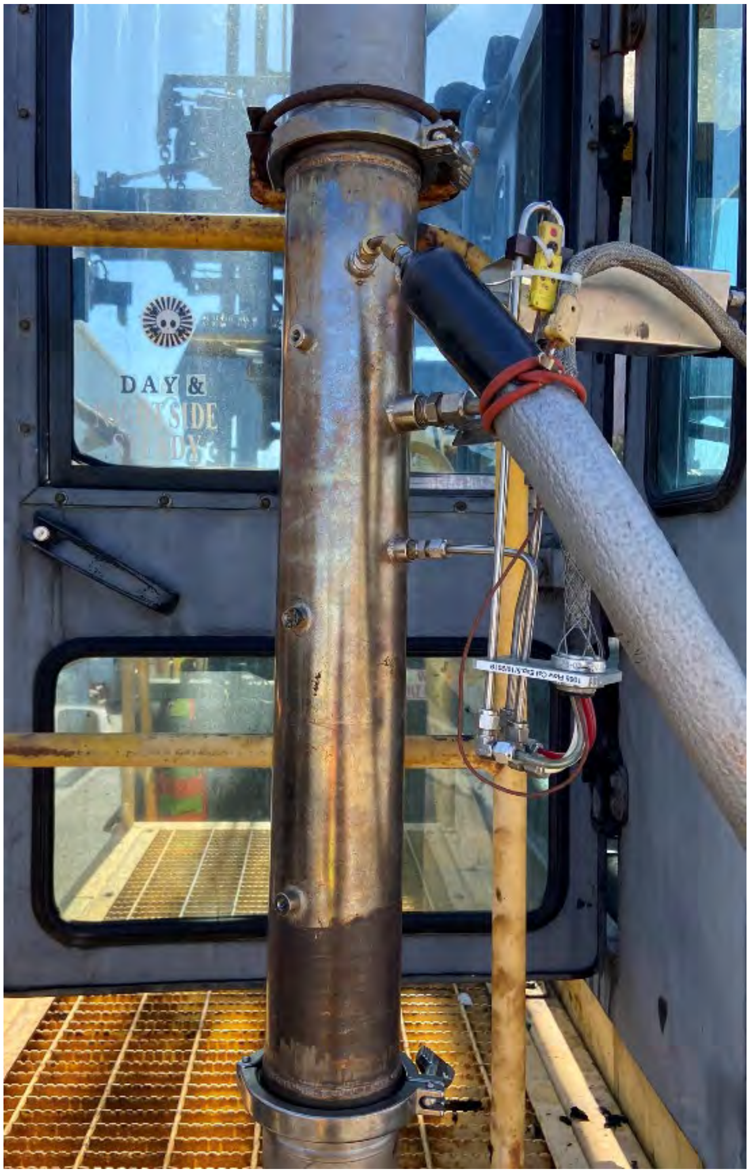


Figure 7. Picture of Sensors Exhaust Flow Meter attached to the exhaust of the top handler.

For the yard tractor, spatial constraints on the equipment required the use of a smaller mini-PEMS that occupied a smaller footprint on the equipment, such that there would not be any impairment to its operation during the normal course of business. For the diesel yard tractor testing, a parSYNC mini-PEMS system was utilized. The parSYNC utilizes electro chemical sensor-based modules to characterize CO, CO_2, NO, NO_2 and PM mass, and particle number (PN). The modules have a shelf life of 1 year and require routine maintenance to manage their accuracy. The quality of the sensors can be managed with standard linearity practices, so the system is safe to use until the linearity starts to decline. The parSYNC unit requires very little space, as shown in Figure 8, and could be utilized in applications where the full regulatory PEMS system could not be realistically mounted, such as a diesel yard tractor. UCR studies have shown correlations between the parSYNC and regulatory compliant PEMS are within 10% for

CO_2 and NOx. PM does not correlate as well and there is limited data on the accuracy of the PM and PN measurement systems at UCR.

Figure 8. parSYNC system installed on the yard tractor.

In conjunction with the PEMS measurements, a full range of information from the ECM was also conducted. This information was collected using a HEM data logger, as described in section 2.1.1.

2.2.1 PEMS Data Analysis

The PEMS data were analyzed to determine emissions on a grams/mile (g/mi), grams per brake-horsepower hour (g/bhp-hr), grams per gallon (g/gal.), grams per hour (g/hour), and grams per day (g/day).

3. Results

3.1 Top Handler Activity

3.1.1 Electric Equipment

The SSA top handler 80361 (#1) averaged 382 kWhr, 38% of SOC use, 67 kWhr/hr, 5.2 hours, 3 mph, and 18 miles, per day of use. The SSA top handler 80368 (#2) averaged 301 kWhr, 43% of SOC use, 57 kWhr/hr, 4.7 hours, 2.5 mph, and 13 miles per day. The LBCT top handler averaged 63 kWhr, 7% of SOC use, 28 kWhr/hr, 2.6 hours, 0.5 mph, and 1 mile, per day of use. The figures in this section provide more information on the daily averages of these pieces of equipment over data logging period. It should be noted that only the days where the equipment was operating and the data logging recorded data are presented in the graphs throughout this report. Gaps in data between days can represent downtime for the equipment, terminal shutdown, or days where data logger data was not available.

Figures 1, 2, and 3 showed the daily energy consumption for each of the top handlers on a kWhr basis. The amount of energy consumed per day ranged from about 15 to over 700 kWhr for the SSA top handers. For SSA #1 top handler, the daily energy use averaged about 382 kWhr, while the SSA #2 top handler averaged about 301 kWhr. The top handler at LBCT daily energy use was around 63 kWhr per day of use.

Figures 4, 5, and 6 show the daily energy consumption for each of the top handlers on a SOC basis. For the SSA top handers, the amount of SOC varied by day from less than 5% to about 90%, with an average of about 38%. For SSA #1 top handler, the daily energy use averaged about 43% of SOC, while the SSA #2 top handler averaged about 34% of SOC. The top handler at LBCT daily SOC use was less than 8%.

Figures 7, 8, and 9 show the energy consumption per hour for each of the top handlers. The amount of energy consumed per day ranged from about 5 to over 100 kWhr per hr for the SSA top handers. For SSA #1 top handler, the daily energy use averaged about 67 kWhr per hour, while the SSA #2 top handler averaged slightly less than 57 kWhr per hour. The top handler at LBCT was not used extensively, so its daily energy use was 28 kWhr per hour.

Figures 10, 11, and 12 show the daily number of hours of use for each top handler. The SSA top handers were operational for between less than 1 hour to about 7 hours per day, with an average of about 5.2 hours for SSA #1 and 4.7 hours for SSA #2. The LBCT top handler was used, on average, less than 3 hours a day of use. Note that the down time in Spring 202 for SSA #2 is likely due to drastic decrease in throughout, as well as a cracked differential drive motor, where the repair was delayed, both situations due to the COVID-19 pandemic.

Figures 13, 14, and 15 show the daily average speed for each top handler. Because the top handlers do considerable work in place without travelling, their average speeds were typically low. Average daily speeds range from less than 1 mph to slightly less than 7 miles per hour. The average speeds for the SSA top handlers ranged from 2-3 miles per hour, while the average speed for the LBCT top handler was less than 1 mph.

Figures 16, 17, and 18 show the daily miles traveled for each top handler. Similar to the other metrics of moving activity, the number of miles travel per day was also relatively low. The number of miles traveled for the SSA top handlers ranged from less than 5 to slightly more than 40 miles traveled per day. The SSA top handlers averaged about 18 miles per day for SSA #1 and 13 miles per day for SSA #2. The LBCT averaged 1 mile of travel per day of use.

In all activity figures, the average for the specified parameter is displayed in red at the end of each figure.

Figures 19, 20, and 21 include plots of the routes followed by the SSA top handler #1, the SSA top handler #2, and the LBCT top handler, respectively, for a typical day. Figure 27 includes a plot of the routes followed by the SSA top handler #1 for about 3 hours of work. In this workday, the top handler drove 8.5 miles, averaged a speed of 2.6 mph, and used 15% of its total charge. Figure 28 includes a plot of the routes followed by the SSA top handler #2 for about 6 hours of work. In this workday, the top handler drove 15 miles, averaged a speed of 2.6 mph, and used 38% of its total charge. Figure 29 shows the route of the LBCT top handler during a typical day. In this workday, the top handler operated for 5.1 hours, traveled 1.2 miles, and used 11% of its total charge.

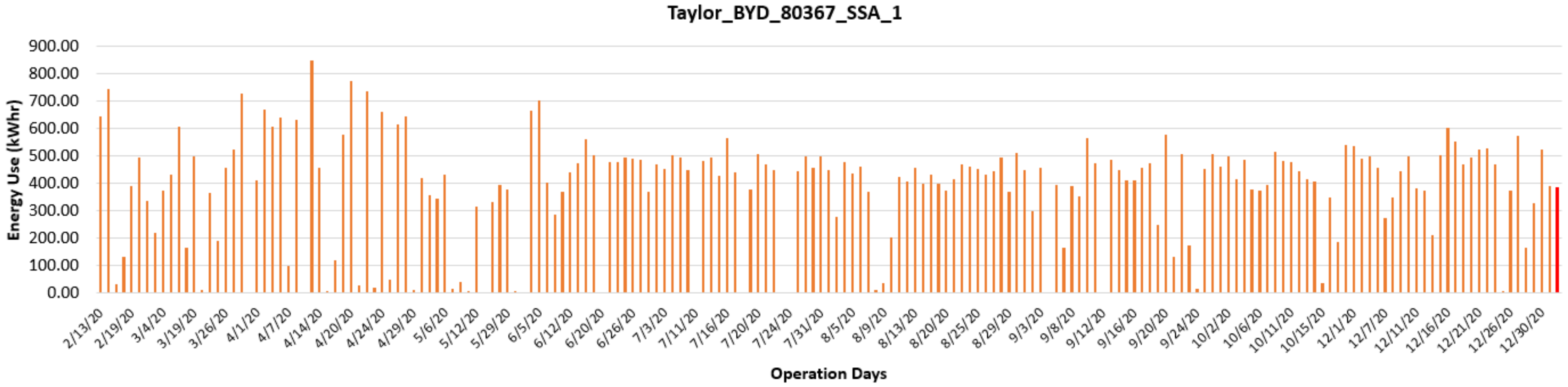


Figure 9. Daily energy consumption in terms of kWhr for SSA #1 top handler.

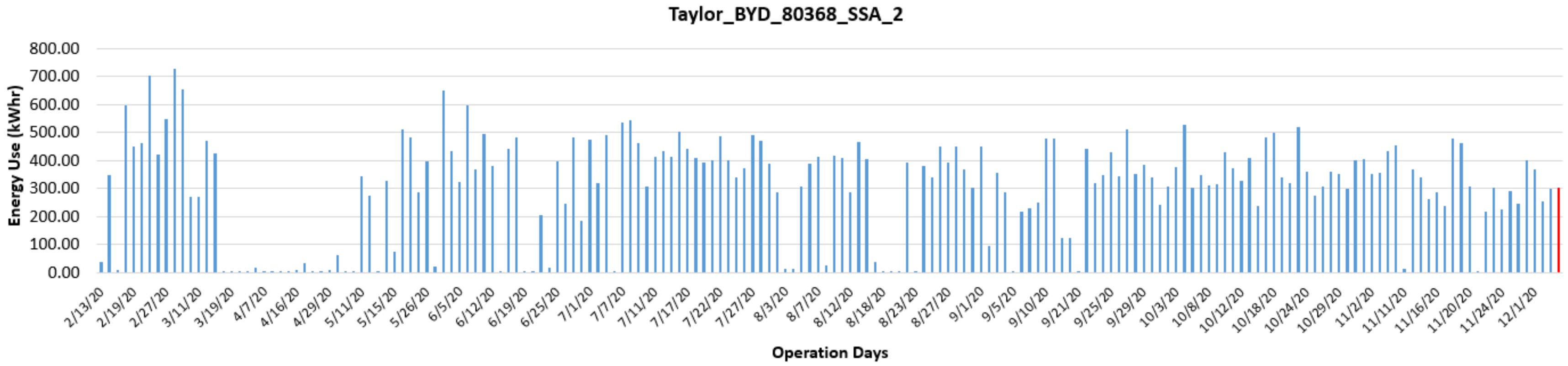


Figure 10. Daily energy consumption in terms of kWhr for SSA #2 top handler.

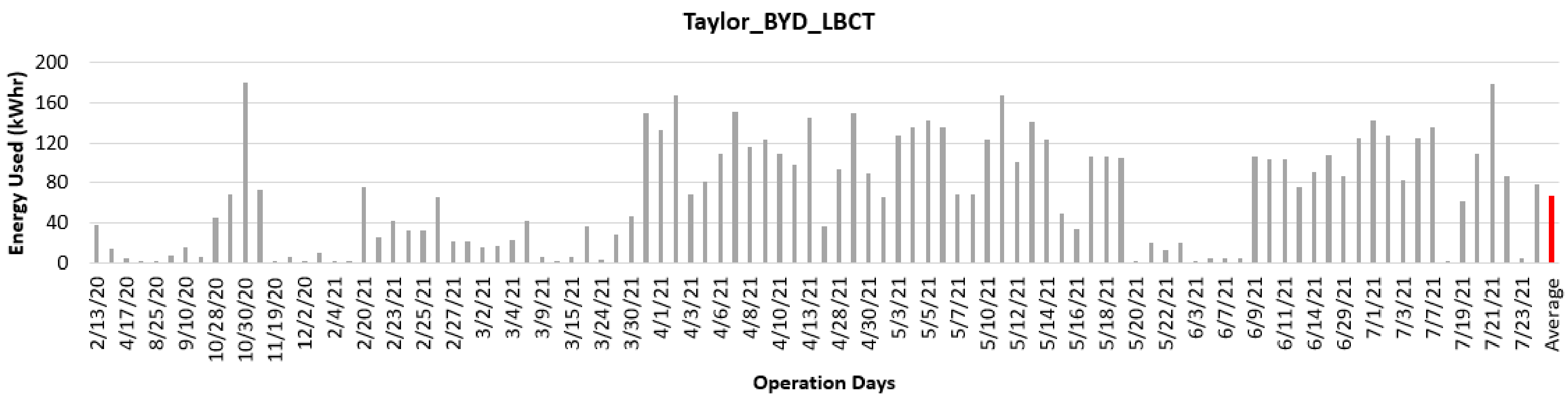


Figure 11. Daily energy consumption in terms of kWhr for LBCT top handler.

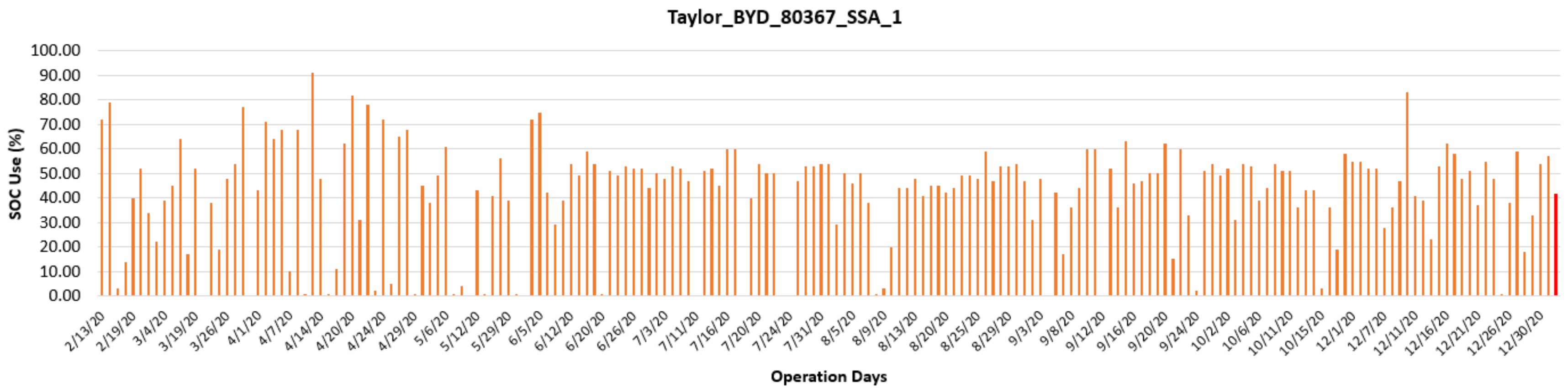


Figure 12. Daily energy consumption in terms of SOC for SSA #1 top handler.

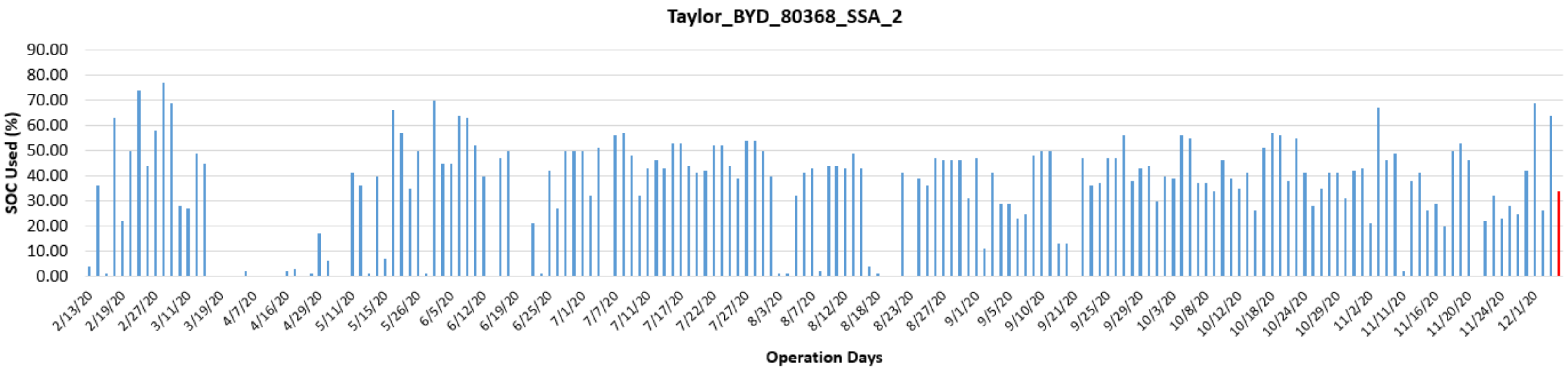


Figure 13. Daily energy consumption in terms of SOC for SSA #2 top handler.

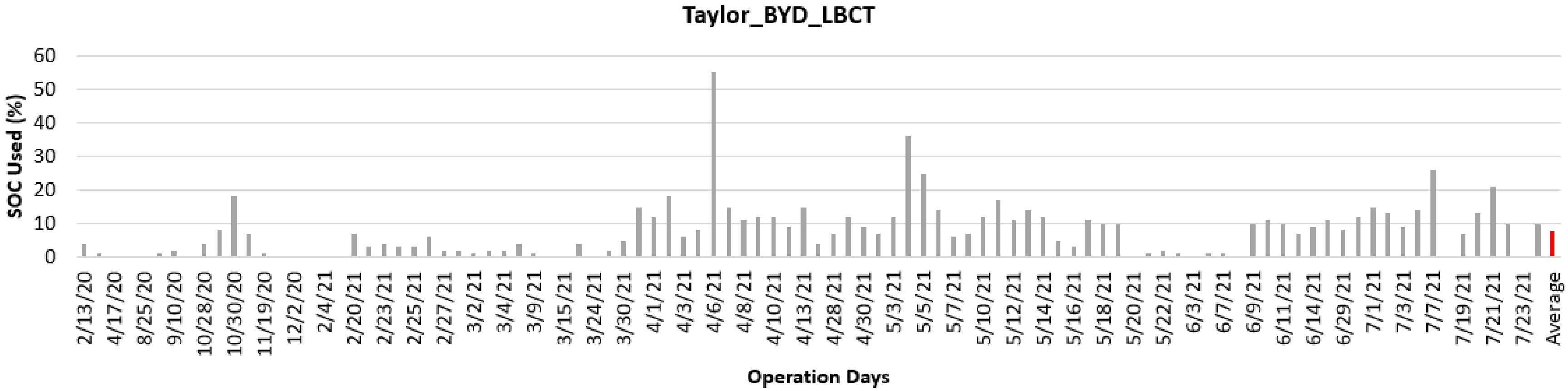


Figure 14. Daily energy consumption in terms of SOC for LBCT top handler.

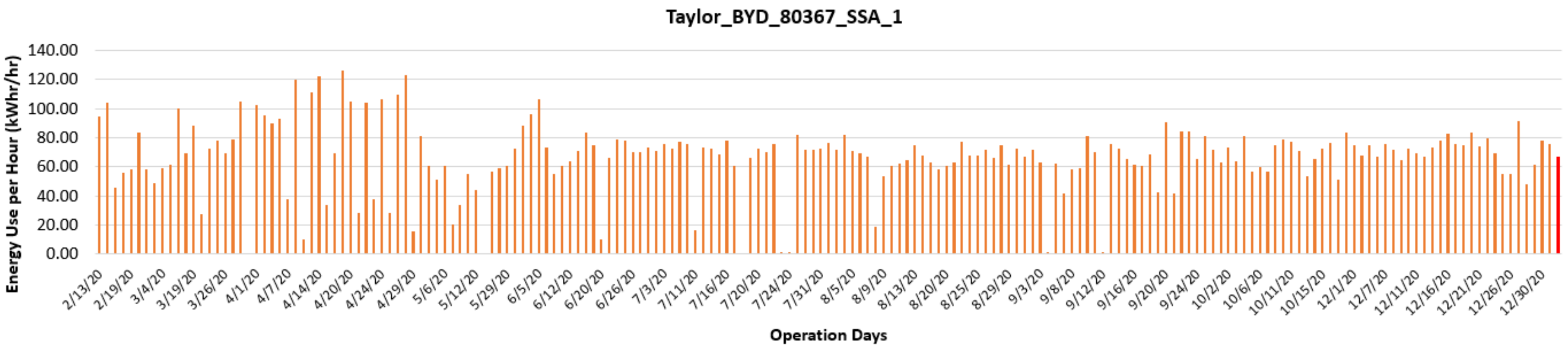


Figure 15. Energy consumption per hour of use for SSA #1 top handler.

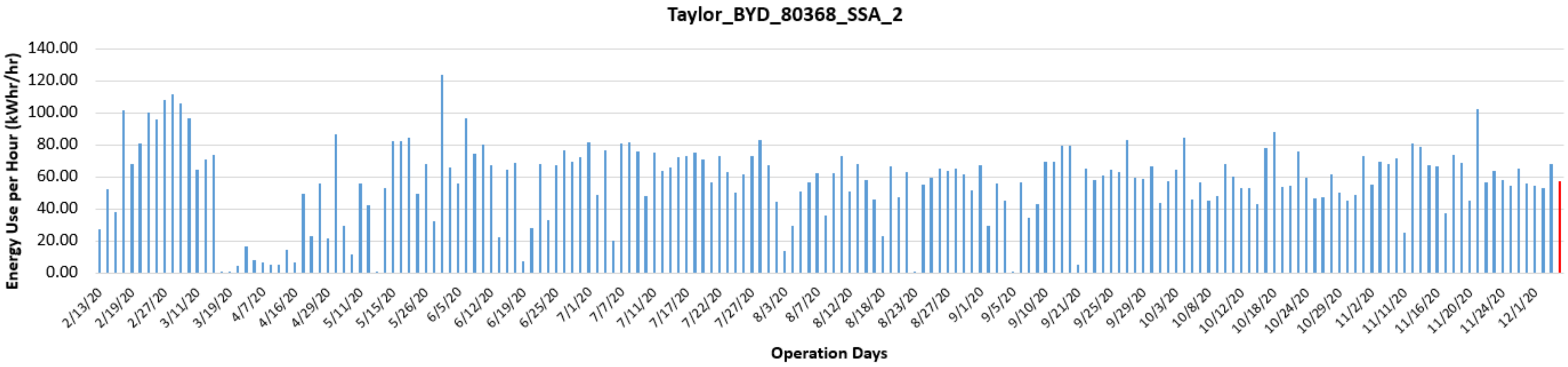


Figure 16. Energy consumption per hour of use for SSA #2 top handler.

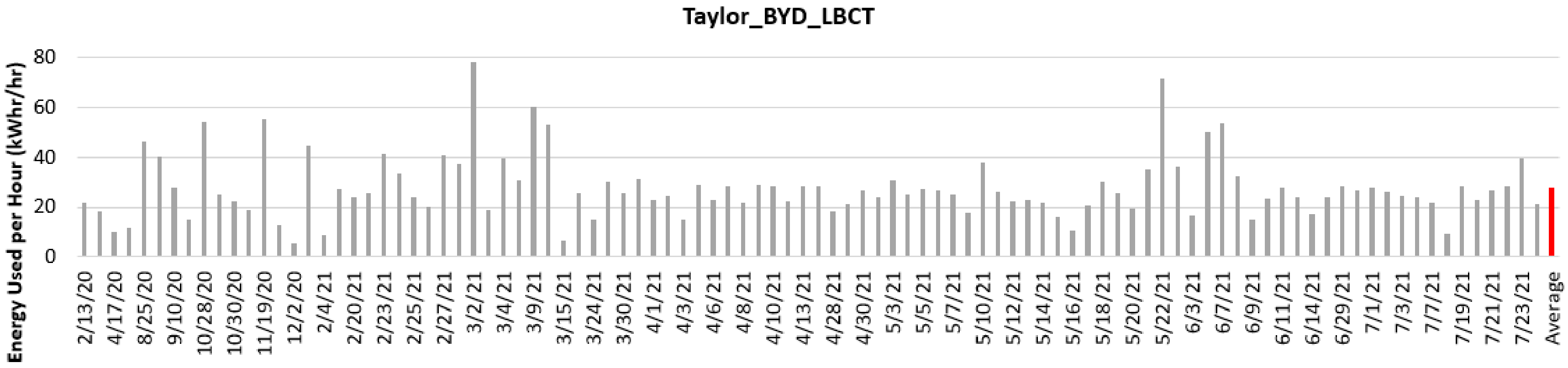


Figure 17. Energy consumption per hour of use for LBCT top handler.

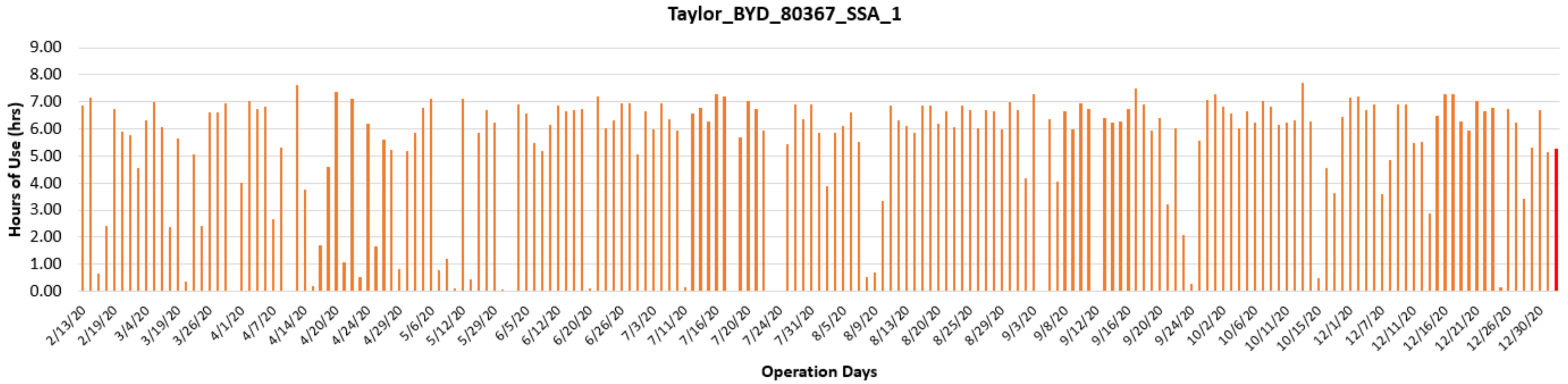


Figure 18. Daily hours of use for SSA #1 top handler.

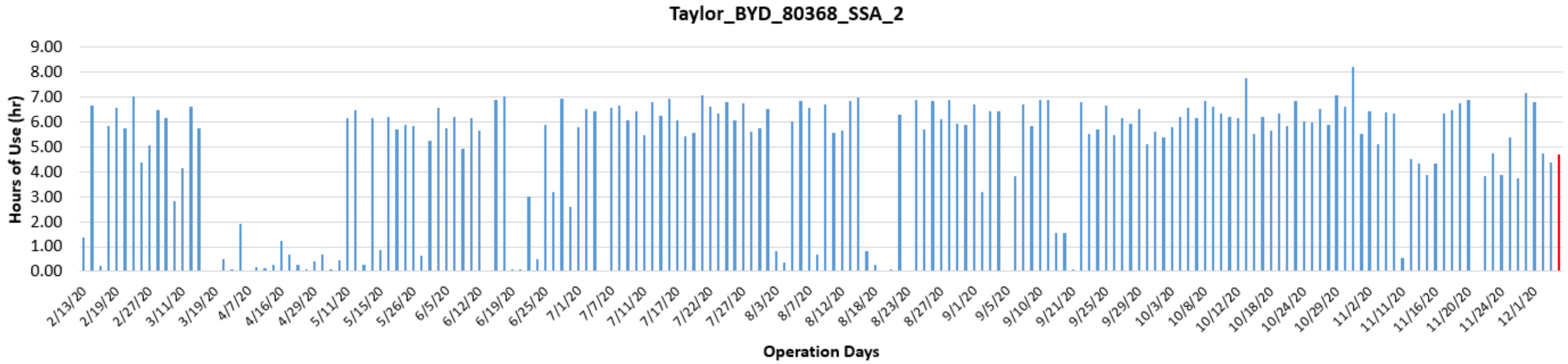


Figure 19. Daily hours of use for SSA #2 top handler.

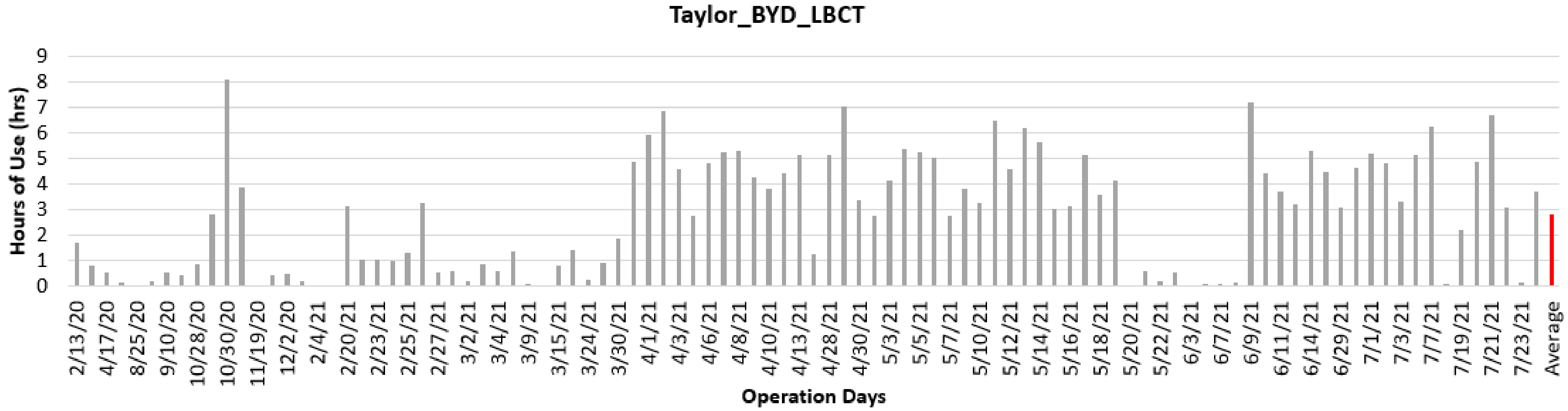


Figure 20. Daily hours of use for LBCT top handler.

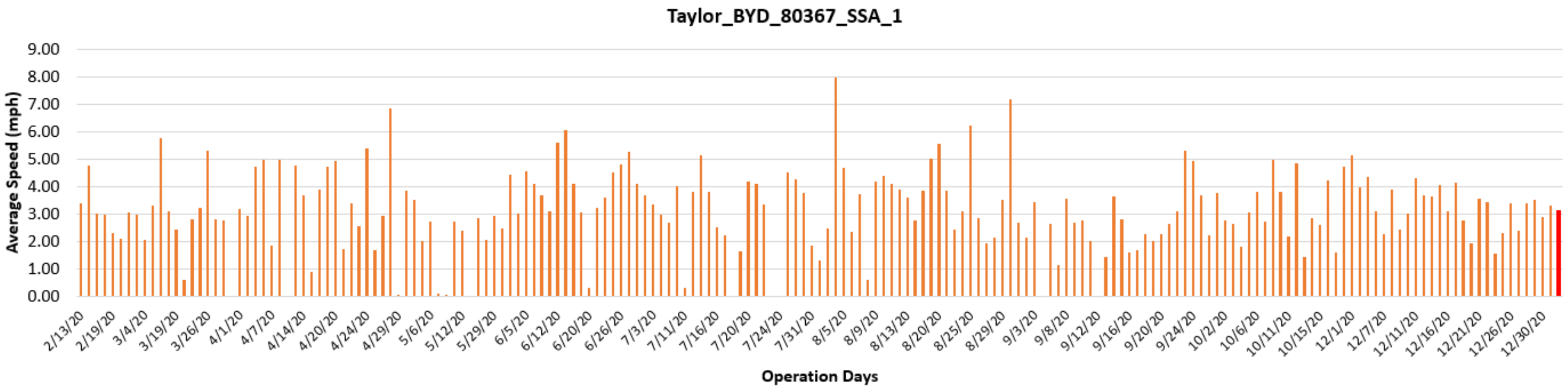


Figure 21. Average Daily Speed for SSA #1 top handler.

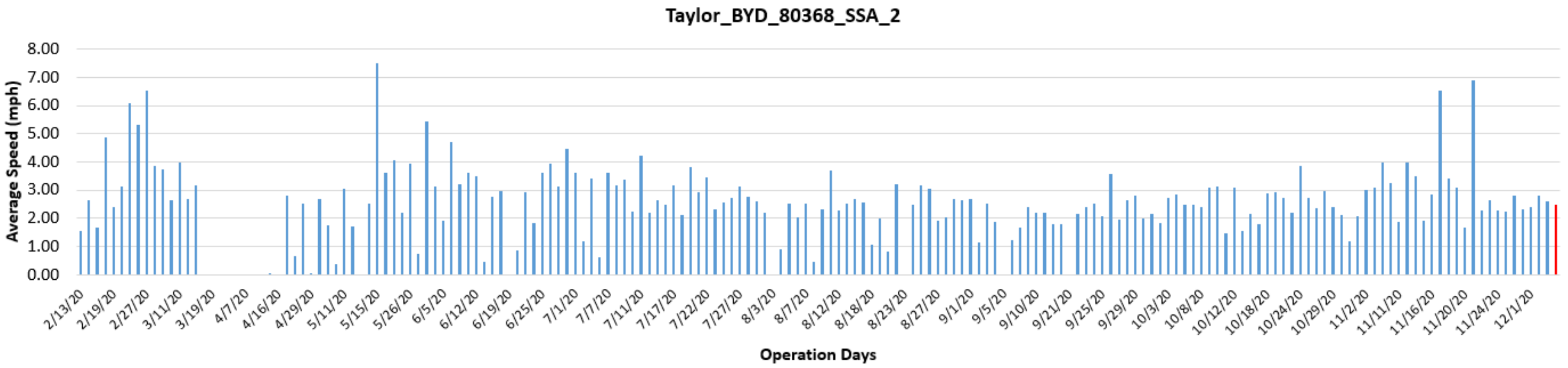


Figure 22. Average Daily Speed for SSA #2 top handler.

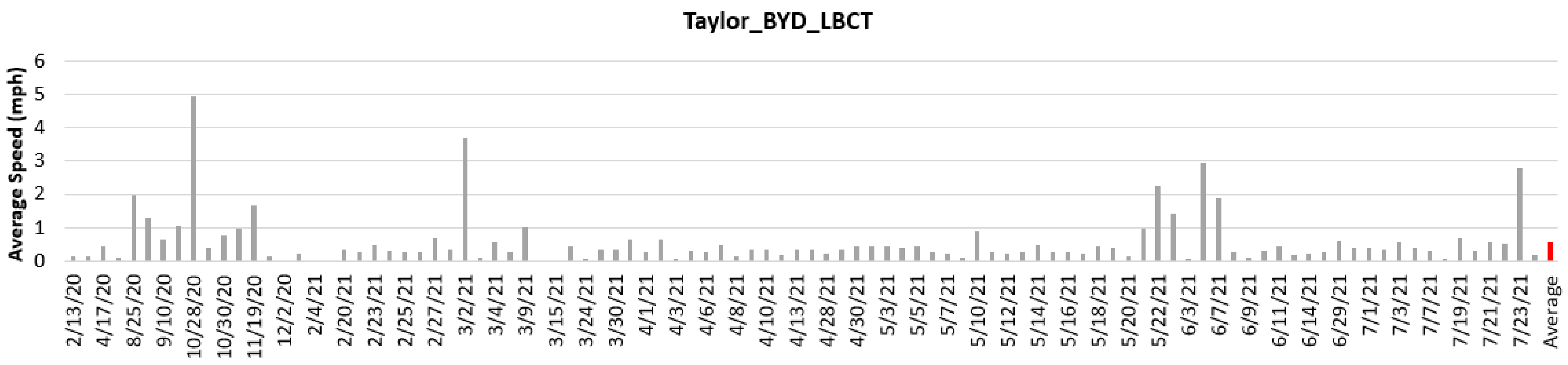


Figure 23. Average Daily Speed for LBCT top handler.

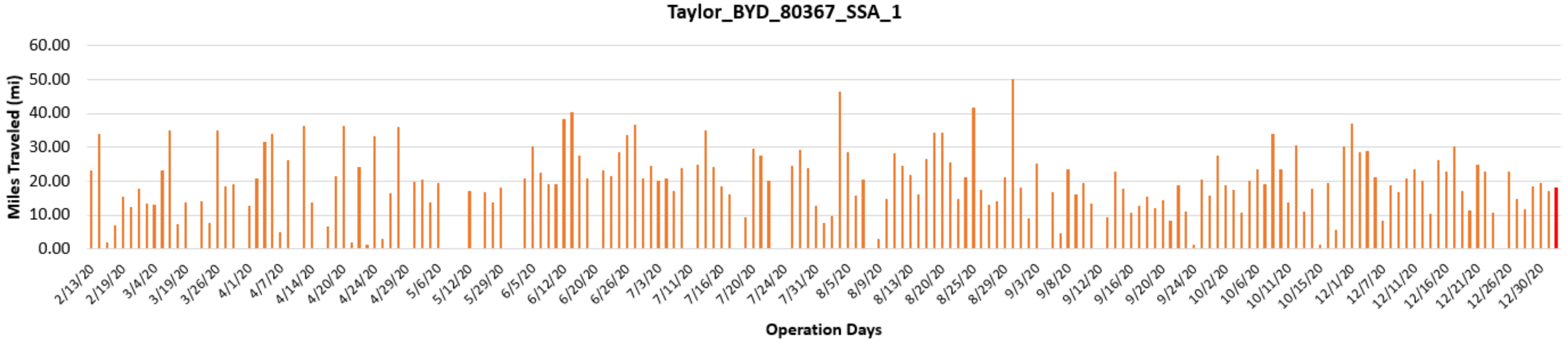


Figure 24. Daily Miles Traveled for SSA #1 top handler.

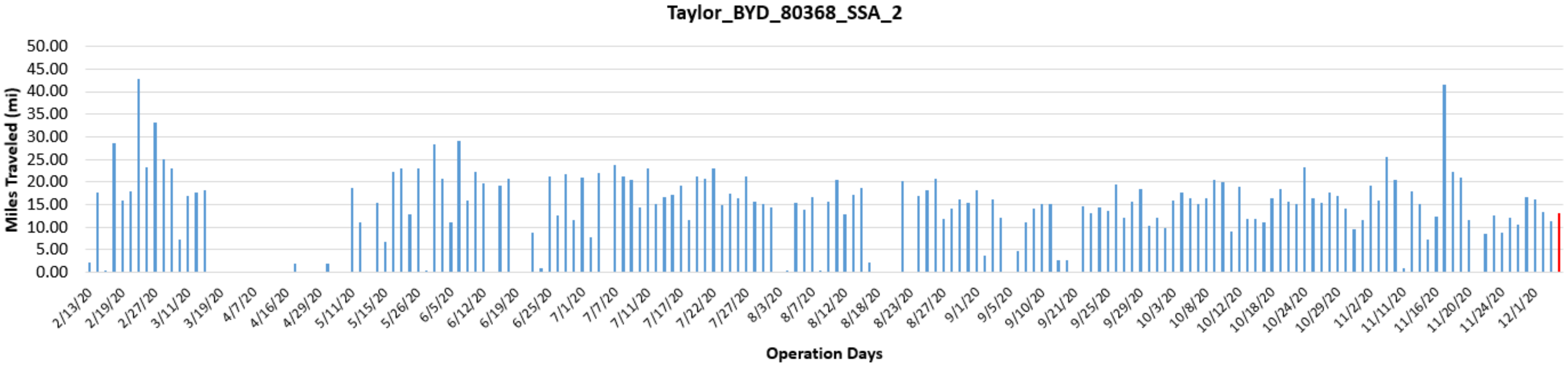


Figure 25. Daily Miles Traveled for SSA #2 top handler.

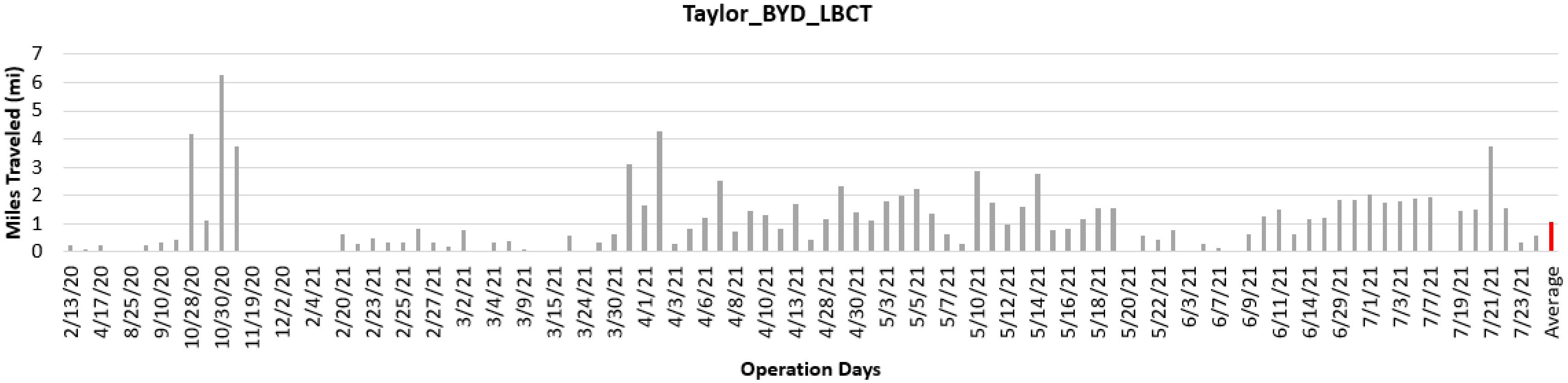


Figure 26. Daily Miles Traveled for LBCT top handler.

Figure 27. Data showing the routes taken over the course of a representative day for top handler #1 at the SSA Terminal on 9/21/20.

Figure 28. Data showing the routes taken over the course of a representative day for top handler #2 at the SSA Terminal on 9/28/20.

Figure 29. Data showing the routes taken over the course of a representative day for the top handler at the LBCT Terminal.

3.1.2 Electric Top Handler Duty Cycle

The duty cycle of SSA top handler 80367 (#1) is presented in Figure 30 through Figure 32. In Figure 30, the output power in Wh and vehicle speed in mph is presented from 9/21/2020. This day was selected as GPS data was captured during the operation. The data from the GPS capture period is presented in Figure 31. The duty cycle of this piece of equipment can be characterized through Figure 31 and the plotted route of the equipment in Figure 32. During this day of operation, the top handler operated for approximately 2 and a half hours, used 103.4 kWh, and averaged a speed of 4 mph. While the aerial photo of the port is out of date, there is still a sense of what the typical movements patterns of the equipment.

The duty cycle of SSA top handler 80368 (#2) is presented in Figure 33 through Figure 35. In Figure 33, the output power in Wh and vehicle speed in mph is presented from 9/28/2020. This day was selected as GPS data was captured during the operation. The data from the GPS capture period is presented in Figure 34. The duty cycle of this piece of equipment can be characterized through Figure 34 and the plotted route of the equipment in Figure 35. During this day of operation, the top handler operated for approximately 6 hours, used 350.5 kWh, and averaged a speed of 2.6 mph. While the aerial photo of the port is out of date, there is still a sense of what the typical movements patterns of the equipment. The top handler transports and organizes shipping containers within specific area of the port.

The duty cycle of LBCT top handler is presented in Figure 36 through Figure 38. In Figure 36, the output power in Wh and vehicle speed in mph is presented from 4/10/2021. This day was selected because GPS data was captured during the operation. During this day of operation, the top handler operated took three breaks approximately 1.5 hours long at 10:01, 11:35, and 13:05. A single event of operation during the GPS capture period is presented in Figure 37. The duty cycle of this piece of equipment can be characterized through Figure 37 and the plotted route of the equipment in Figure 38. The single event of operation is presented in blue in Figure 38, while the whole route is in red. During this day of operation, the top handler operated for approximately 3.8 hours, used 109.5 kWh, and averaged a speed of 0.34 mph. While the aerial photo of the port is out of date, there is still a sense of what the typical movements patterns of the equipment.

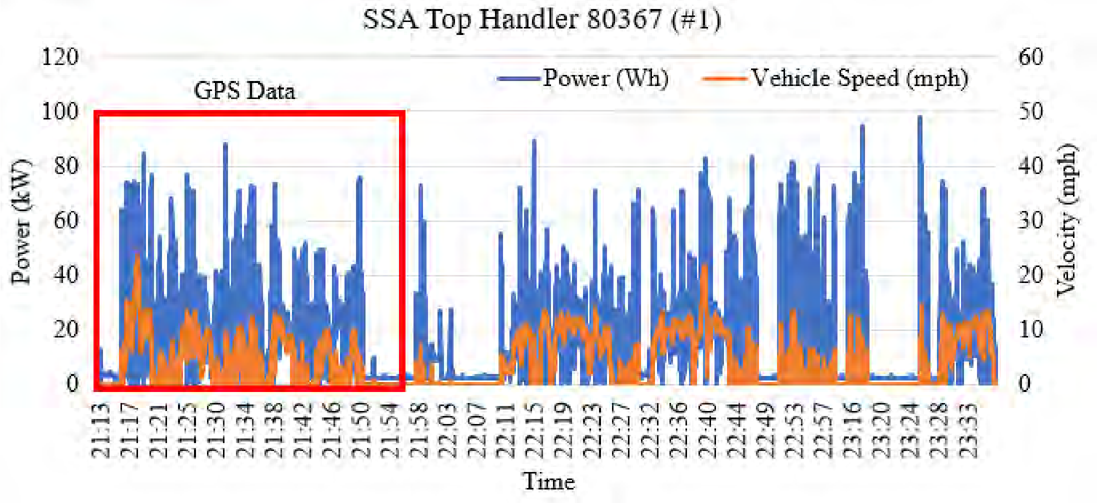


Figure 30. Duty cycle of SSA top handler 80367 (#1) for operation on 9/21/2020.

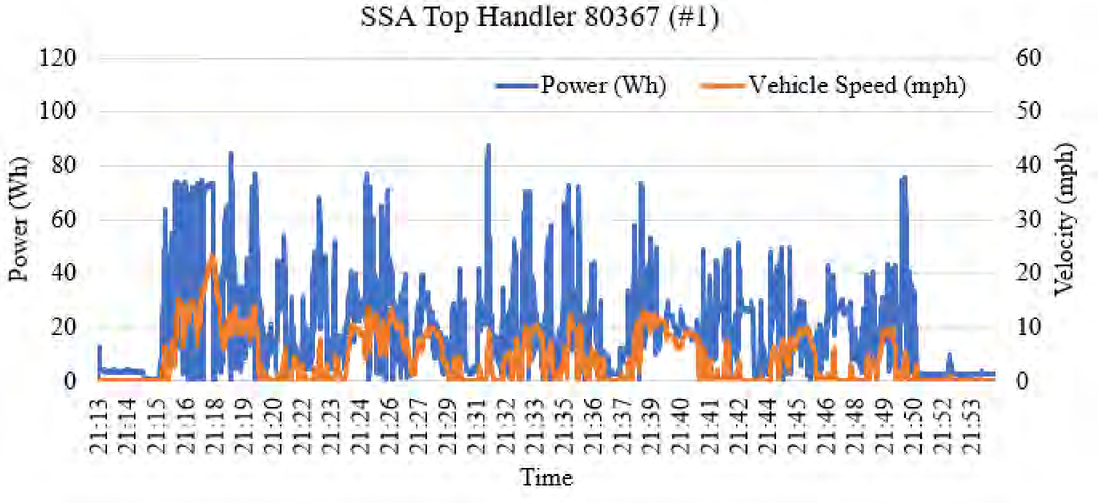


Figure 31. Expanded duty cycle of SSA top handler 80367 (#1) for operation on 9/21/2020 during GPS data capture.

Figure 32. Plotted GPS route of SSA top handler 80367 (#1) from 9/21/2020.

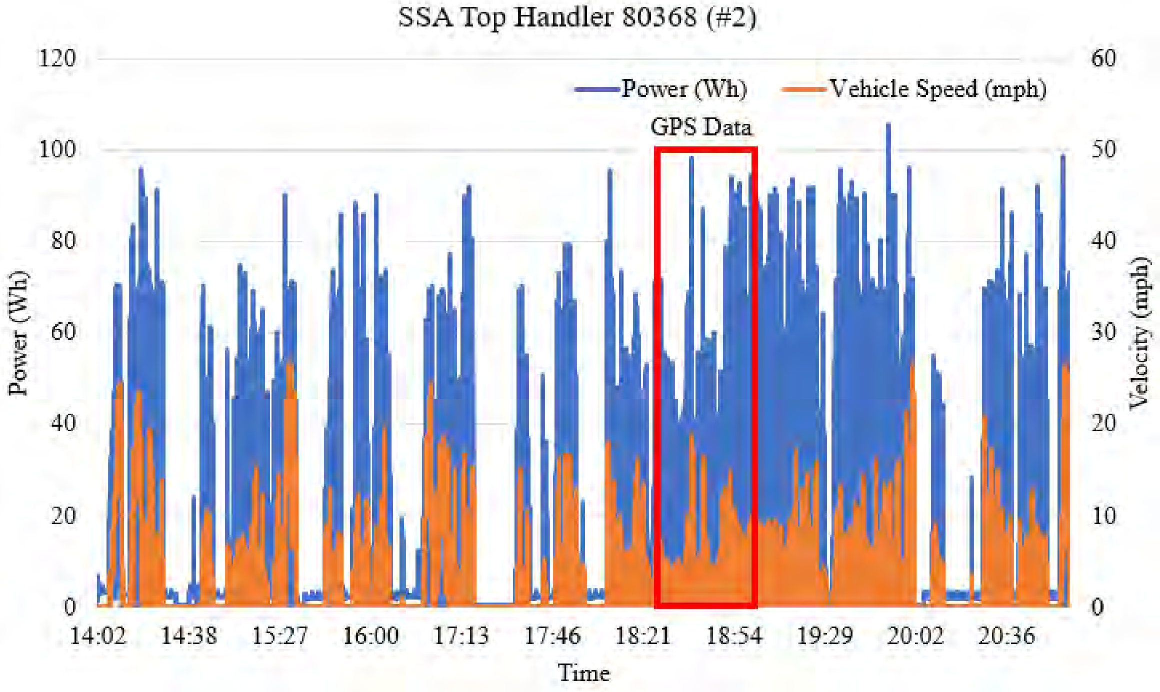


Figure 33. Duty cycle of SSA top handler 80368 (#2) for operation on 9/28/2020.

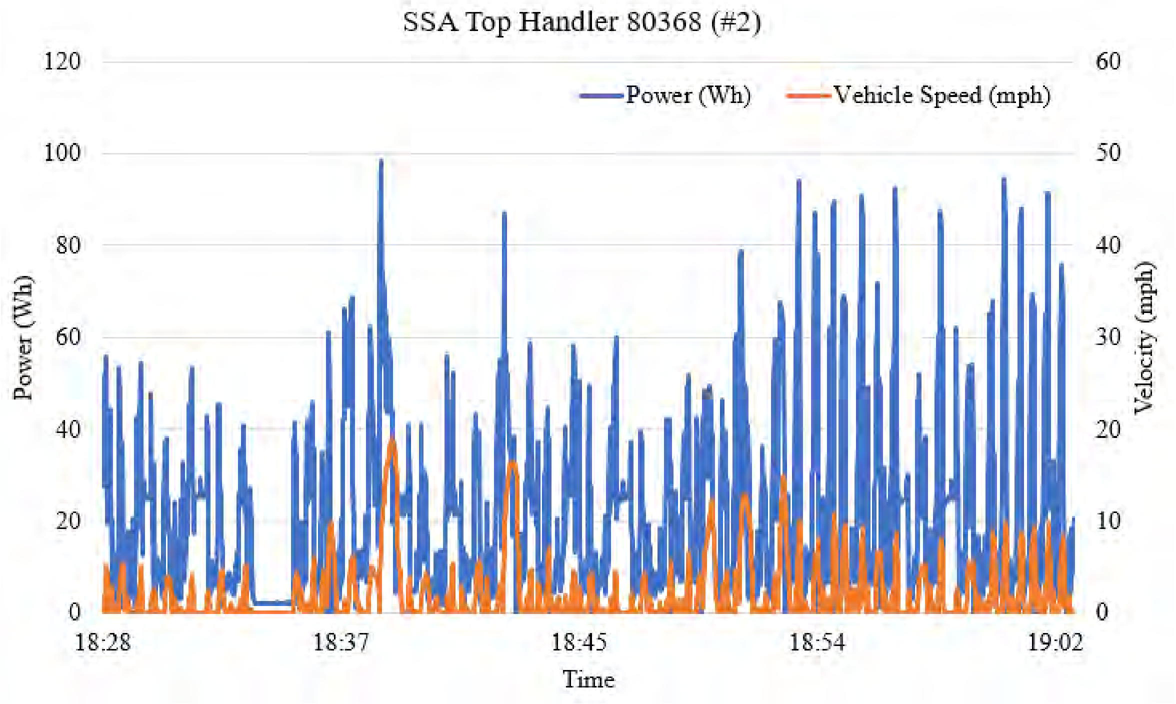


Figure 34. Expanded duty cycle of SSA top handler 80368 (#2) for operation on 9/28/2020 during GPS data capture.

Figure 35. Plotted GPS route of SSA top handler 80368 (#2) from 9/28/2020.

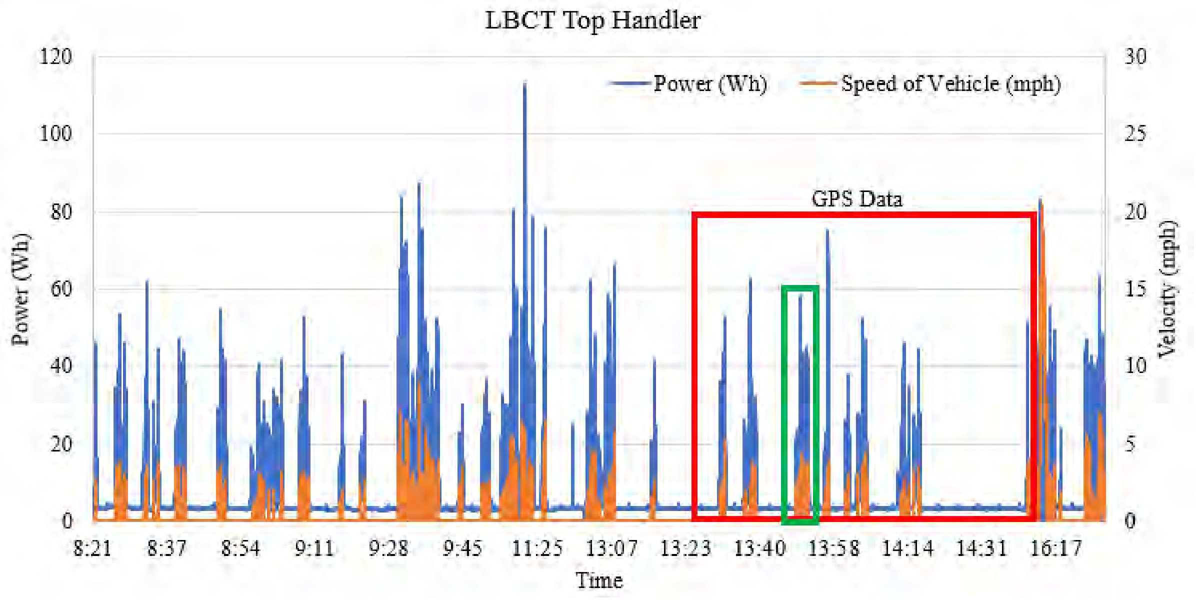


Figure 36. Duty cycle of LBCT top handler for operation on 4/10/2021.

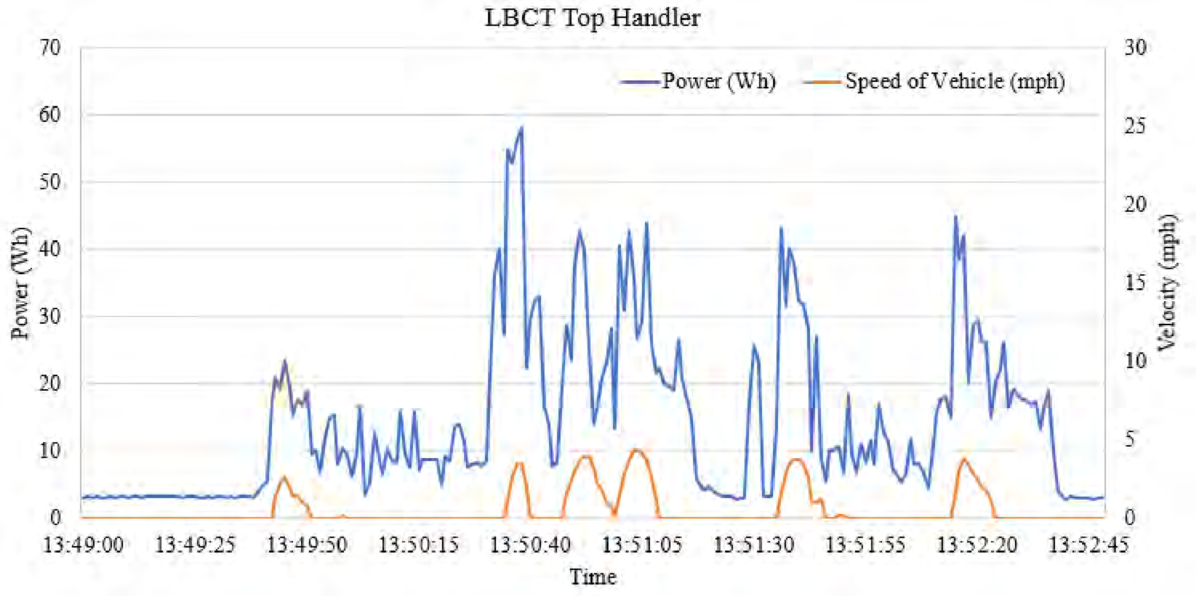


Figure 37. Expanded duty cycle of LBCT top handler for a single event of operation on 4/10/2021 during GPS data capture.

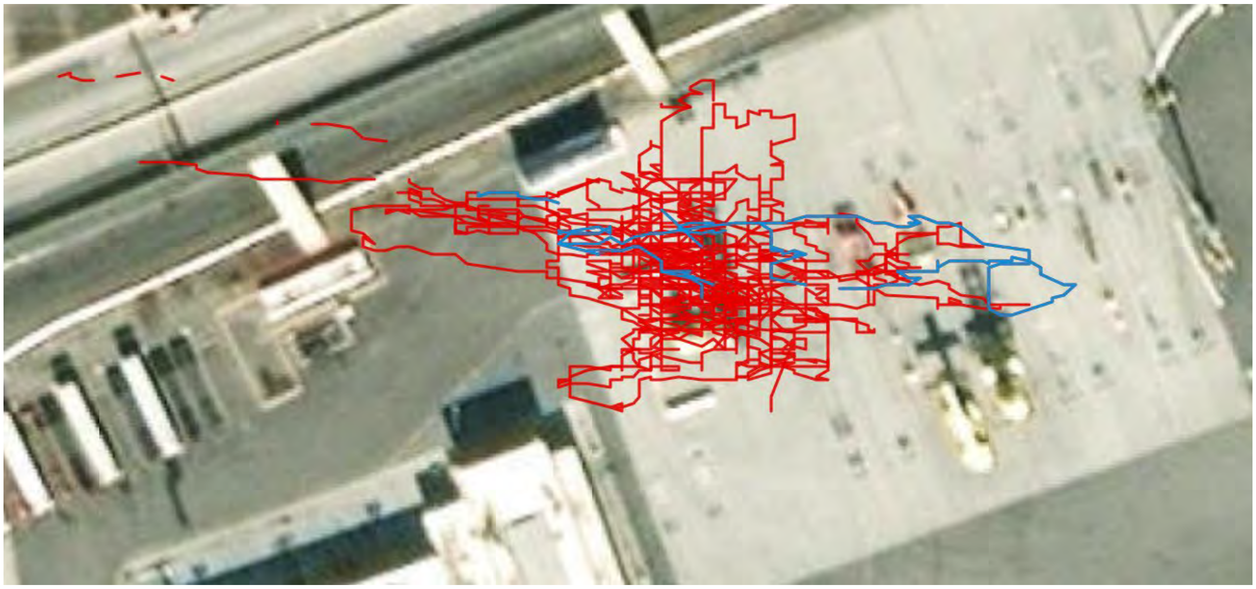


Figure 38. Plotted GPS route of LBCT top handler from 4/10/2021. The single event of operation is highlighted in blue.

3.1.3 Diesel Equipment

One diesel top handler was originally planned to have been instrumented at SSA. Data collection on diesel top handler 80290 was halted on 10/26/2020 due to HEM logger malfunctions caused by excess engine heat. Diesel top handler 80361 was instrumented on 10/26/2020 to extend the data collection of diesel top handlers.

SSA diesel top handler 80290 (a) averaged 41% engine load, 31.1% engine torque, 5 hours, 1.6 mph, 7.4 miles, and used 29 gallons of fuel, per day. SSA diesel top handler 80361 (b) averaged 22% engine load, 22.8% engine torque, 4.8 hours, 1.4 mph, 8.5 miles, and used 21.7 gallons of fuel, per day. The figures in this section provide more information on the daily averages of these pieces of equipment over the data logging period.

Figure 39 shows the average engine load percentage for SSA diesel top handler 80290 (a) and diesel top handler 80361 (b). The diesel top handler (a) engine load did not vary greatly. It was typically between 20 and 50 percent, with an average of about 41 percent. The average engine load percentage for the diesel SSA top handler (b) was 22 percent engine load, which varied between less than 1 to 46 percent.

Figure 40 shows the average engine torque percentage for SSA diesel top handler 80290 (a) and diesel top handler 80361 (b). The diesel top handler (a) engine torque did not vary greatly. It was typically between 20 and 35 percent, with an average of about 31.1 percent. The average engine torque percentage for the diesel SSA top handler (b) did not vary greatly. It was typically between 20 and 30 percent, with an average of about 22.8 percent

Figure 41 shows the daily number of hours of use for SSA diesel top handler 80290 (a) and diesel top handler 80361 (b). Diesel top handler (a) was used for an average of about 5 hours per day, with a range from less than 1 hour to greater than 13 hours per day. The daily number of hours of use for Diesel top handler (b) was used for an average of about 4.8 hours per day, with a range from less than 1 hour to greater than 12 hours per day.

Figure 42 shows the daily average speed for SSA diesel top handler 80290 (a) and diesel top handler 80361 (b). Because the top handlers do considerable work in a small section of the port the average speed is kept low. Average daily speeds ranged from 1 mph to less than 7 miles per hour. The average speed for the diesel top handler (a) was 1.6 miles per hour. The daily average speed for the diesel top handler (b) ranged from 1 mph to less than 3 miles per hour. The average speed for the diesel top handler (b) was 1.4 miles per hour.

Figure 43 shows the daily miles traveled for SSA diesel top handler 80290 (a) and diesel top handler 80361 (b). The number of miles travel per day varied greatly from about 1 to more than 20 miles traveled per day. This metric was estimated using the number of hours of use and the average speed. The diesel top handler (a) averaged about 7.4 miles per day. The number of miles travel per day varied greatly from about 1 to more than 25 miles for the diesel top handler (b). The diesel top handler (b) averaged about 8.5 miles per day.

Figure 44 shows the average fuel usage rate for SSA diesel top handler 80290 (a) and diesel top handler 80361 (b). The diesel top handler (a) fuel rate varied from less than 13 gallons to above 66 gallons, with an average of about 29 gallons per day. The diesel top handler (b) fuel rate varied from more than 1 gallon to more than 64 gallons, with an average of about 21.7 gallons per day.

In all figures, the average for the specified parameter is displayed in red at the end of each figure.

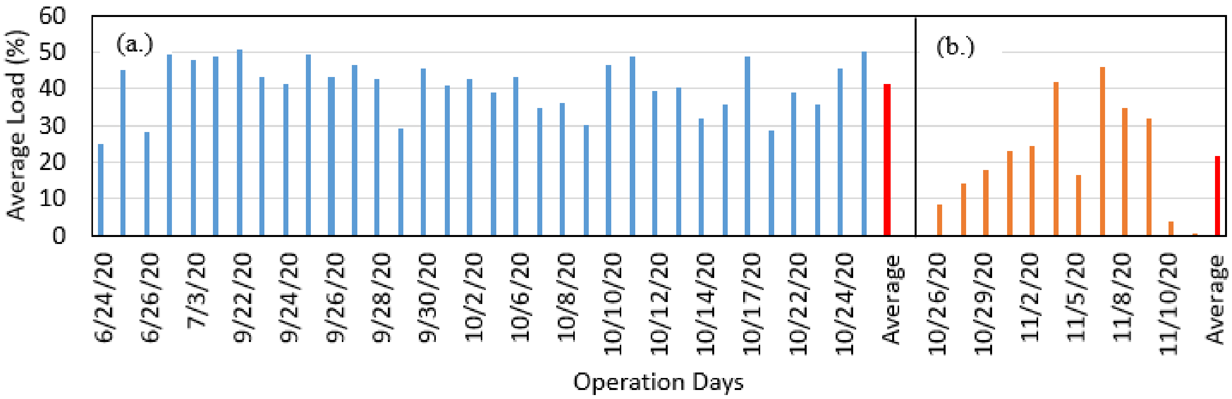


Figure 39. Average daily engine load percentage for diesel top handler 80290 (a) and diesel top handler 80361 (b) at SSA.

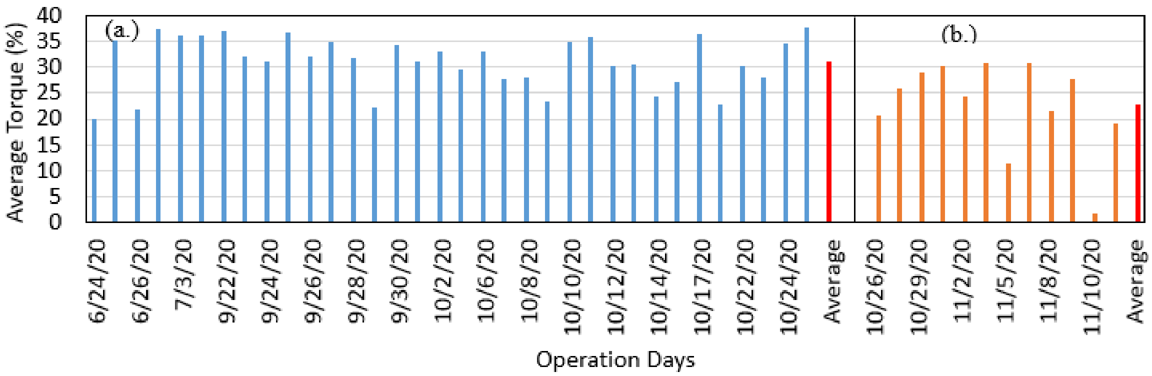


Figure 40. Average daily torque percentage for diesel top handler 80290 (a) and diesel top handler 80361 (b) at SSA.

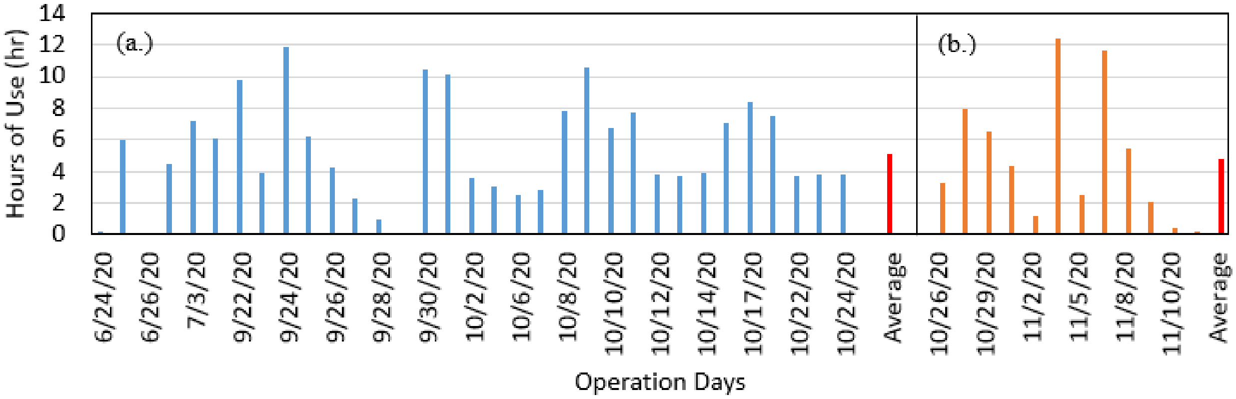


Figure 41. Number of daily hours of use for diesel top handler 80290 (a) and diesel top handler 80361 (b) at SSA.

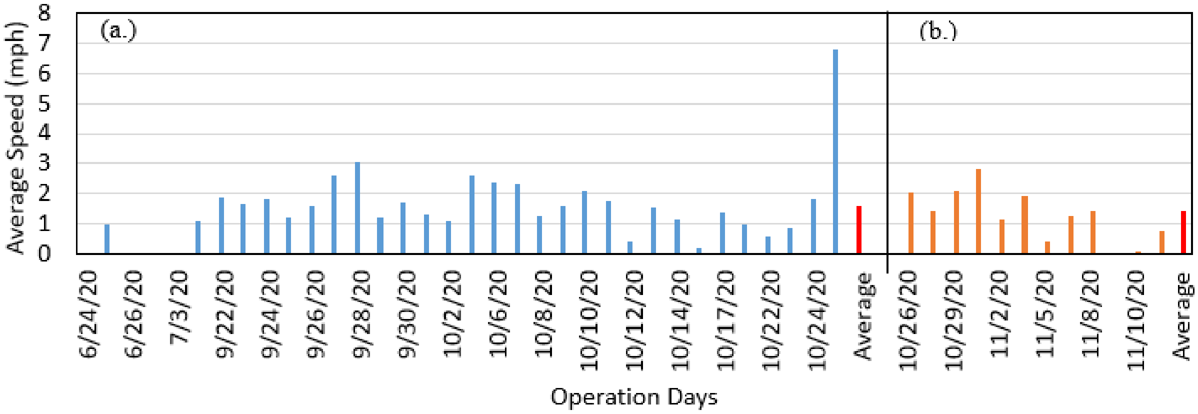


Figure 42. Average daily speed for diesel top handler 80290 (a) and diesel top handler 80361 (b) at SSA.

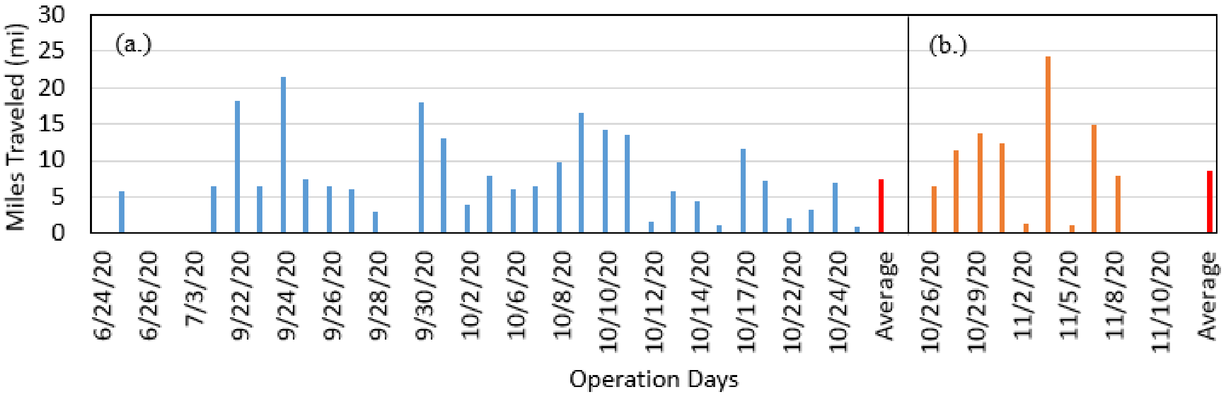


Figure 43. Distance traveled daily for diesel top handler 80290 (a) and diesel top handler 80361 (b) at SSA.

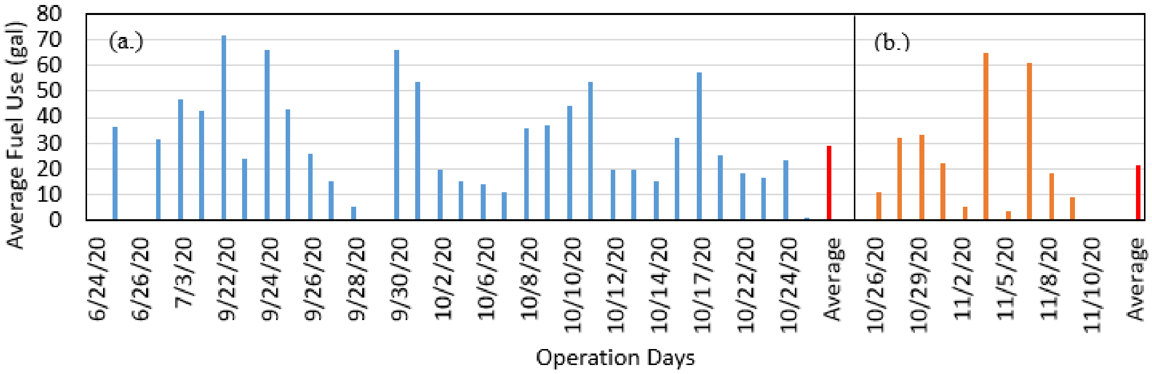


Figure 44. Daily Fuel usage rate for diesel top handler 802090 (a) and diesel top handler 80361 (b) at SSA.

3.1.4 Top Handler Baseline Comparison

The electric and diesel top handlers at SSA shared similar statistics over the course of the data logging period. Both types of top handlers were used on average about 5 hours per day. The electric top handlers at SSA traveled almost twice as far as their diesel counterparts. Both types averaged about the same speed of 1.5-2.5 mph. The electric top handler at LBCT displays a different pattern of activity than the top handlers at SSA. The LBCT top handler was not used as extensively and averaged under 3 hours of operation per day, less than 1 mile per day, and less than 1 mph. It was estimated using the fuel rate of the diesel top handers and the hours of use that they used on average 29 and 21.7 gallons of fuel per day for diesel top handler (a) and (b), respectively. Converting this to kWhr gives 1093 and 818 kWhr on average per day for diesel top handlers (a) and (b), respectively. The electric top handlers averaged 382, 301, and 63 kWhr of energy per day for the SSA top hander (1) and (2) and the LBCT top handler, respectively. Dividing these energy values by the average daily number of miles traveled gives 180 and 158 kWhr/mi for the diesel top handlers (a) and (b), respectively. The electric top handlers on average consumed 27, 25, and 110 kWhr/mi for the SSA top hander (1) and (2) and the LBCT top handler, respectively.

3.2 Yard Tractor Activity

3.2.1 Electric Equipment

The LBCT yard tractor averaged 95 kWhr, 56% of SOC use, 15 kWhr/hr, 6 hours, 8 mph, and 42 miles, per day. The figures in this section provide more information on the daily averages of these pieces of equipment over data logging period.

Figure 45 shows the daily energy consumption for the yard tractor on a kWhr basis. The LBCT yard tractor used an average of about 95 kWhr per day. The amount of energy consumed per day ranged from about 7 to 120 kWhr.

Figure 46 shows the daily energy consumption for the LBCT yard tractor on a SOC basis. The LBCT yard tractor used an average of about 56% of total charge per day. The amount of energy consumed per day in terms of SOC ranged from about 4 to 130%. The yard tractor was charged multiple times a day on some occasions.

Figure 47 shows the energy consumption per hour for the LBCT yard tractor. The amount of energy consumed per day ranged from about 7 to over 50 kWhr per hr. The LBCT yard tractor used an average of about 15 kWhr per hr.

Figure 48 shows the daily number of hours of use for the LBCT yard tractor. The LBCT yard tractor were operational for between less than 1 hour to about 14 hours per day, with an average of about 6 hours.

Figure 49 shows the daily average speed for the LBCT yard tractor. Because the yard tractors do considerable work in a small section of the port the average speed is kept to low. Average daily speeds ranged from 6 mph to slightly greater than 9 miles per hour. The average speed for the yard tractor was 8 miles per hour.

Figure 50 shows the daily miles traveled for the LBCT yard tractor. The number of miles traveled ranged from less than 5 to slightly more than 80 miles traveled per day. The LBCT yard tractor averaged about 42 miles per day.

Figure 51 include a plot of the routes followed by the LBCT yard tractor for a 6.5-hour workday. In this workday, the yard tractor drove 47 miles, averaged a speed of 9.2 mph, and used 65% of its total charge.

In all figures, the average for the specified parameter is displayed in red at the end of each figure.

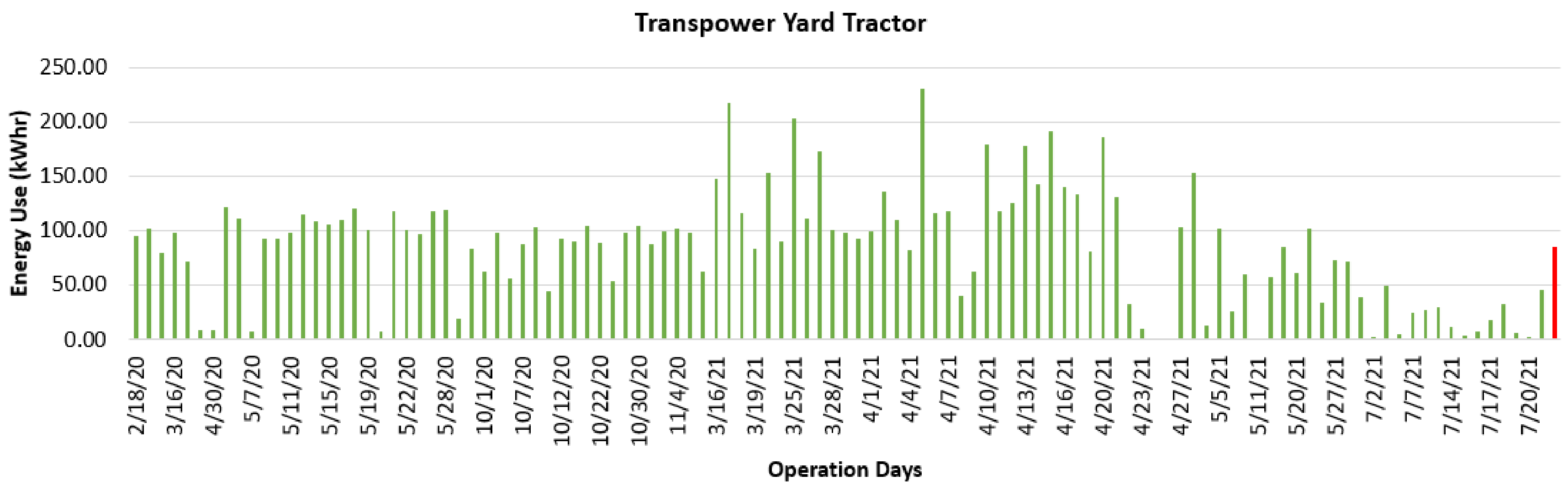


Figure 45. Daily energy consumption in terms of kWhr for LBCT Yard Tractor

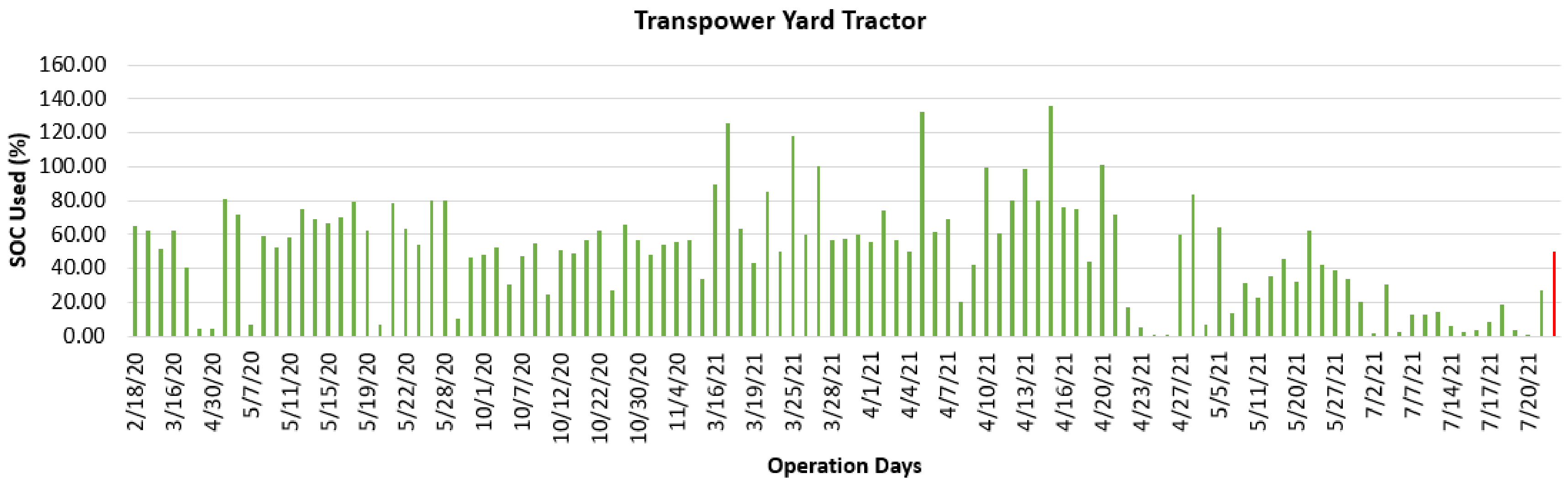


Figure 46. Daily energy consumption in terms of SOC for LBCT Yard Tractor

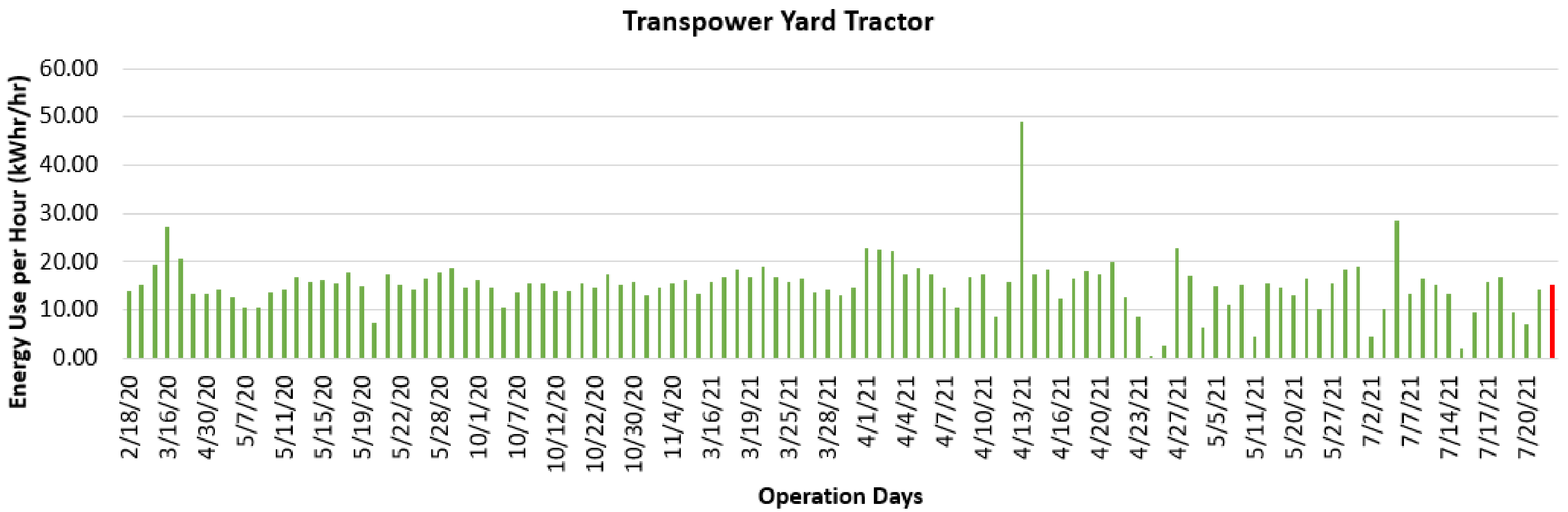


Figure 47. Energy consumption per hour of use for LBCT Yard Tractor

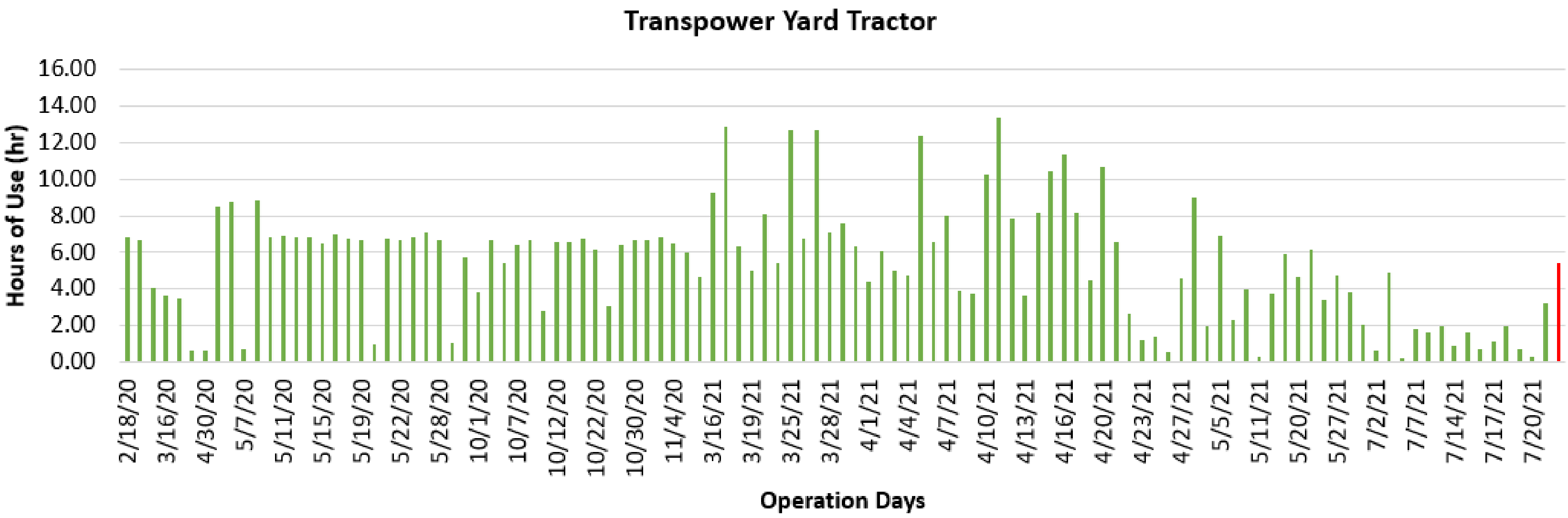


Figure 48. Daily hours of use for LBCT Yard Tractor

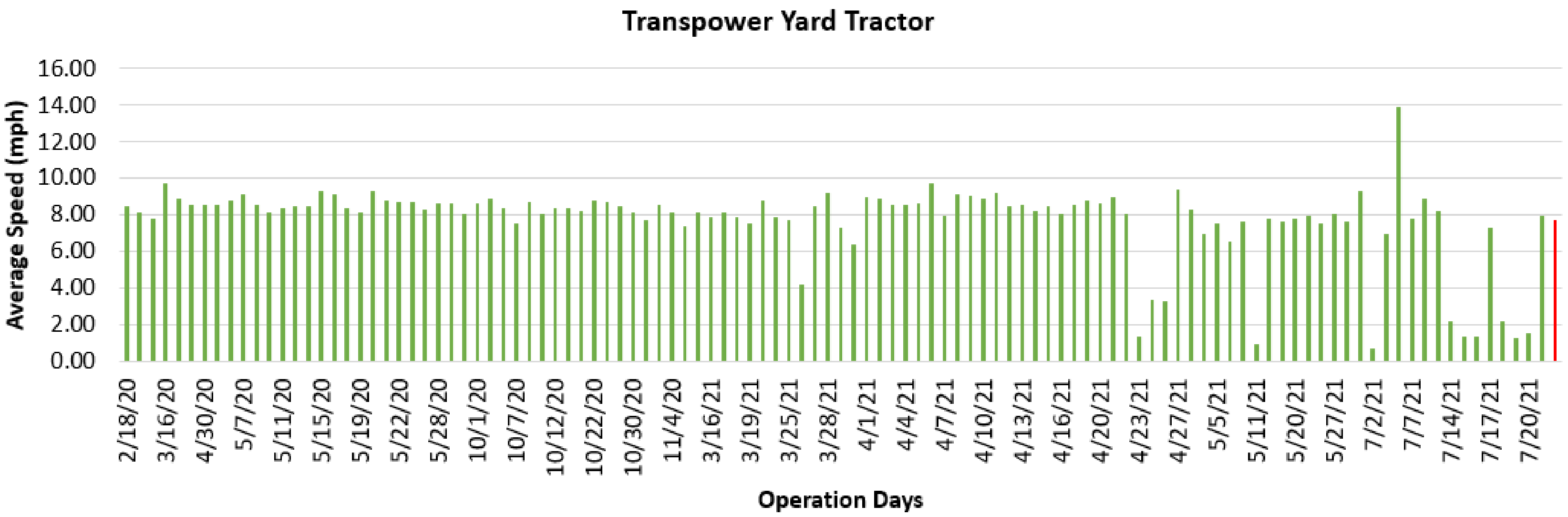


Figure 49. Average Daily Speed for LBCT Yard Tractor

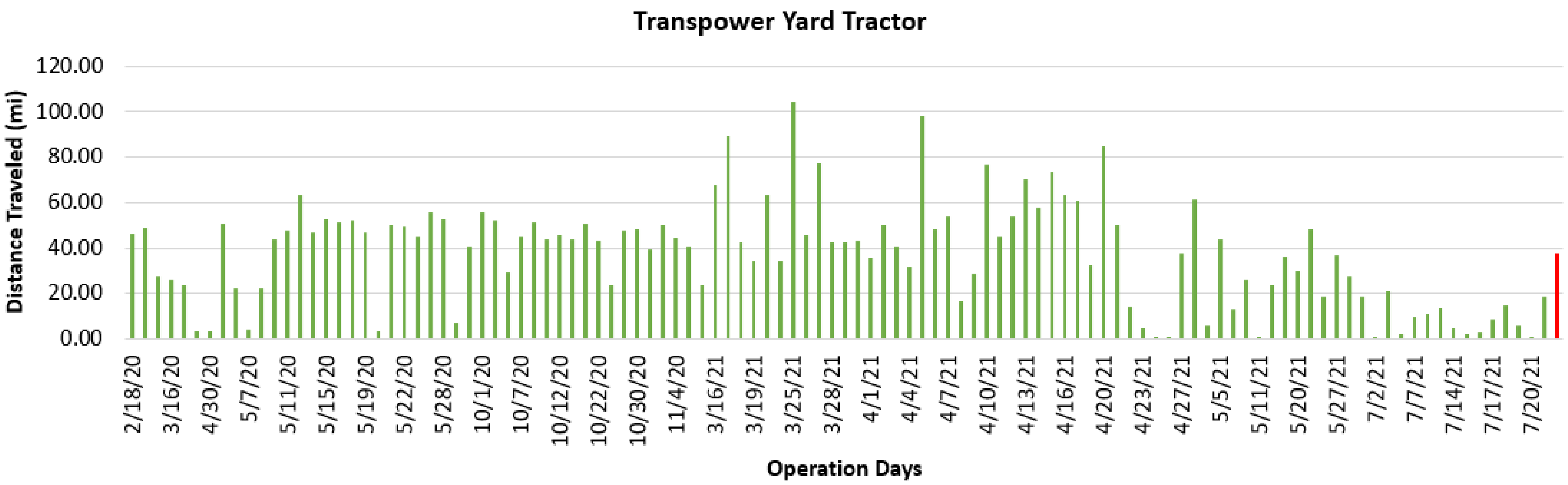


Figure 50. Daily Miles Traveled for LBCT Yard Tractor

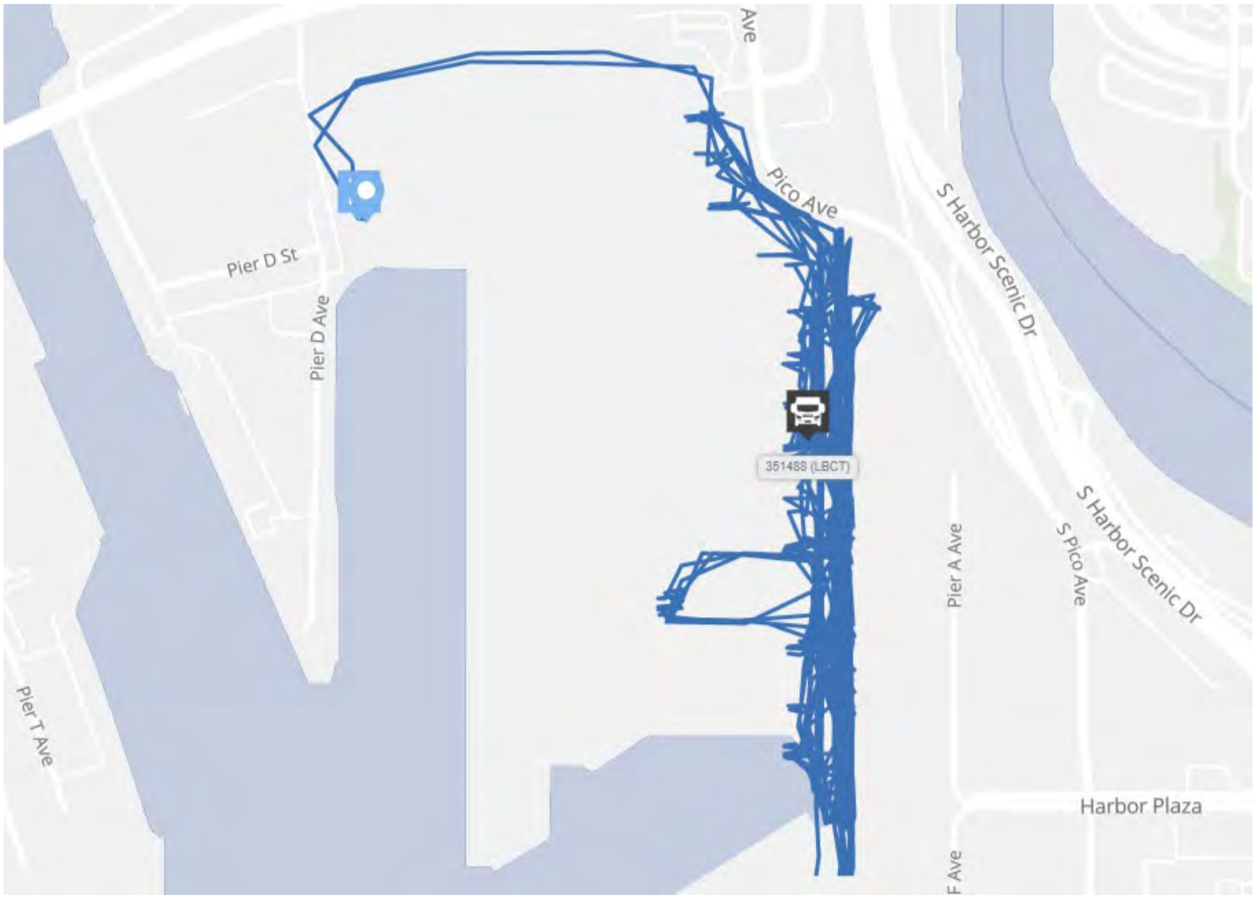


Figure 51. Data showing the routes taken over the course of a representative day for the yard tractor at the LBCT Terminal.

3.2.2 Electric Yard Tractor Duty Cycle

The duty cycle of LBCT yard tractor is presented in Figure 52 through Figure 54. In Figure 52, the output power in Wh and vehicle speed in mph is presented from 4/13/2021. In this day of operation, the yard tractor took a break between 11:01 and 13:09. It then returned to the charging station at 15:50 until 17:17. The duty cycle of this piece of equipment can be characterized through Figure 53, which shows an expanded section of the equipment's operation, and the plotted route of the expanded section in blue of the equipment in Figure 54. The blue route begins in the top left corner of the aerial photo at the charging location. The GPS route for the entire day of operation was collected and is presented in red in Figure 54. During this day of operation, the top handler operated for approximately 8.2 hours, used 172.4 kWh, and averaged a speed of 8.7 mph. While the aerial photo of the port may be out of date, there is still a sense of what the typical movements patterns of the equipment. The LBCT yard tractor makes many trips between the racks of containers on the left and the rail cars on the right in Figure 54.

Figure 52. Duty cycle of LBCT top handler for operation on 4/10/2021.

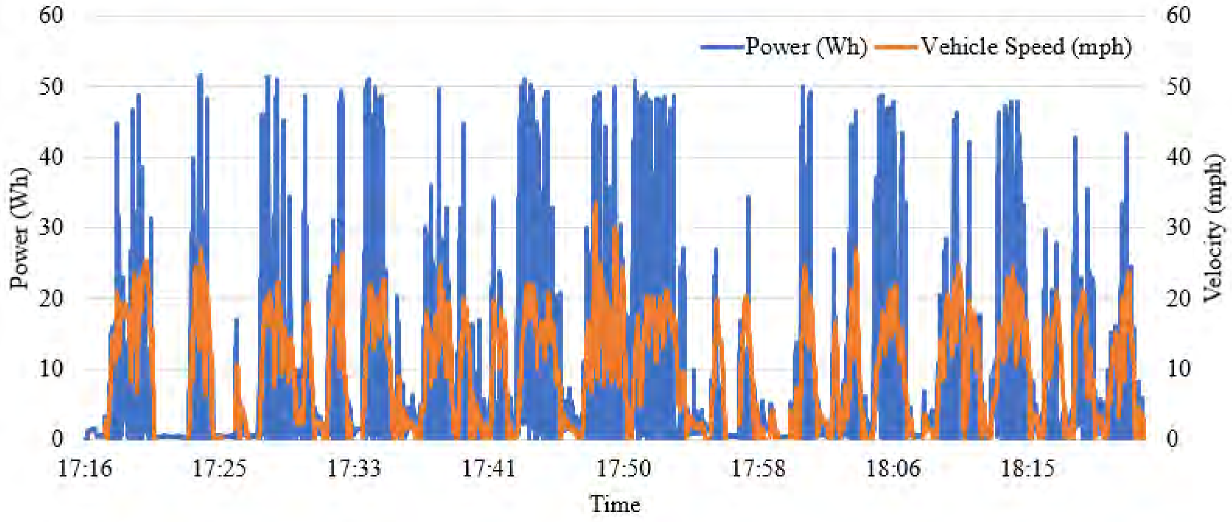


Figure 53. Expanded duty cycle of LBCT top handler for a single event of operation on 4/10/2021 during GPS data capture.

Figure 54. Plotted GPS route of LBCT top handler from 4/10/2021. The single event of operation is highlighted in blue.

3.2.3 Diesel Equipment

The LBCT diesel yard tractor averaged 28% engine load, 21.1% engine torque, 7 hours, 5.5 mph, 44 miles, and used 12 gallons of fuel, per day. The figures in this section provide more information on the daily averages of these pieces of equipment over data logging period.

Figure 55 shows the daily average engine load percentage for the diesel LBCT yard tractor. The diesel yard tractor engine load did not vary greatly. It was typically between 15 and 40 percent, with an average of about 28 percent.

Figure 56 shows the daily average engine torque percentage for the diesel LBCT yard tractor. The diesel yard tractor engine torque did not vary greatly. It was typically between 15 and 25 percent, with an average of about 21.1 percent.

Figure 57 shows the daily average fuel usage rate for the diesel LBCT yard tractor. The diesel yard tractor fuel rate varied from less than 1 gallon to above 25 gallons, with an average of about 12 gallons per day.

Figure 58 shows the daily number of hours of use for the diesel LBCT yard tractor. The diesel yard tractor was operational for between less than 1 hour to above 13 hours per day, with an average of about 7 hours.

Figure 59 shows the daily average speed for the diesel LBCT yard tractor. Because the yard tractors do considerable work in a small section of the port the average speed is kept to low. Average daily speeds ranged from 2 mph to slightly greater than 10 miles per hour. The average speed for the yard tractor was 5.5 miles per hour.

Figure 60 shows the daily miles traveled for the diesel LBCT yard tractor. The number of miles traveled ranged from less than 5 to more than 90 miles traveled per day. The diesel yard tractor averaged about 44 miles per day.

In all figures, the average for the specified parameter is displayed in red at the end of each figure.

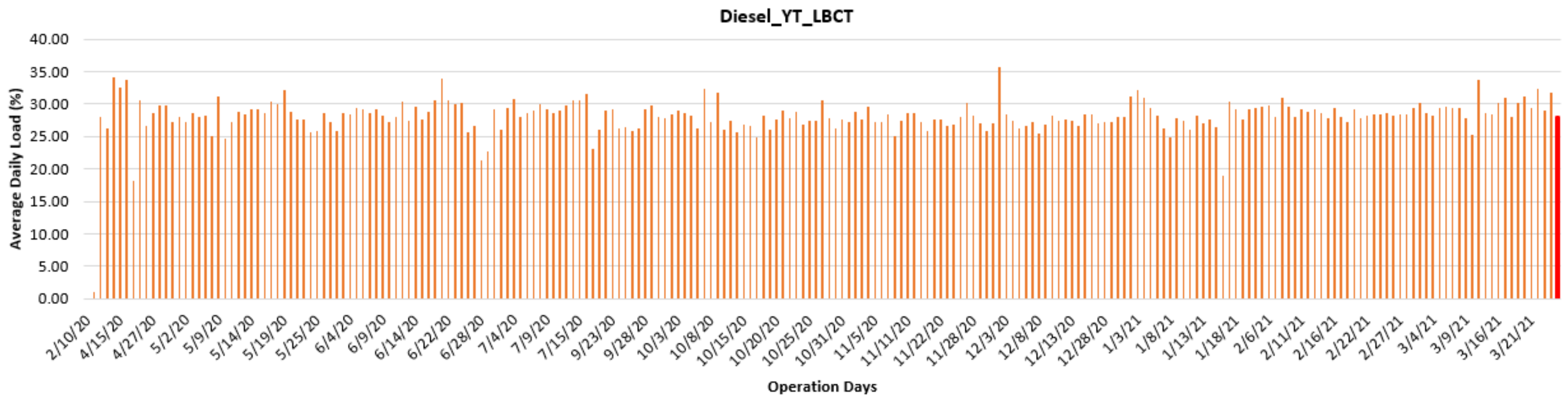


Figure 55. Average engine load percentage for the diesel yard tractor at LBCT.

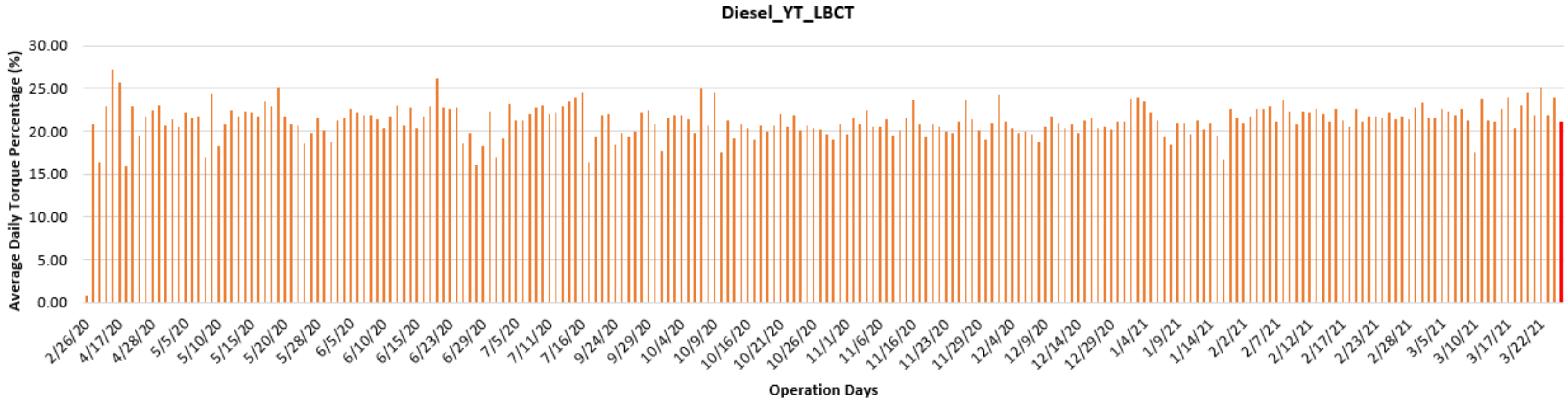


Figure 56. Average torque percentage for the diesel yard tractor at LBCT.

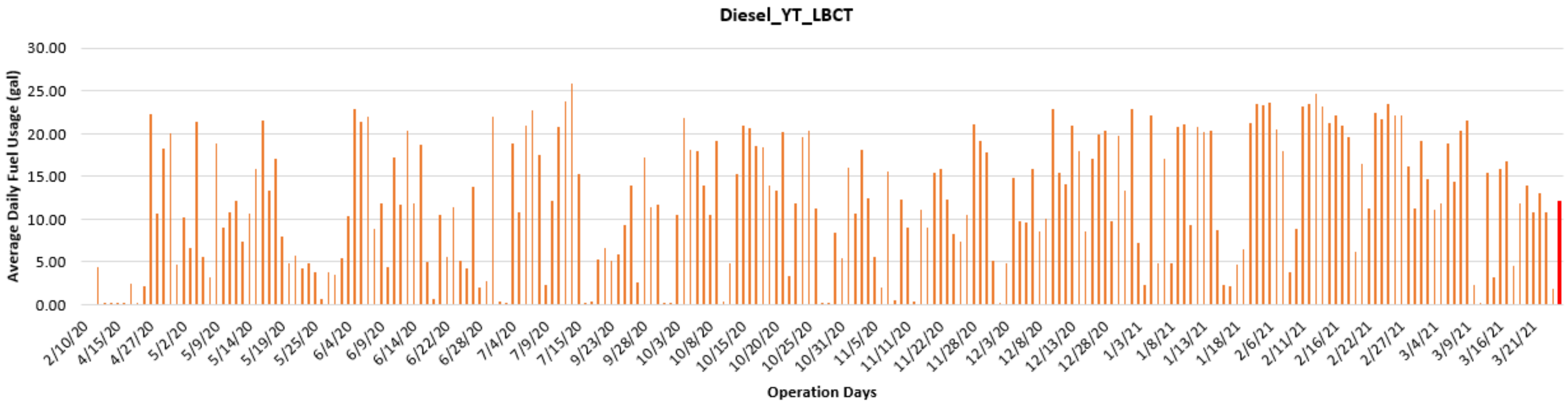


Figure 57. Average fuel usage rate in gallons per day for the diesel yard tractor at LBCT.

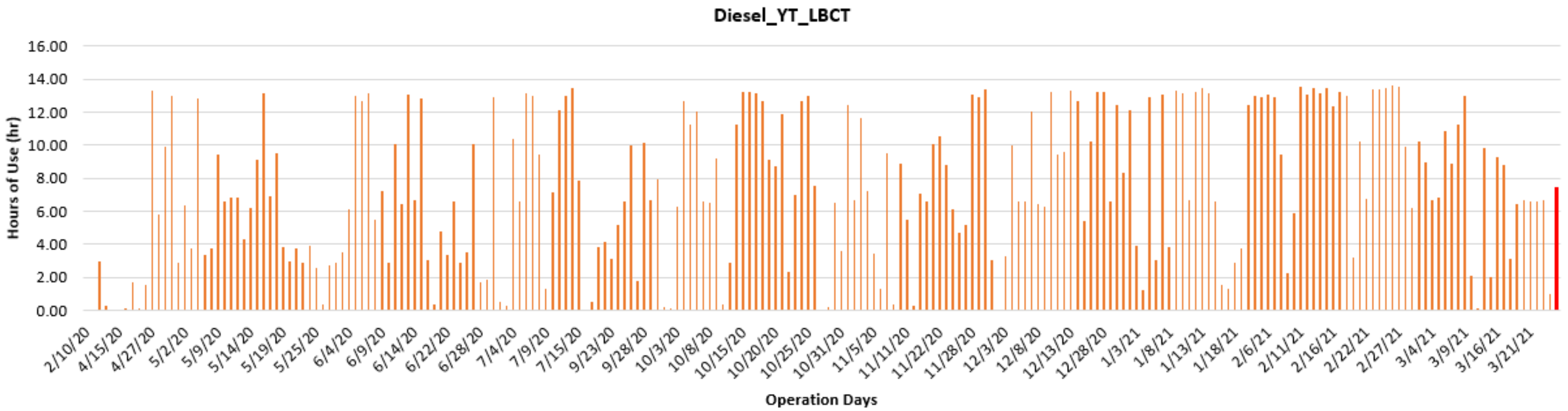


Figure 58. Daily hours of operation for the diesel yard tractor at LBCT.

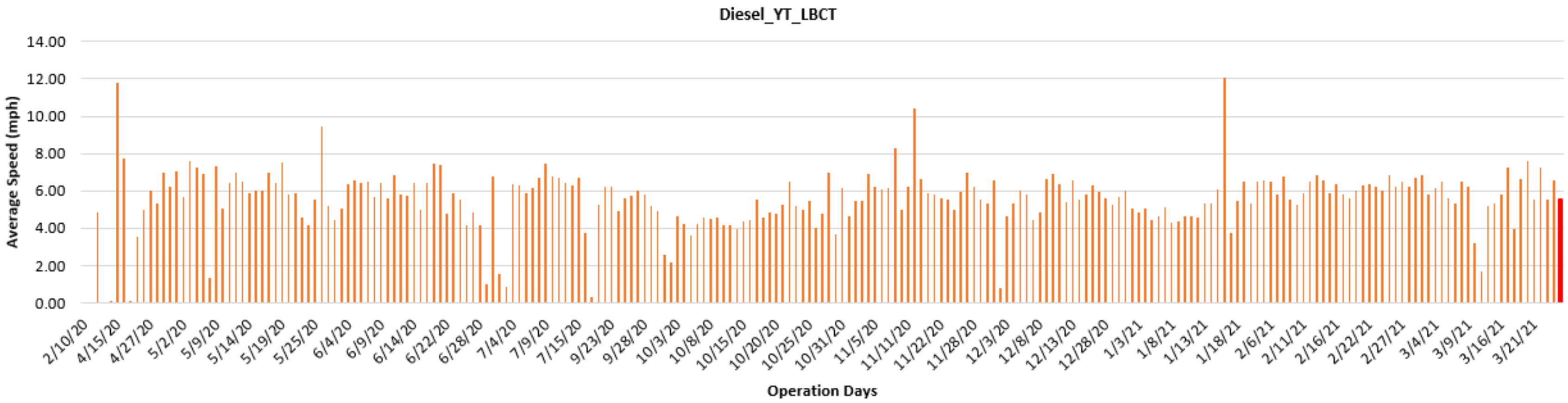


Figure 59. Average speed for the diesel yard tractor at LBCT.

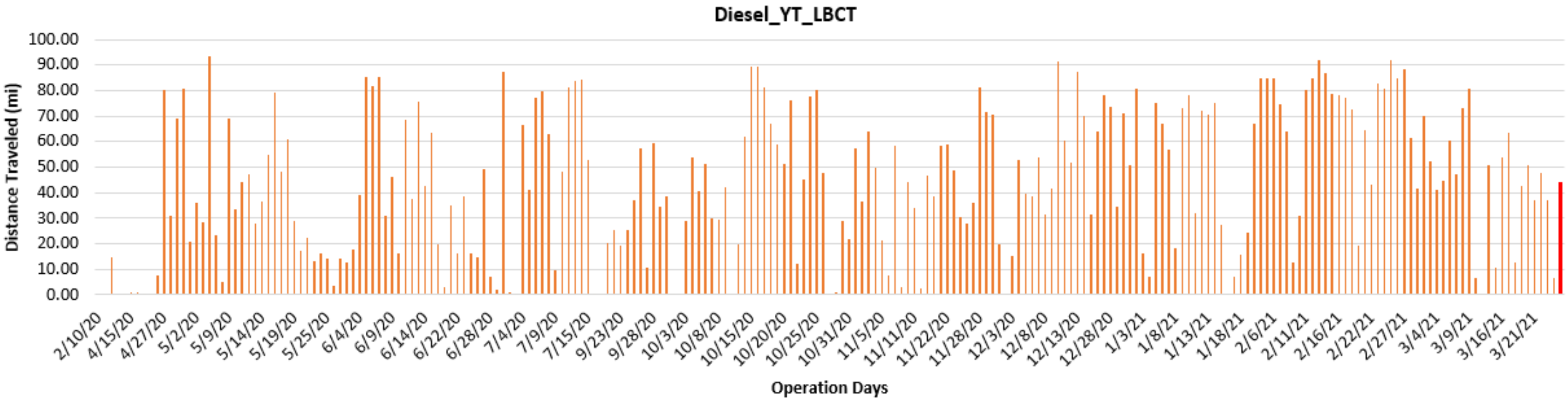


Figure 60. Distance traveled daily of the diesel yard tractor at LBCT.

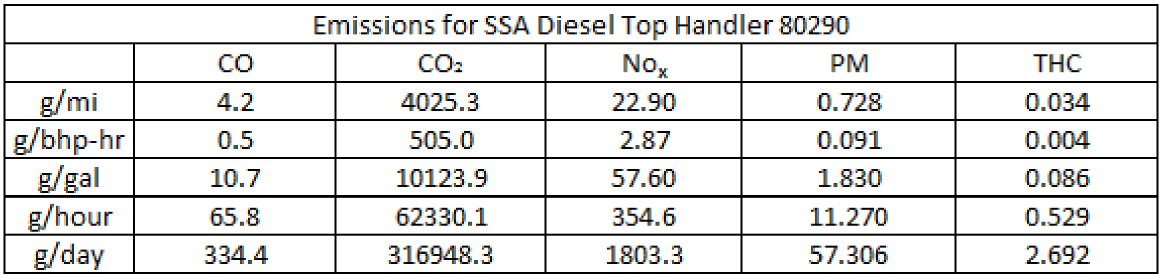
3.2.4 Yard Tractor Baseline Comparison

The electric yard tractor performed similarly to its diesel counterpart at LBCT. Both yard tractors traveled on average over 40 miles per day. The electric yard tractor averaged a slightly higher speed. The diesel yard tractor averaged a higher operating time than the electric yard tractor, but both were able to perform over 12 hours of use during a single day. It was estimated using the fuel rate of the diesel yard tractor and the hours of use that it used on average 13.6 gallons of fuel per day. Converting this to kWhr gives 510.8 kWhr on average per day. The electric yard tractor averaged 95.1 kWhr of energy. Dividing these energy values by the average daily number of miles traveled gives 13.5 and 2.35 kWhr/mi for the diesel and electric yard tractors, respectively.

3.3 Portable Emissions Measurement System (PEMS) Results

3.3.1 Diesel Top Handler

The emissions results for the diesel top handler are presented in Table 3, in g/mi, g/bhp-hr, g/gal, g/hour, and g/day units. The daily average NOx emissions for the diesel top handler were 22.9 grams/mile (g/mi), 2.87 grams per brake-horsepower hour (g/bhp-hr), 57.6 grams per gallon (g/gal.), 355 grams per hour (g/hour), and 1803 grams per day (g/day). The daily average PM emissions for the diesel top handler were 0.73 g/mi, 0.09 g/bhp-hr, 1.83 g/gal., 11.3 g/hour, and 57.3 g/day. The daily average THC emissions for the diesel top handler were 0.03 g/mi, 0.004 g/bhp-hr, 0.09 g/gal., 0.53 g/hour, and 2.69 g/day. The daily average CO emissions for the diesel top handler were 4.25 g/mi, 0.53 g/bhp-hr, 10.7 g/gal., 65.8 g/hour, and 334 g/day. The daily average CO_2 emissions for the diesel top handler were 4,025 g/mi, 505 g/bhp-hr, 10,124 g/gal., 62,330 g/hour, and 316,948 g/day.



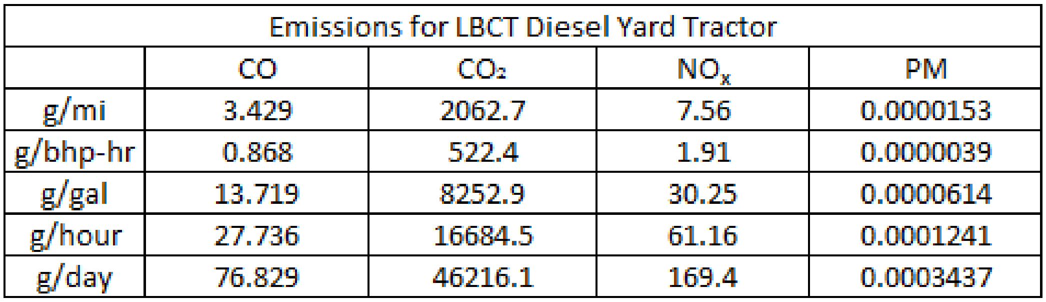
Emissions for SSA Diesel Top Handler 80290

	CO	CO_2	No_x	PM	THC
g/mi	4.2	4025.3	22.90	0.728	0.034
g/bhp-hr	0.5	505.0	2.87	0.091	0.004
g/gal	10.7	10123.9	57.60	1.830	0.086
g/hour	65.8	62330.1	354.6	11.270	0.529
g/day	334.4	316948.3	1803.3	57.306	2.692

Table 3. Emissions for SSA Diesel top handler 80290

3.3.2 Diesel Yard Tractor

The emissions results for the LBCT diesel yard tractor are presented in Table 4, in g/mi, g/bhp-hr, g/gal, g/hour, and g/day units. The daily average NOx emissions for the diesel yard tractor were 7.56 g/mi, 1.91 g/bhp-hr, 30.25 g/gal., 61.16 g/hour, and 1768.57 g/day. The daily average PM emissions for the diesel yard tractor were 0.015 mg/mi, 0.004 mg/bhp-hr, 0.061 mg/gal., 0.124 mg/hour, and 0.344 mg/day. The daily average CO emissions for the diesel yard tractor were 3.43 g/mi, 0.87 g/bhp-hr, 13.72 g/gal., 27.74 g/hour, and 76.83 g/day. The daily average CO_2 emissions for the diesel yard tractor were 2,062 g/mi, 522 g/bhp-hr, 8,252 g/gal., 16,684 g/hour, and 46,216 g/day.



Emissions for LBCT Diesel Yard Tractor

	CO	CO_2	NO_x	PM
g/mi	3.429	2062.7	7.56	0.0000153
g/bhp-hr	0.868	522.4	1.91	0.0000039
g/gal	13.719	8252.9	30.25	0.0000614
g/hour	27.736	16684.5	61.16	0.0001241
g/day	76.829	46216.1	169.4	0.0003437

Table 4. Emissions for LBCT diesel yard tractor.

3.4 Charging Data

Table 5 provides an overview table of the charging data and statistics for the top handlers and yard tractor. The charging data for the SSA terminal was collected using hand-written logs provided by the terminal. The charging data from LBCT was collected from power meters that were installed at the terminal specifically for C-PORT. The data from the chargers at LBCT were downloaded every 11 days, or more frequently. SOC information for the LBCT equipment was taken from the operational data loggers by compare the SOC between the time when the equipment started to charge and when the charging was completed each time. It should be noted that charging data was collected over a much shorter period of time, as approved by CARB and resulting in a grant amendment, compared to the data logging of the equipment activity, which was considerably longer than 3 months for most equipment.

Table 5. Overall averages of available charge meter data.

Equipment	Location	ID	Number of Days Charging Logged (no.)	Number of Days Observed (no.)	Average Charging Time (hrs)	Average Starting SOC (%)	Average SOC Charged Percentage (%)	Average Energy Amount (kWhr)
TH	SSA	80367	68	120	7.9	53.5	43.5	444.0
TH	SSA	80368	62	120	7.1	59.0	38.0	401.9
TH	LBCT	43144	13	129	4.1	35.5	63.8	517.5
YT	LBCT	351488	75	129	4.6	41.4	48.4	82.8

Figure 61 through Figure 64 show daily charging times, SOC increase from the charging, and energy use for SSA top handlers 80361 and 80368. Note that Figure 65 displays that there were apparently charging events where the unit was charging for hours but received no energy. According to the real-time power meter data, it seems there was an unexplained decrease in the peak charging energy transfer to the unit. Note that the average charging time for the LBCT equipment was based on the average time that the charger was actually outputting energy to the equipment, based on the real-time charging data. For SSA, the charging time was the recorded manually on hand-written logs, which likely represents the total time that the equipment was hooked up the charger, not just the amount of time for outputting of energy to the equipment.

Figure 65 through Figure 68 show the power readings for kWh delivered, SOC increase from the charging, and the charging times for the electric yard tractor and top handler at the LBCT terminal.

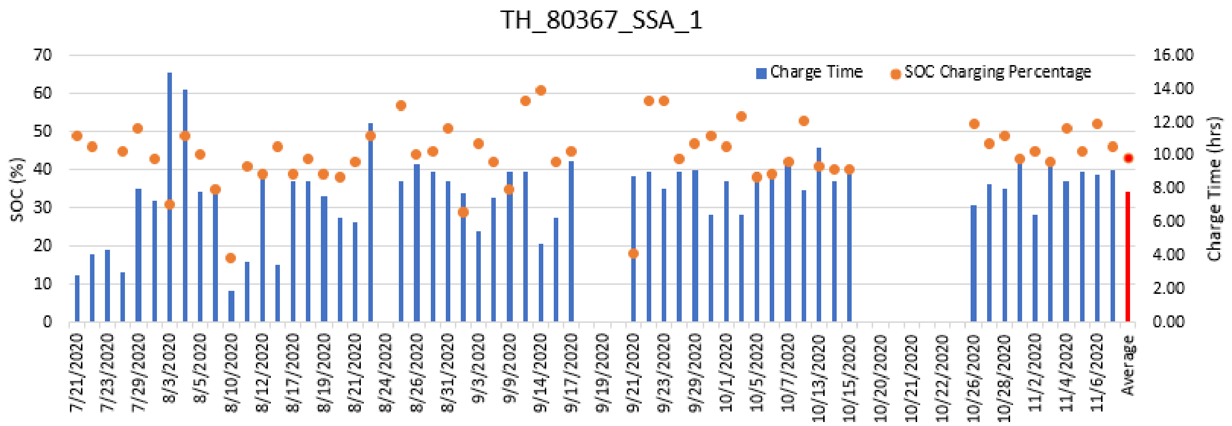


Figure 61. Daily charge time and SOC percentage charged for SSA top handler 80367.

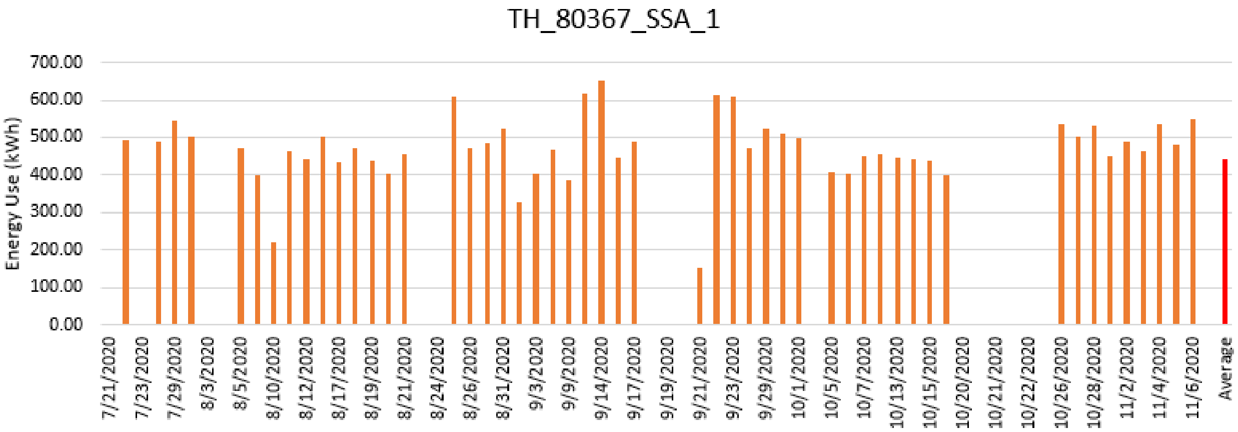


Figure 62. Daily Charging Energy in kWh for SSA top handler 80367.

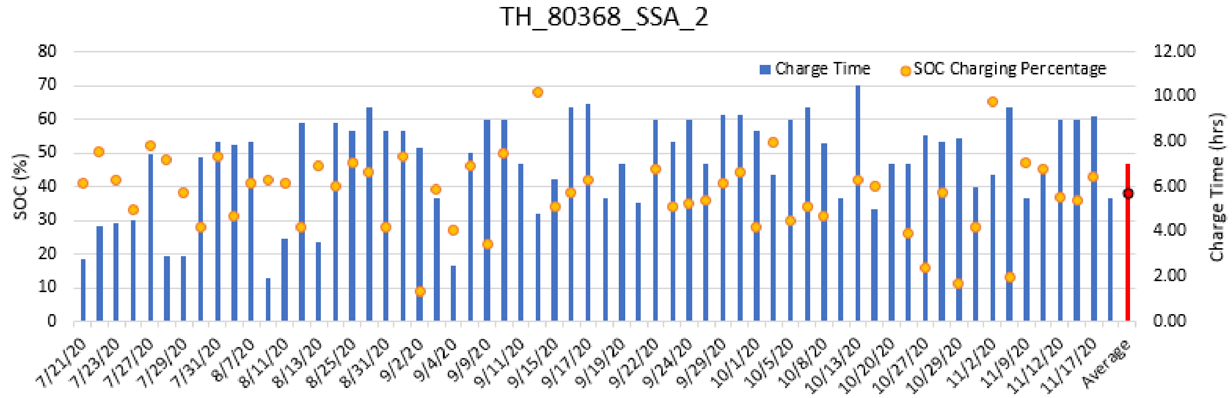


Figure 63. Daily charge time and SOC percentage charged for SSA top handler 80368.

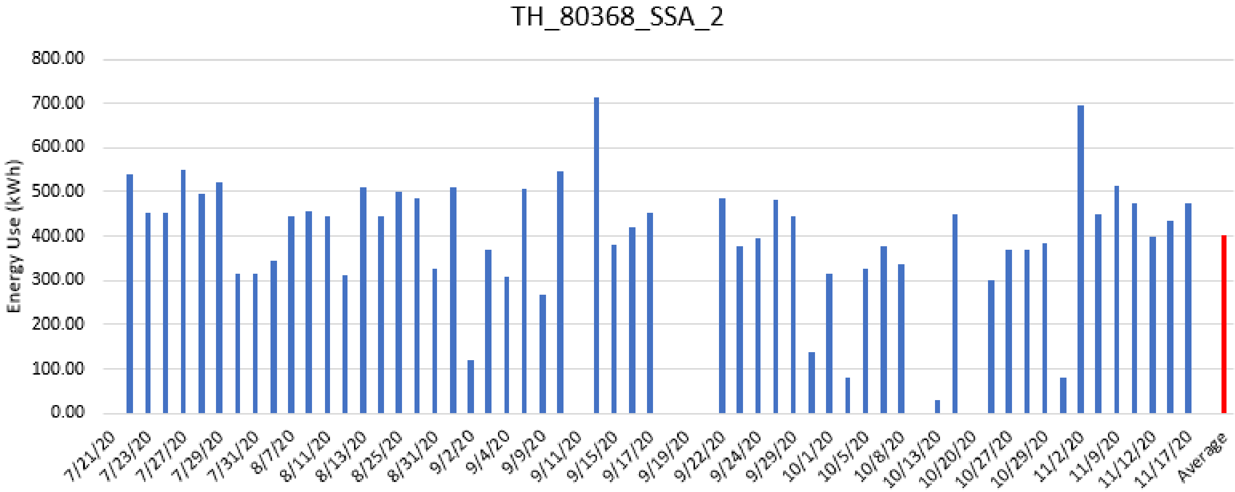


Figure 64. Daily Charging Energy in kWh for SSA top handler 80368.

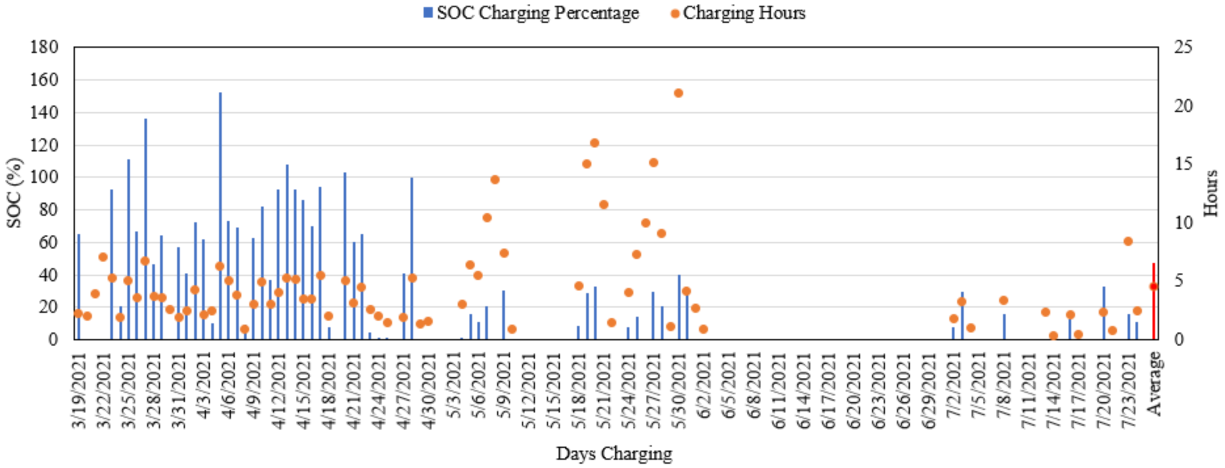


Figure 65. Daily charging time and SOC percentage charged for LBCT yard tractor.

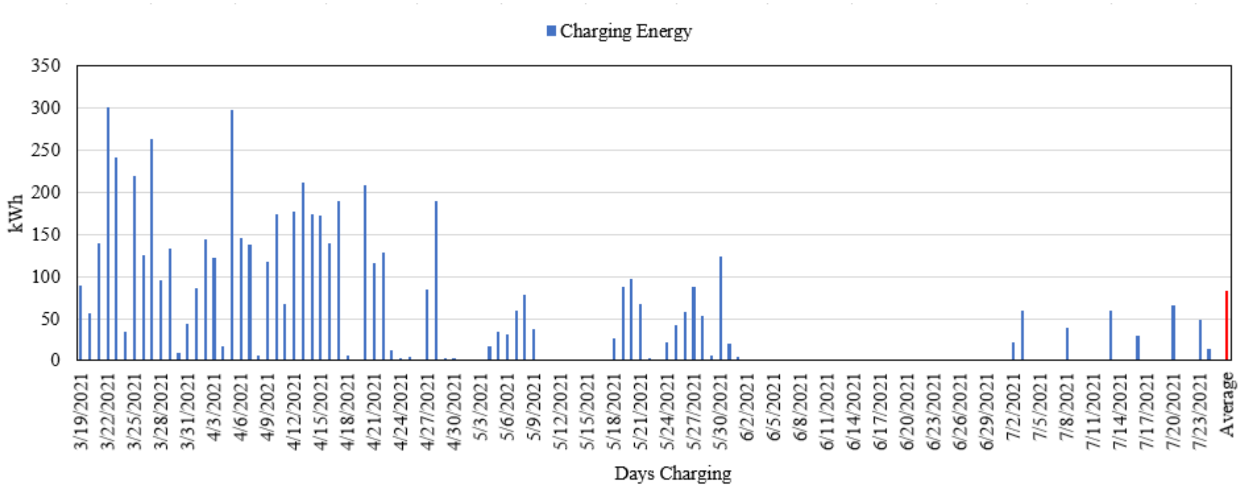


Figure 66. Daily charging energy in kWh for LBCT yard tractor.

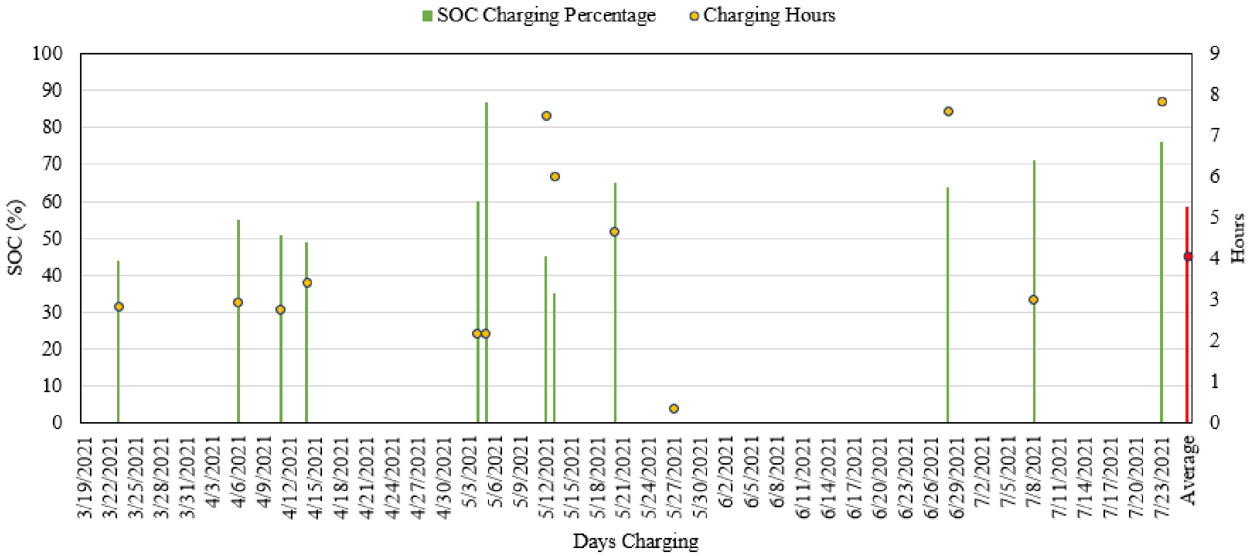


Figure 67. Daily charging time and SOC percentage charged for LBCT top handler.

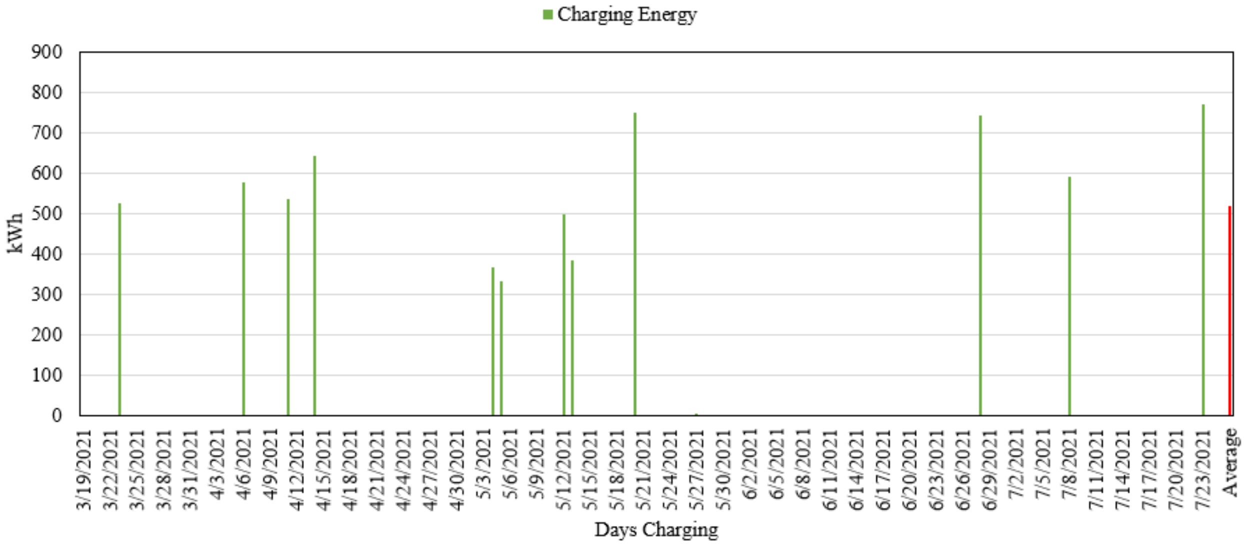


Figure 68. Daily charging energy in kWh for LBCT top handler.

3.5 CARB Appendix F Data Collection Requirements

Table 6 and Table 7 provide summary tables with the results available data points, as required per Appendix F of CARB's Off-Road Advanced Technology Demonstration Projects solicitation. Most of the data is provided in the tables and graphics elsewhere within this report. Some Appendix F data points are not applicable to this off-road cargo handling equipment demonstration project, or unavailable. Additional data, such as maintenance records, will be provided by the OEMs in their respective final reports. Figure 69 through Figure 72 provide the battery degradation plots of the battery electric equipment, which did not show any readily quantifiable battery degradation over the period the equipment was data logged.

Table 6. Summary of results for CARB Appendix F Data Collection Requirement.

Appendix F Requirements		**Equipment**						
Vehicle Operation	**Units**	**TH_SSA_80367**	**TH_SSA_80368**	**TH_LBCT**	**YT_LBCT**	**TH_Diesel_SSA_80290**	**TH_Diesel_SSA_80361**	**YT_Diesel_LBCT**
Hours of Operation (Total Processed)	(hours)	974.3	840.6	273.5	594.4	166.2	62.8	1216.4
Number of Days Logged	days	329.0	329.0	329.0	278.0	124.0	30.0	341.0
Number of days Operating	days	186.0	179.0	98.0	110.0	34.0	12.0	224.0
Days of Operation per Year	(days/yr)	206.4	198.6	108.7	144.4	100.1	146.0	239.8
Odometer reading (Mileage)	miles	N/A	N/A	N/A	8033.0	N/A	N/A	38448.0
Dashboard Odometer (Hours)	Hours	1161.1	1155.6	307.9	N/A	7405.4	6231.2	6617.5
GPS data		Available	Available	Available	Available	Available	Available	Available
Origin and Destination		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Miles traveled per trip (Average)	(mi/day)	17.9	13.2	1.1	37.2	66.3	53.8	43.6
Number of stops per mile		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duration per trip (Average)	(hr/day)	5.2	4.7	2.8	5.4	5.0	5.1	7.3
Idling/queing time		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Weight of load (Average)	tons	25	25	25	25	Unavailable	Unavailable	Unavailable
Battery Degradation (capacity/power over project length)	(kWhr/% SOC Used)	See Plot	See Plot	See Plot	See Plot			
Vehicle/Equipment Performance								
Miles between road calls		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Number of road calls		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Battery Degradation (capacity/power over project length)	(kWhr/% SOC Used)	See Plot	See Plot	See Plot	See Plot			
Vehicle availability		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vehicle zero emission range	miles	40.1	35.2	15.8	76.57			
	hours	14.48	15.5	36.8	12.8			

Table 7. Summary of results for CARB Appendix F Data Collection Requirement.

Appendix F Requirements		Equipment						
Fuel/Energy Consumption	**Units**	**TH_SSA_80367**	**TH_SSA_80368**	**TH_LBCT**	**YT_LBCT**	**TH_Diesel_SSA_80290**	**TH_Diesel_SSA_80361**	**YT_Diesel_LBCT**
Amount of fuel/electricity		Reference Tables	Reference Tables	Reference Tables	Reference Tables	Reference Tables	Reference Tables	Reference Tables
Odometer reading (Mileage)	miles	N/A	N/A	N/A	8033	N/A	N/A	38448
Last Date Recorded	yyyymmdd	20201231	20201203	20210724	20210723	20201026	20201120	20210325
Fuel Price/Electricity Rate (Est.)	$/kWh	0.162	0.162	0.162	0.162	Unavailable	Unavailable	Unavailable
SOC (Average Usage)	%	42.6	34.1	7.66	49.96	[redacted]	[redacted]	[redacted]
Refuel/Charging time	hours	7.9	7.1	4.1	4.6	N/A	N/A	N/A
Distance traveled to refuel/charge (if off-site)		On-Site	On-Site	On-Site	On-Site	On-Site	On-Site	On-Site
Refueling/Charging source		Grid Electricity SCE	Grid Electricity SCE	Grid Electricity SCE	Grid Electricity SCE	N/A	N/A	N/A
Off-peak and/or renewable energy load shifting potential		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Refueling/Charge frequency		Reference Tables	Reference Tables	Reference Tables	Reference Tables	Reference Tables	Reference Tables	Reference Tables
Fuel efficiency	(mi/SOC %) or (mi/gal)	0.4	0.4	0.2	0.8	0.3	0.4	3.4
Energy consumption rate per distance driven	(kWhr/mi)	31.7	42.2	104.8	2.3	180.1	157.7	13.5
Energy consumption rate per operation hour	(kWhr/hr)	66.9	56.9	27.6	15.2	204.8	139.1	65.9
Fuel/energy consumption while idling		N/A	N/A	N/A	N/A	N/A	N/A	N/A

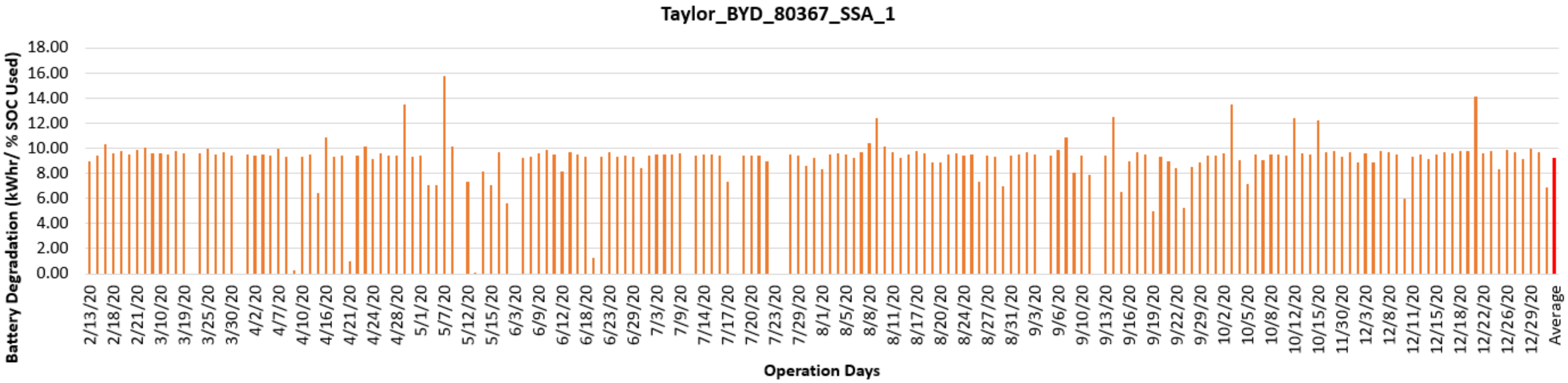


Figure 69. Battery degradation of top handler 1 at SSA.

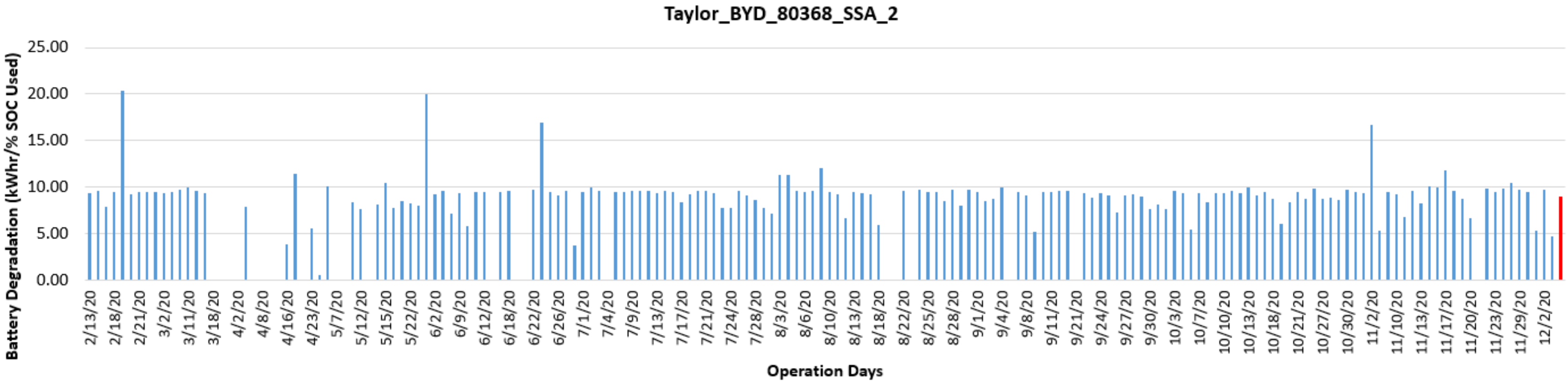


Figure 70. Battery degradation of top handler 2 at SSA.

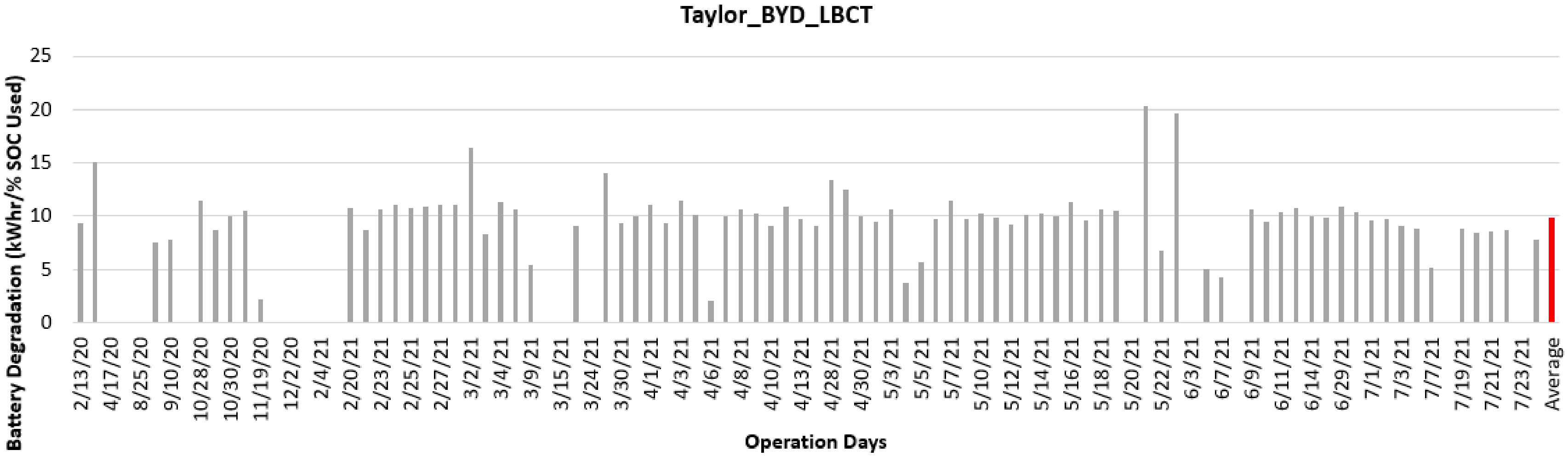


Figure 71. Battery degradation of the LBCT top handler.

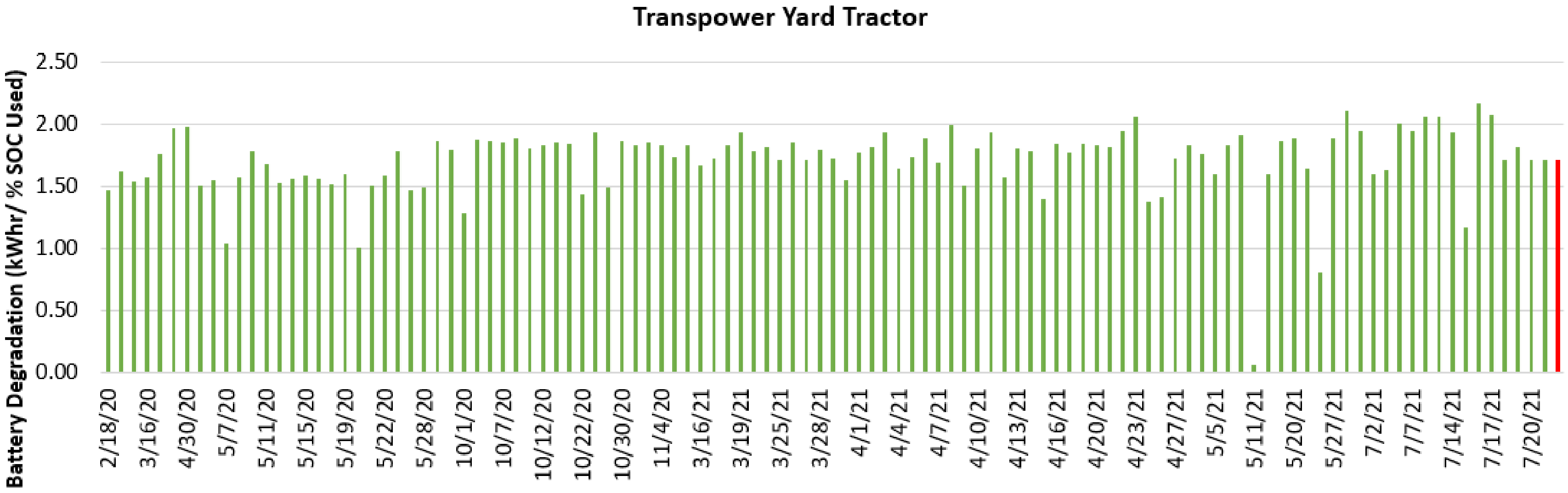


Figure 72. Battery Degradation of the TransPower yard tractor.

4. Summary

The goal of this part of the demonstration project was to better understand the activity, performance, and emissions benefits of the advanced ZE technology equipment. As part of this project, activity data were obtained from four (4) pieces of zero-emissions equipment and two (2) baseline diesel equipment using PAMS data loggers. This included three (3) ZE battery-electric top handlers (Taylor/BYD Motors) [two (2) at Pier J SSA and one (1) at Pier E LBCT], and one (1) ZE battery-electric yard tractor (Kalmar/TransPower) at Pier E LBCT. Information was collected by the data loggers from the equipment CAN network, and the data was analyzed to characterize the activity patterns of the equipment, including hours of operation, days of operation per year, average miles traveled per day, and average value and distribution of speed and acceleration. Baseline emissions testing was also conducted on one diesel top handler at SSA, and one diesel yard truck at LBCT, which were compared to data from the advanced ZE units.

Top Handler Activity

For the battery electric top handlers, SSA top handler 80361 (#1) averaged 382 kWhr, 38% of SOC use, 67 kWhr/hr, 5.2 hours, 3 mph, and 18 miles, per day. SSA top handler 80368 (#2) averaged 301 kWhr, 43% of SOC use, 57 kWhr/hr, 4.7 hours, 2.5 mph, and 13 miles, per day. The LBCT top handler was less heavily used, and averaged 63 kWhr, 7% of SOC use, 28 kWhr/hr, 2.6 hours, 0.5 mph, and 1 mile, per day.

For the diesel top handlers, SSA diesel top handler 80290 (a) averaged 41% engine load, 31.1% engine torque, 5 hours, 1.6 mph, 7.4 miles, and used 29 gallons of fuel, per day. SSA diesel top handler 80361 (b) averaged 22% engine load, 22.8% engine torque, 4.8 hours, 1.4 mph, 8.5 miles, and used 21.7 gallons of fuel, per day.

The electric and diesel top handlers at SSA shared similar statistics over the course of the data logging period. Both types of top handlers were used on average about 5 hours per day. The diesel top handlers did utilize much more energy, on an energy equivalent basis, averaging 1093 and 818 kWhr on average per day (based on 29 and 21.7 gallons of fuel used per day), as opposed to the electric top handlers, which averaged 382, 301, and 63 kWhr of energy for the SSA top handlers (1) and (2) and the LBCT top handler, respectively. As one terminal, SSA, states the battery technology did not meet its two-shift required for tis duty cycle, it should be noted that the comparison to traditional diesel top handler operations are limited, as only a single diesel top handler was monitored for activity, as approved in the Baseline Emissions Test Plan. Additional information collected and analysis would need to be conducted to assess how representative the diesel top handler was of the overall diesel top handler fleet at the terminal to conduct a more comprehensive comparison of battery electric versus diesel top handler performance.

Yard Tractor Activity

The LBCT electric yard tractor averaged 95 kWhr, 56% of SOC use, 15 kWhr/hr, 6 hours, 8 mph, and 42 miles, per day. The LBCT diesel yard tractor averaged 28% engine load, 21.1% engine torque, 7 hours, 5.5 mph, 44 miles, and used 12 gallons of fuel, per day.

The electric yard tractor performed similarly to its diesel counterpart at LBCT. Both yard tractors traveled on average about 40 miles per day. The diesel yard tractor did average a higher operating time than the electric yard tractor, but both were able to perform over 12 hours of use during a single day. The diesel yard tractor did utilize much more energy, on an energy equivalent basis, averaging 510.8 kWhr on average per day (based on 13.6 gallons of fuel used per day), compared to the 95.1 kWhr of energy used per day by the electric yard tractor. As with the top handler analysis, it should be noted that this comparison is limited, as only a single diesel yard tractor was monitored for activity, as approved in the Baseline Emissions Test Plan.

Charging

Charging data was collected over the course of 120 days for the electric top handlers at SSA and 83 days for the electric equipment at LBCT. Regular charging at SSA showed that the top handlers received an average of 420 kWhr during a typical charging period that lasted on average about 7.5 hours. The electric yard tractor at LBCT received almost daily charging and occasionally charged multiple times a day. The LBCT top handler received charging approximately once a week.

Emissions Testing

PEMS testing was completed on a baseline diesel top handler at SSA and a diesel yard tractor at LBCT.

For the diesel top handler, the daily average NOx emissions for the diesel top handler were 22.9 g/mi, 2.87 g/bhp-hr, 57.6 g/gal., 355 g/hour, and 1803 g/day. The daily average PM emissions for the diesel top handler were 0.73 g/mi, 0.09 g/bhp-hr, 1.83 g/gal., 11.3 g/hour, and 57.3 mg/day.

For the diesel yard tractor, the daily average NOx emissions for the diesel yard tractor were 7.56 g/mi, 1.91 g/bhp-hr, 30.25 g/gal., 61.16 g/hour, and 1768.57 g/day. The daily average PM emissions for the diesel yard tractor were 0.015 mg/mi, 0.004 mg/bhp-hr, 0.061 mg/gal., 0.124 mg/hour, and 0.344 mg/day.

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Attachment A. List of Operational Parameters Requested for Transpower Yard Tractor

Name	
Tractor Weight (KG and lbs.)	Operation State SCM ()
Payload (KG and lbs.)	ESS Abs SOC ()
Vehicle Speed KMPH (KMPH and mph)	ESS Current (A)
Odometer (KM and miles)	ESS Max Cell V No ()
Accelerator Pedal Position (%)	ESS Min Cell V No ()
Charge Complete ()	ESS Voltage (V)
Parking Brake Applied ()	Voltage DC DC12V (V)
Brake Applied ()	Fifth Wheel Weight (lbs)
Charge Motor AC Current (A)	Shift Col Pos Cmd ()
Charge Motor AC Voltage (V)	Shift Col Pos Meas ()
Charging DC Current Limit (A)	Shifter Position RNDL ()
Total Shifts ()	Shift Current Gear ()
Max String Voltage (V)	Shift New Gear ()
Min String Voltage (V)	Shift Low Range Active ()
Max String Voltage ID ()	Shift High Range Active ()
Min String Voltage ID ()	Operation State PCM ()
Max Cell Volt String ID (ID)	Fault Level PCM ()
Min Cell Volt String ID (ID)	Shift Output Shaft Speed (RPM)
String ID ([0|0])	Shift Row Pos Cmd ()
String1_Current ([0|0])	Shift Row Pos Meas ()
String10_Current ([0|0])	Temp Cooling Pump1 (°C)
String9_Current ([0|0])	Temp Cooling Pump2 (°C)
String8_Current ([0|0])	Temp DC DC (°C)
String7_Current ([0|0])	Temp Lenze (°C)
String6_Current ([0|0])	Temp Power Electronics (°C)
String5_Current ([0|0])	Fault Level SCM ()
String4_Current ([0|0])	Traction Inverter Voltage (W and hp)
String3_Current ([0|0])	Traction Motor Power In (kW and hp)
String2_Current ([0|0])	Traction Motor Power Out (kW and hp)
Ceiling Drive Torque (%)	Traction Motor Speed (RPM)
State Radiator Fan ()	Traction Motor Temperature (°C)
State Hydraulic Pump ()	Traction Motor Torque (%)
State Heater ()	Power Air Comp Air Cond (KW and hp)
State Air Conditioner ()	Power Coolant Pump1 (W and hp)
State Air Compressor ()	Power Coolant Pump2 (W and hp)
Torque Req Pre Load (%)	Power Hydraulic Pump (KW and hp)
Torque Req Pedal (%)	Missed Shifts ()
Torque Req Traction Motor (%)	Stater Temp (°C)
Current DC DC12V (A)	

Attachment B. List of Operational Parameters Requested for Taylor-BYD Top Handler

Name	
Requested_Speed (rpm)	Lift_MC_Maximum_output_torque (N.M)
Requested_Torque (%)	Lift_MC_Real_Time_Torque (N.M)
Actual_Drive_Motor_Output_Percentage (%)	Lift_Motor_Speed (rpm)
Drive_Motor_Speed ()	Lift_MC_DC_Voltage (V)
Speed_of_Vehicle (mile/h)	Lift_Motor_Temperature (Celsius)
Lift_Motor_Speed ()	Lift_MC_Radiator_Temperature (°C)
Lift_Motor_Torque ()	Lift_MC_Voltage_Status ()
Steering_Motor_Speed ()	Steer_MC_Maximum_output_torque (N.M)
Steering_Motor_Torque ()	Steer_MC_Real_Time_Torque (N.M)
Maximum_Allowed_Discharging_Power (kw)	Steer_Motor_Speed (rpm)
Maximum_Allowed_Charging_Power (kw)	Steer_MC_DC_Voltage (V)
The_third_decimal_of_SOC (%)	Steer_Motor_Temperature (Celsius)
Low_Battery_SOC_determination ()	Steer_MC_Radiator_Temperature (°C)
Instant_Power (kwh/100km)	Steer_MC_Voltage_Status ()
Mileage (km)	Drive_Motor_Torque (N.M)
Request_to_Detect_Normal_Leakage_Signal ()	Real_Time_Motor_output_Torque (%)
Total_Voltage_of_Current_Battery_Package (V)	Lift_Motor_Speed_Command (%)
Total_current_of_Current_Battery_Package (A)	Steer_Motor_Speed_Command (%)
Battery_Health_Index (%)	Battery_Pack_Leakage_Status ()
SOC (%)	Battery_Pack_Temperature_Status ()
Current_Contactor_Control_Flow_Status ()	Battery_Pack_Discharging_Status ()
Drive_battery_Real_time_Discharging_Power (kw)	Battery_Pack_Charging_Status ()
Drive_battery_Real_time_Charging_Power (kw)	SOC_Status ()
Feedback_of_Total_Capacity (kwh)	BMS_Working_Status ()
Times_of_Charge ()	BMS_Discharging_Permission ()
SOC_Left (kwh)	Drive_Precharge_Status ()
Charging_System_Error_Status ()	Drive_Precharge_Contactor_Status ()
Charging_System_Error_Status ()	Steering_Precharging_Contactor_ ()
Water_Pump_Controler_Percentage ()	Steering_Precharging_Status ()
Coolant_Temp (Celsius)	Drive_Contactor_Controller_Statu ()
DC_DC1_DC_Voltage (V)	Steering_Contactor_Control_Statu ()
DC_DC2_DC_Voltage (V)	DC_Precharging_Status ()
Drive_MC_Maximum_output_torque (N.M)	Drive_MC_Voltage_Status ()
Drive_MC_Real_Time_Torque (N.M)	
Drive_MC_IGBT_Temperature (°C)	
Drive_Motor_Speed (rpm)	
Drive_MC_DC_Voltage (V)	
Drive_Motor_Temperature (°C)	
Drive_MC_Radiator_Temperature (°C)	

C-PORT Final Report

Appendix H: General Outreach Report

Port of
LONG BEACH
THE PORT OF CHOICE

The Commercialization of POLB Off-Road Technology Demonstration

C-PORT

General Outreach Report

August 2021

Overview: As part of the Commercialization of the Port of Long BeachOff-Road Technology Project (C-PORT), the Port committed to prepare a *General Outreach Plan* (August 2018) and *General Outreach Plan,* to educate and inform target stakeholders about the benefits and innovations of the project. Note, DAC specific efforts, led by Green Education, Inc., were reported in the *Final Report: DAC Outreach* (January 2020).

Targeted Stakeholders:

- General public
- Residents surrounding the Port
- Port tenants
- Local and state elected officials
- Students and Instructors at LBCC, LBUSD and CITT
- Other interested stakeholders

Objective:

Objectives were outlined in the *General Outreach Plan* (August 2018) and include:

- Publish information on the Port of Long Beach Website
- Conduct high-profile ribbon cutting ceremony at the beginning of the demonstration period, inviting targeted stakeholders.
- News stories and Pres release by the Port and other stakeholders.
- Discuss the project in the Port's "Let's Talk Port" and other community forums.
- Collaborate with Long Beach Unified School District (LBUSD) and Center for International Trade and Technology (CITT) for curriculum, including a cap stone project and Port tours for POLB's Academy of Global Logistics, in partnership with Cabrillo High School.

Attachments include

A: C-PORT Zero-Emissions Demonstration Project Fact Sheet (Original)
B: Clean Air Day Ribbon Cutting Event Photographs and Invite
C: Press Releases and Selection of News Articles
D: State of Port, Port 101 and "Let's Talk Port" Templates

E: AGL Brochure, Photographs, Press Release, Award Agenda and Selection of News Articles
F: Green Education Inc. Community Presentation

General Outreach Report

Attachment A

Fact Sheet

C-PORT Zero-Emissions Demonstration Project

Port of
LONG BEACH
The Green Port

Purpose

The Port of Long Beach, in partnership with SSA Marine and Long Beach Container Terminal, will demonstrate five zero-emissions cargo handling vehicles. The demonstration will include three never-before-tested battery-electric top handlers and feature a unique, head-to-head comparison of a hydrogen fuel cell yard truck versus a battery-electric yard truck.

The Port has approved the Clean Air Action Plan that sets goals for the transition to zero-emissions terminal equipment, in an effort to further reduce the Port's impact on the environment and neighboring communities. This project will help test the performance of clean technologies that could play a role in meeting the zero-emissions goals.

The California Air Resources Board awarded a $5.3 million grant to fund the demonstration, known as the Commercialization of POLB Off-Road Technology Demonstration, or C-PORT.

The Project's zero-emissions equipment will reduce greenhouse gases, smog, diesel particulates and toxic air emissions, particularly benefiting disadvantaged communities surrounding the Port. The C-PORT Demonstration will begin with equipment being deployed in 2019 and is expected to be completed by 2020.

Project Component

- Demonstrate two battery-electric top handlers for SSA Marine at Pier J
- Demonstrate one fuel cell yard tractor, one battery-electric top handler and one battery-electric yard tractor for Long Beach Container Terminal at Pier E

Partners

Academy of Global Logistics

Air Products

BYD

California Air Resources Board

CNHTC/Sinotruk UQM

Grant Farm

Green Education, Inc.

International Longshore and Warehouse Union

Kalmar Transpower

Long Beach Container Terminal

Loop Energy

South Coast Air Quality Management District

SSA Marine

Taylor Machine Works

Tetra Tech

Contact

For more information, contact Environmental Specialist Rose Siengsubcharti at 562-283-7100 or ***rose.sieng@polb.com.***

General Outreach Report

Attachment B

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

What can I do to clean the air?

PLANT SOMETHING

- Plant a home garden
- Plant a tree
- Plant an indoor plant in your office and/or home

REDUCE VEHICLE EMISSIONS

Leave your car at home by:

- Telecommuting
- Walking, biking or riding a scooter to work/school
- Taking public transit
- Carpooling
- Attending meetings remotely
- Bringing a lunch to work or walking to lunch

- Don't idle your engine
- Switch from an old gas-guzzler car to a hybrid or zero-emission vehicle
- Take a carpool when ride hailing

SWITCH IT OUT

- Change your home air filter
- Change your car cabin air filter
- Replace gas-powered yard tools with electric- or hand-powered tools
- Switch to using natural all-purpose cleaner only
- Make all online purchases in one order each week

Port of LONG BEACH The Green Port

CITY OF LONG BEACH

Clean Air Day Ribbon Cutting Ceremony

Clean Air Day Ribbon Cutting Ceremony

Take the pledge for a chance to win an Air Purifier!

Coverage Area: 1100 SqFt

Removes 99% of particles greater than 0.3 microns

Energy Star Certified: 105 watts on highest speed

HEPA-pure filter life: 8-9 months

Winner will be notified via email.

Cleanairday.org

CITY OF LONG BEACH

JOIN US !

California Clean Air Day
in Downtown Long Beach

Wednesday, Oct. 2 | 4 to 5 p.m.
Long Beach Civic Center Plaza
411-415 W. Ocean Blvd., Long Beach, CA 90802

The Port of Long Beach is celebrating California Clean Air Day, and you're invited to join us in kicking off a new milestone in zero-emissions technology and cleaner air!

Come see the zero-emissions yard trucks and other human-operated cargo-handling equipment that will be on display to the public at the new Long Beach Civic Center Plaza. The clean equipment was purchased through a $5.3 million grant from the California Air Resources Board as part of ongoing clean air technology demonstrations in partnership with labor, marine terminal operators and regulatory agencies. Soon, the equipment will be operated by International Longshore and Warehouse Union members to move cargo at the SSA Marine Pacific Container Terminal and at Long Beach Container Terminal in the Port of Long Beach.

Please respond by Friday, Sept. 27, 2019 to *www.polb.com/cleanairdayrsvp*
For questions contact: Veronica Quezada at (562) 283-7722
or *veronica.quezada@polb.coom*

#CACleanAirDay @CleanAirDay @LongBeachCity
@LBSustainability @PortofLongBeach

Port of LONG BEACH *The Green Port*
CALIFORNIA CLIMATE INVESTMENTS Cap and Trade Dollars at Work
Long Beach Container Terminal
SSATerminals A Matson and Carrix Collaboration
TAYLOR
KALMAR
TransPower
BYD
中国重汽 SINOTRUK CNHTC
Green Education, Inc.
AIR PRODUCTS
LONG BEACH CITY COLLEGE
TETRA TECH
long beach unified school district
ILWU International Longshore and Warehouse Union An Injury To One Is An Injury To All
CALIFORNIA AIR RESOURCES BOARD
South Coast AQMD

The Commercialization of POLB Off-Road Technology Demonstration, or C-PORT is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment — particularly in disadvantaged communities.

General Outreach Report

Attachment C

Port of Long Beach
The Green Port

News Release

Port Receives Zero-Emissions Equipment Grant

Cap-and-trade funds electric vehicle demonstration

July 10, 2018

As part of its commitment to transition to zero-emissions operations, the Port of Long Beach will use a $5.3 million grant from the California Air Resources Board (CARB) to deploy hydrogen- and electric-powered cargo-handling equipment at two shipping terminals.

The funds for the Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT) leverage Long Beach's place as the nation's second-busiest seaport to test the viability of zero-emissions vehicles that are used on the docks. The demonstration project is part of [California Climate Investments](), a statewide initiative that puts billions of cap-and-trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment — particularly in disadvantaged communities.

The demonstration will include three cargo-moving vehicles known as "top handlers" with never-before-tested battery-electric systems. The project will also feature a unique, head-to-head comparison of hydrogen fuel cell vs. battery-electric technology in yard trucks. In total, five vehicles will be demonstrated: two battery-electric top handlers at SSA Marine's Pacific Container Terminal at Pier J; and one fuel cell yard tractor, one battery-electric top handler and one battery-electric yard tractor at Long Beach Container Terminal at Pier E.

"The progress we've made in reducing pollution is a model for seaports everywhere, with diesel emissions alone down almost 90 percent since we adopted the Clean Air Action Plan in 2005," said Harbor Commission President Lou Anne Bynum. "Still, we are not satisfied. This equipment will further contribute to a cleaner environment for our neighboring communities."

"Our partnerships with the California Air Resources Board and other agencies provide crucial funding for these vital demonstration projects as we work to create a zero-emissions seaport," said Mario Cordero, Port of Long Beach Executive Director.

The equipment is expected to be put into use to begin the demonstration next year. As part of the project, information about the demonstration will also be integrated into the coursework at the Port-sponsored Academy of Global Logistics at Cabrillo High School to support education and workforce development for new port technologies.

The Port of Long Beach is one of the world's premier seaports, a gateway for trans-Pacific trade and a trailblazer in goods movement and environmental stewardship. With 175 shipping lines connecting Long Beach to 217 seaports, the Port handles $180 billion in trade annually, (office), (562) 519-2177 (cell), lee.peterson@polb.com.

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Port of LONG BEACH The Green Port

News Release

Zero-Emissions Equipment Deployed to Port Terminals

CARB Grant Helped Fund C-PORT Demonstration Project

Oct. 3, 2019

In recognition of California Clean Air Day, the Port of Long Beach on Wednesday announced the demonstration of hydrogen- and electric-powered cargo handling equipment at two shipping terminals, in pursuit of its goal to become the world's first zero-emissions seaport.

The new equipment was purchased through a $5.3 million grant from the California Air Resources Board as part of the "C-PORT," or Commercialization of POLB Off-Road Technology Project. The Port has several ongoing clean-air technology demonstrations in partnership with labor, marine terminal operators and regulatory agencies.

The CARB grant falls under the umbrella of California Climate Investments, a statewide initiative that puts billions of cap-and-trade dollars to work by reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment – particularly in disadvantaged communities similar to those adjacent to the Port.

"Today, you see some of the equipment with the potential to take us to the next level – zero emissions," said Long Beach Harbor Commission President Bonnie Lowenthal. "The equipment, which will be operated by our longshore partners at the Port, will help us reduce our impact on our neighborhoods and contribute to the Port's ability to increase trade."

Five vehicles will be demonstrated as part of C-PORT: two battery-electric top handlers at SSA Marine's Pacific Container Terminal at Pier J; and one fuel cell yard tractor, one battery-electric top handler and one battery-electric yard tractor at Long Beach Container Terminal at Pier E.

As part of the project, information about the demonstration was recently integrated into the coursework at the Port-sponsored Academy of Global Logistics at Cabrillo High School to support education and workforce development for new port technologies.

"Projects like these are designed to take us down the road to being the world's first zero-emissions seaport," said Port of Long Beach Executive Director Mario Cordero. "We have our labor partners of the ILWU, our terminal operators SSA and LBCT, and our regulatory agencies all working together to find the right technologies to reach our zero-emissions goals. With teamwork and cooperation like that, I think we can look forward to many more innovative projects to demonstrate new technologies."

The Port of Long Beach is one of the world's premier seaports, a gateway for trans-Pacific trade and trailblazer in goods movement and environmental stewardship. With 175 shipping lines connecting Long Beach to 217 seaports, the Port handles $200 billion in trade annually, supporting 575,000 Southern California jobs.

Media Contact: Lee Peterson, Port of Long Beach Media Relations Manager, (562) 283-7715 (office), (562) 519-2177 (cell), lee.peterson@polb.com.

Caption: A battery-powered yard truck manufactured by Kalmar is among five pieces of zero-emissions cargo handling equipment that will be demonstrated at two shipping terminals at the Port of Long Beach. The new equipment was purchased through a $5.3 million grant from the California Air Resources Board as part of the "C-PORT," or Commercialization of POLB Off-Road Technology Project.

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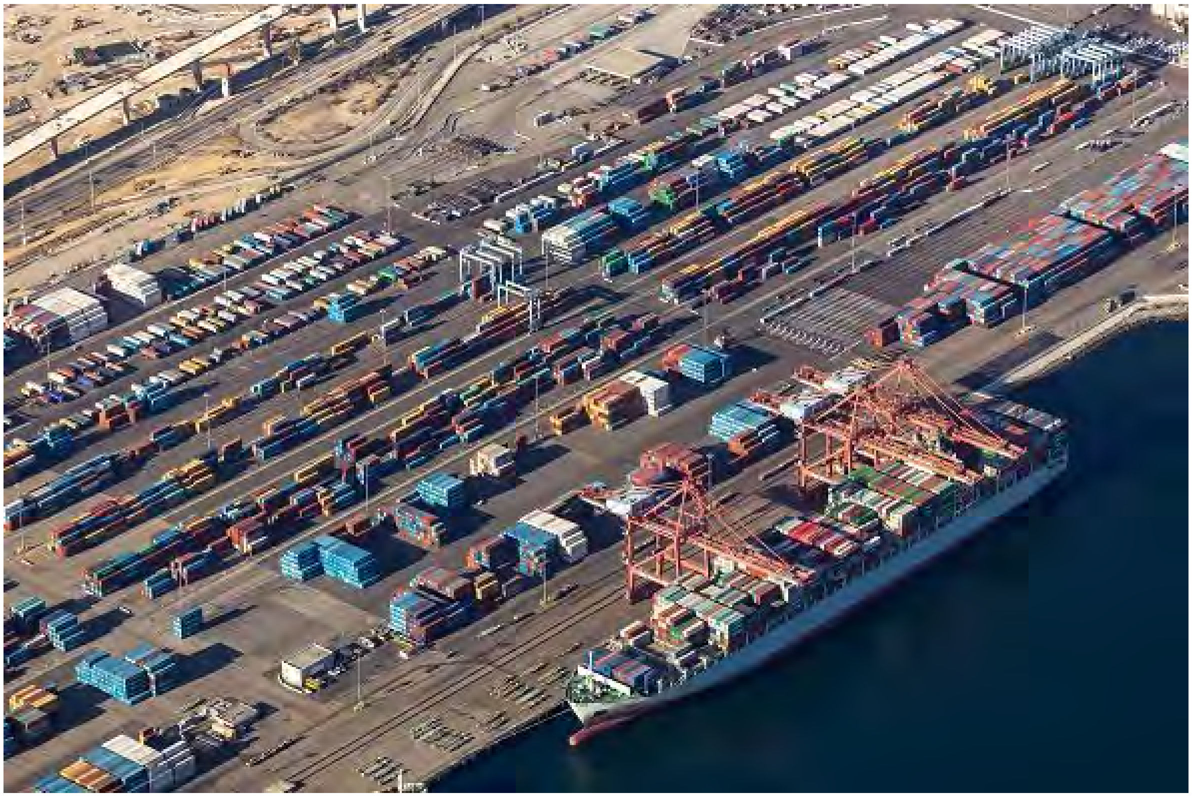
Port of Long Beach to Test Zero-Emissions Equipment

porttechnology.org/news/port_of_long_beach_to_test_zero_emissions_equipment

12 Jul 2018 02.31pm



The Port of Long Beach will deploy hydrogen- and electric-powered vehicles after receiving a $5.3 million grant from the California Air Forces Board (CARB). Two terminals at North America's second-busiest seaport are to test the viability of zero-emissions vehicles.

The Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT), which is carrying out the tests, is part of California Climate Investments.

The statewide initiative is seeking to reduce greenhouse gas (GHG) emissions, as well as strengthen the economy and improve public health.

Daniel Mahr discusses how renewable energy might be used to handle bulk in a recent Port Technology technical paper

In total, five vehicles will be used at the port, including three battery-electric top handlers, one fuel cell yard tractor, and one battery-electric yard tractor.

As part of its commitment to make its operations emissions-free, the Port of Long Beach will start using the vehicles in 2019.

Harbour Commission President Lou Anne Bynum commented: “The progress we’ve made in reducing pollution is a model for seaports everywhere, with diesel emissions alone down almost 90% since we adopted the Clean Air Action Plan in 2005.”

Mario Cordero, Port of Long Beach Executive Director, said: “Our partnerships with the California Air Resources Board, and other agencies, provide crucial funding for these vital demonstration projects as we work to create a zero-emissions seaport.”

Read more:

- **The ports of Long Beach and Los Angeles have approved new measures to ensure clean engine standards for drayage trucks**
- **The International Chamber of Shipping (ICS) has released a new publication to support the global shipping industry in phasing out CO2 emissions**

Container Handling, Environment , Ports

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Related News

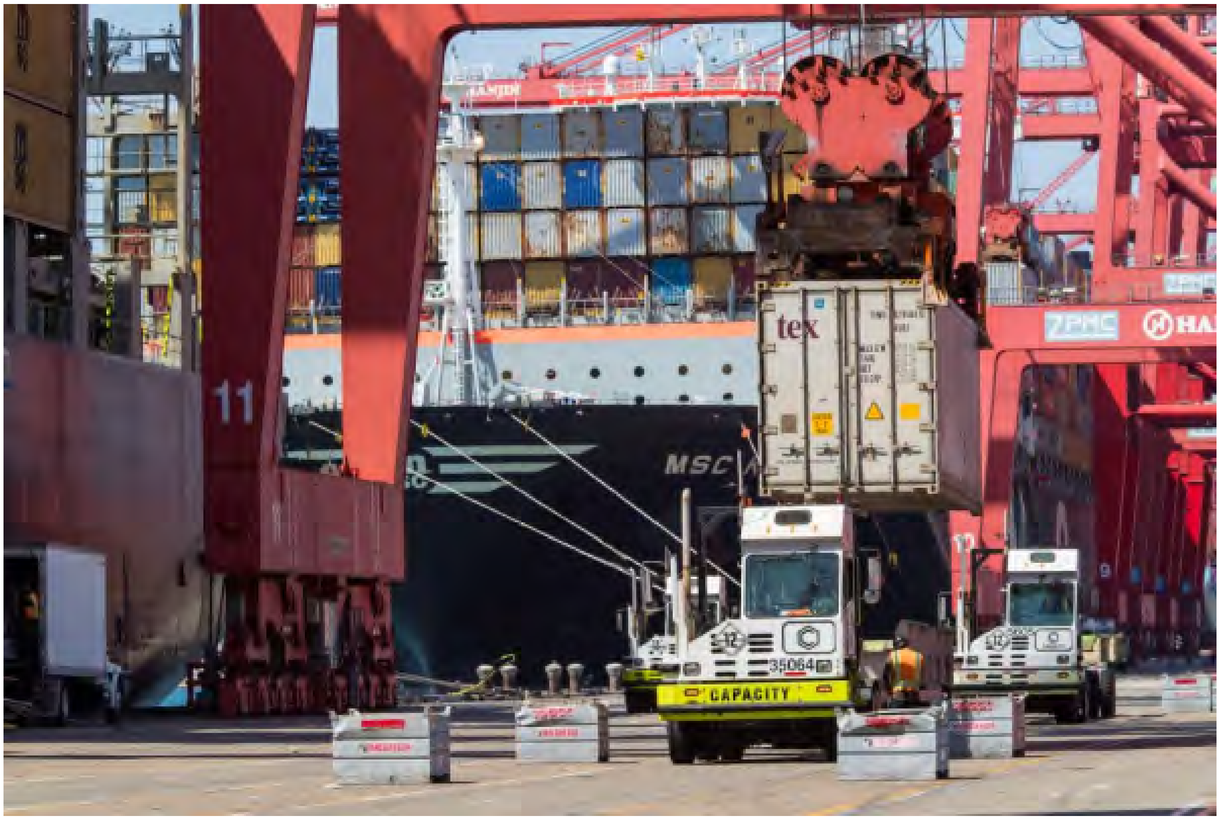
Port of Long Beach receives zero-emissions equipment grant

ajot.com/news/port-of-long-beach-receives-zero-emissions-equipment-grant

By AJOT

Cap-and-trade funds electric vehicle demonstration

As part of its commitment to transition to zero-emissions operations, the Port of Long Beach will use a $5.3 million grant from the California Air Resources Board (CARB) to deploy hydrogen- and electric-powered cargo-handling equipment at two shipping terminals.



California Climate Investments logoThe funds for the Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT) leverage Long Beach's place as the nation's second-busiest seaport to test the viability of zero-emissions vehicles that are used on the docks. The demonstration project is part of California Climate Investments, a statewide initiative that puts billions of cap-and-trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment — particularly in disadvantaged communities.

The demonstration will include three cargo-moving vehicles known as "top handlers" with never-before-tested battery-electric systems. The project will also feature a unique, head-to-head comparison of hydrogen fuel cell vs. battery-electric technology in yard trucks. In total, five vehicles will be demonstrated: two battery-electric top handlers at SSA Marine's Pacific Container Terminal at Pier J; and one fuel cell yard tractor, one battery-electric top handler and one battery-electric yard tractor at Long Beach Container Terminal at Pier E.

“The progress we’ve made in reducing pollution is a model for seaports everywhere, with diesel emissions alone down almost 90 percent since we adopted the Clean Air Action Plan in 2005,” said Harbor Commission President Lou Anne Bynum. “Still, we are not satisfied. This equipment will further contribute to a cleaner environment for our neighboring communities.”

“Our partnerships with the California Air Resources Board and other agencies provide crucial funding for these vital demonstration projects as we work to create a zero-emissions seaport,” said Mario Cordero, Port of Long Beach Executive Director.

The equipment is expected to be put into use to begin the demonstration next year. As part of the project, information about the demonstration will also be integrated into the coursework at the Port-sponsored Academy of Global Logistics at Cabrillo High School to support education and workforce development for new port technologies.

The Port of Long Beach is one of the world’s premier seaports, a gateway for trans-Pacific trade and a trailblazer in goods movement and environmental stewardship. With 175 shipping lines connecting Long Beach to 217 seaports, the Port handles $180 billion in trade annually, supporting hundreds of thousands of Southern California jobs.

Long Beach Port Receives Zero-Emissions Equipment Grant

hellenicshippingnews.com/long-beach-port-receives-zero-emissions-equipment-grant

As part of its commitment to transition to zero-emissions operations, the Port of Long Beach will use a $5.3 million grant from the California Air Resources Board (CARB) to deploy hydrogen- and electric-powered cargo-handling equipment at two shipping terminals.

The funds for the Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT) leverage Long Beach's place as the nation's second-busiest seaport to test the viability of zero-emissions vehicles that are used on the docks. The demonstration project is part of California Climate Investments, a statewide initiative that puts billions of cap-and-trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment — particularly in disadvantaged communities.

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The equipment is expected to be put into use to begin the demonstration next year. As part of the project, information about the demonstration will also be integrated into the coursework at the Port-sponsored Academy of Global Logistics at Cabrillo High School to support education and workforce development for new port technologies.
Source: Port of Long Beach

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“Our partnerships with the California Air Resources Board and other agencies provide crucial funding for these vital demonstration projects as we work to create a zero-emissions seaport,” said Mario Cordero, Port of Long Beach Executive Director.

The equipment is expected to be put into use to begin the demonstration next year. As part of the project, information about the demonstration will also be integrated into the coursework at the Port-sponsored Academy of Global Logistics at Cabrillo High School to support education and workforce development for new port technologies.
Source: Port of Long Beach

Port of Long Beach receives grant to deploy zero-emissions equipment

ship-technology.com/news/port-long-beach-receives-grant-deploy-zero-emissions-equipment

July 11, 2018

The Port of Long Beach in the US has received grant funding from California Air Resources Board (CARB) to install hydrogen and electric-powered cargo-handling equipment at two of its shipping terminals.

The $5.3m grant is part of the Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT) and will see the port test the feasibility of zero-emissions equipment that can be used for docking activities.

The test will be conducted under the California Climate Investments programme, a statewide initiative that aims to reduce greenhouse gas emissions, as well as strengthen the economy and improve public health and environment, particularly in deprived communities.

Scheduled to begin next year, the test will also provide input for the port's Academy of Global Logistics at Cabrillo High School to support education and workforce development for new port technologies.

Port of Long Beach Harbor Commission president Lou Anne Bynum said: "The progress we've made in reducing pollution is a model for seaports everywhere, with diesel emissions alone down almost 90% since we adopted the Clean Air Action Plan in 2005.

"This equipment will further contribute to a cleaner environment for our neighbouring communities."
"Still, we are not satisfied. This equipment will further contribute to a cleaner environment for our neighbouring communities."

The proposed test will comprise three cargo-moving vehicles called 'top handlers' with never-before-tested battery-electric systems, as well as two-yard trucks.

Two of the three handlers will be tested at SSA Marine's Pacific Container Terminal at Pier J, while the other one will be trialled at Long Beach Container Terminal at Pier E.

A comparison will also be made between hydrogen fuel cell and battery-electric technology in yard trucks as part of the project.

One of the two-yard trucks will be powered by fuel cell and the other will run on battery-electric. Both the trucks will be tested at Long Beach Container Terminal at Pier E.

RFF **refrigeratedfrozenfood.com**/articles/95198-port-of-long-beach-receives-zero-emissions-equipment-grant

REFRIGERATED & FROZEN FOODS

Home » Port of Long Beach receives zero-emissions equipment grant
Energy ManagementSupply Chain & LogisticsSupplier News

Port of Long Beach receives zero-emissions equipment grant

The demonstration will include three cargo-moving vehicles known as "top handlers" with never-before-tested battery-electric systems.

July 10, 2018

Reprints
No Comments

As part of its commitment to transition to zero-emissions operations, the Port of Long Beach, Long Beach, Calif., will use a $5.3 million grant from the California Air Resources Board (CARB), Sacramento, Calif., to deploy hydrogen- and electric-powered cargo handling equipment at two shipping terminals.

The funds for the Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT) leverage the Port of Long Beach as what will be dubbed the nation's second-busiest seaport to test the viability of zero-emissions vehicles used on the docks. The demonstration project is part of California Climate Investments, a statewide initiative designed to reduce greenhouse gas emissions, strengthen the economy and improve public health and the environment — particularly in disadvantaged communities.

The demonstration will include three cargo-moving vehicles known as "top handlers" with never-before-tested battery-electric systems. The project will also feature a unique, head-to-head comparison of hydrogen fuel cell vs. battery-electric technology in yard trucks. In total, five vehicles will be demonstrated—two battery-electric top handlers at SSA Marine's Pacific Container Terminal at Pier J; and one fuel cell yard tractor, one battery-electric top handler and one battery-electric yard tractor at Long Beach Container Terminal at Pier E.

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"Our partnerships with the California Air Resources Board and other agencies provide crucial funding for these vital demonstration projects as we work to create a zero-emissions seaport," says Mario Cordero, executive director of Port of Long Beach.

The equipment is expected to begin the demonstration next year. As part of the project, information about the demonstration will also be integrated into the coursework at the Port-sponsored Academy of Global Logistics at Cabrillo High School, Long Beach, Calif., to support education and workforce development for new port technologies.

Refrigerated & Frozen Foods Magazine

2018 July

Check out the July edition of Refrigerated and Frozen Foods: State of the Industry 2018 and much more!

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General Outreach Report

Attachment D

ZERO-EMISSIONS RIBBON CUTTING

HUMAN-OPERATED ZERO-EMISSIONS VEHICLES

FUNDING PROVIDED BY THE
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ENERGY
COMMISSION

CALIFORNIA
AIR RESOURCES BOARD

CALIFORNIA CLIMATE INVESTMENTS
Cap and Trade
Dollars at Work

EPA
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SOUTHERN CALIFORNIA
EDISON
Energy for What's Ahead

South Coast
AQMD

US Hybrid

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STAYING A STEP AHEAD
& Leaving Small Footprints

SHIPPERS
TRANSPORT

LONG BEACH
CITY COLLEGE

long
beach
unified
school
district

ILWU
International Longshore and Warehouse Union
An Injury To One Is An Injury To All

GREATER LOS ANGELES
LOCAL UNION NUMBER ELEVEN

IBEW LOCAL 11

Green Education, Inc.

HUMAN-OPERATED ZERO-EMISSIONS VEHICLES

HUMAN-OPERATED ZERO-EMISSIONS VEHICLES

General Outreach Report

Attachment E

ACADEMY MISSION:

The Port of Long Beach Academy of Global Logistics at Cabrillo High School seeks to develop business-educated students prepared for the challenges of global logistics, supply chain management and international trade through hands-on experiences and academic learning.

ACADEMY VISION:

Going places in the world of business through global trade and logistics.

LINKED LEARNING/PATHWAY COURSE OF STUDY:

The POLB Academy of Global Logistics at Cabrillo is committed to providing students with a rigorous academic program incorporating the A-G requirements with a technical focus on careers in the fields of global logistics and supply chain management. Students in the Academy of Global Logistics may also take honors and accelerated courses throughout their four-years at Cabrillo.

Along with general academic courses, students will complete the following technical course of study focused on global logistics:

9th grade – Technology for Global Business

10th grade – Global Logistics

11th grade – Accounting and International Finance

12th grade – Supply Chain Management Principles

Optional electives:

- AP Human Geography
- AP Seminar
- AP Research
- Finite Math
- Pre-Calculus or AP Calculus
- AP Statistics

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Port of
LONG BEACH
The Green Port

long beach unified school district

California State University Long Beach
CITT
Center for International Trade and Transportation

LINKED LEARNING

Port of
LONG BEACH

Academy of Global Logistics

at Cabrillo High School

Academy Overview

"Developing Employees of the Future"

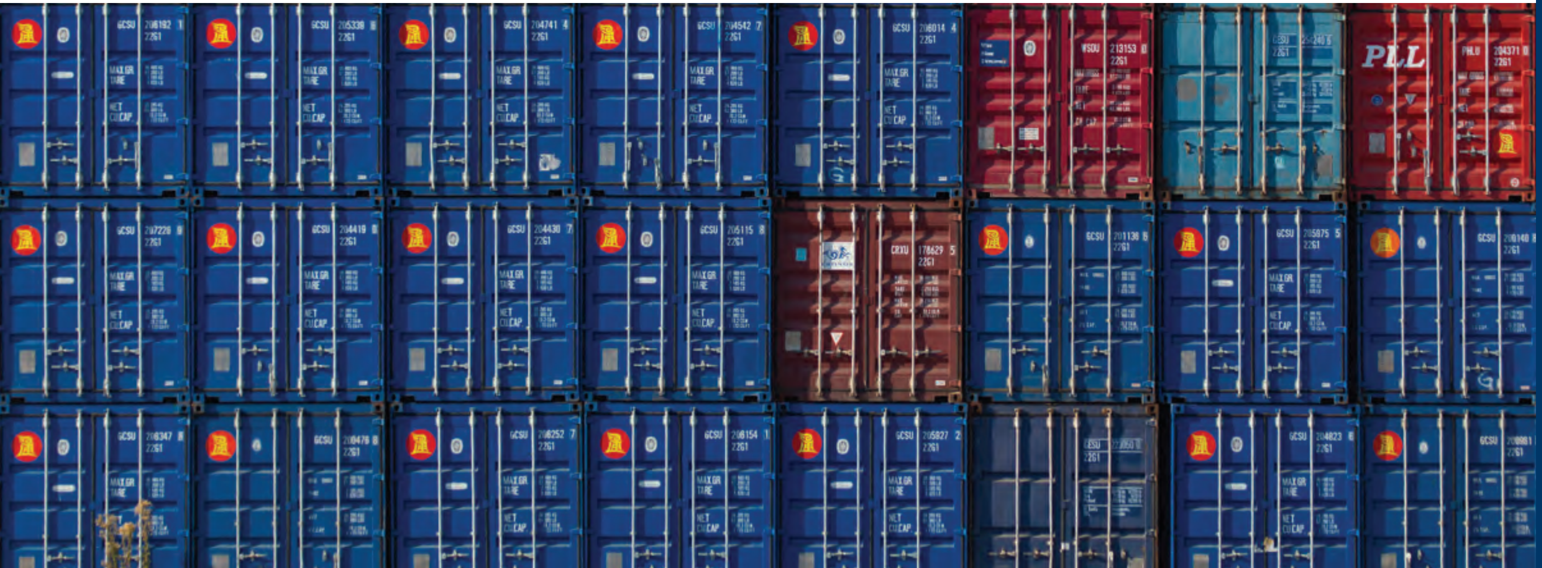
The Port of Long Beach Academy of Global Logistics (AGL) combines academic curriculum with industry-relevant training and information to support academic and career development. The Academy builds on the Long Beach College Promise by introducing high school students to career opportunities in global trade and logistics and showing them how to prepare for those careers through a wide range of training and education programs including certificates, certifications, and degrees offered by Long Beach City College and California State University, Long Beach. The goals are to:

EXCITE – Create excitement around international trade, logistics and supply chain management by bringing real world experiences to the classroom.

ENGAGE – Engage parents, students, teachers and administrators, industry partners, and the community in events to develop a support system for student success.

EMPOWER – Empower students with the knowledge and skills for entry-level career opportunities and/or to pursue higher education either at a community college or four-year university.

The Port of Long Beach is one of the world's premier seaports, a gateway for trans-Pacific trade and a trailblazer in goods movement and environmental stewardship. With 175 shipping lines connecting Long Beach to 217 seaports, the Port handles $194 billion in trade annually, supporting hundreds of thousands of Southern California jobs.



Academy of Global Logistics Outline

9TH GRADE
INTRODUCTION TO THE INDUSTRY

- Overview to the Port of Long Beach
- Introduction to supply chain and operations
- Water tour of the Port of Long Beach
- World Trade Month career exploration workshops
- Career planning and portfolio development

10TH GRADE
CAREER PREPARATION

- Industry Presentations and/or tours of transportation and distribution facilities
- Industry presentations related to trucking, rail and maritime operations
- Career planning and portfolio development

11TH GRADE
NETWORKING/ACADEMIC AND CAREER PLANNING

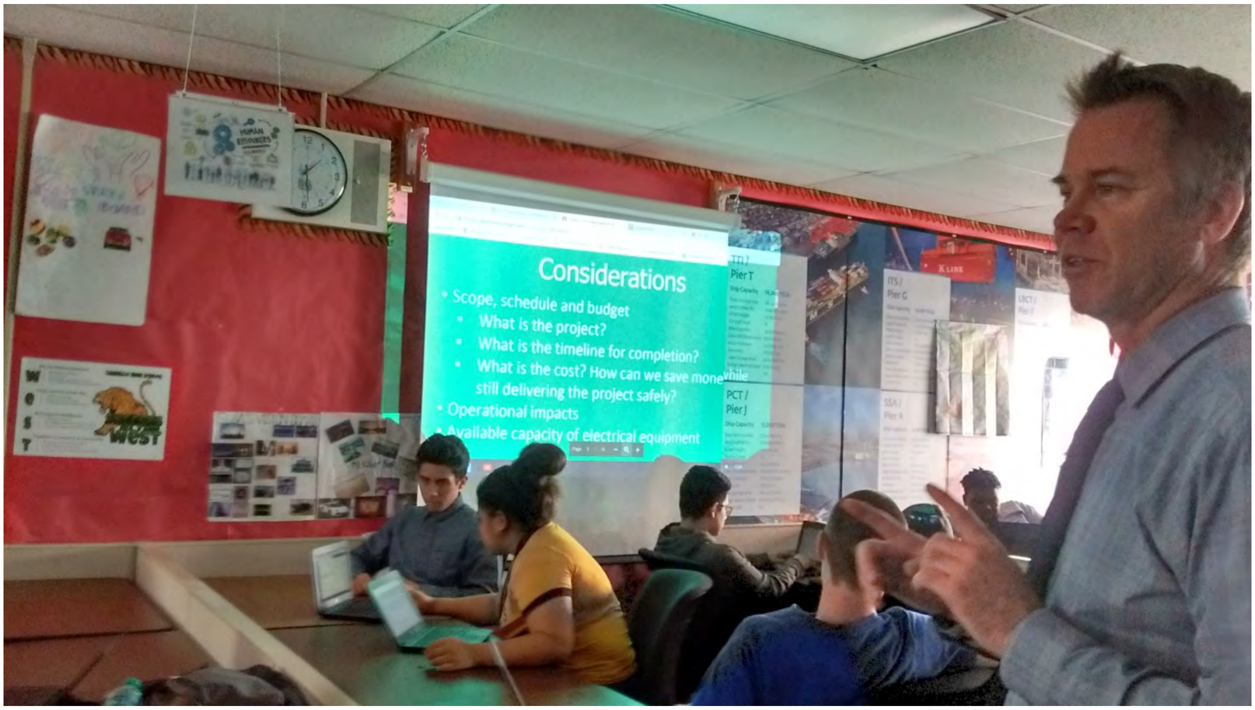
- Overview of technology and environmental programs
- Law enforcement and security measures to protect Port Operations
- Introduction to the Academy Ambassadors Program
- Attend industry events and networking opportunities
- Attend education and career related events at LBCC and CSULB
- Resume building and interview preparation
- Career workshop and mock interviews
- Job shadowing and summer internships*
- Career planning and portfolio development

12TH GRADE
HIGH SCHOOL TO CAREER TRANSITION

- Academy final project presentations
- Port and industry scholarship opportunities
- Attend industry events and networking opportunities
- Job shadowing and summer internships*
- Career planning and portfolio development
- Global Logistics Bootcamp at the Port of Long Beach Maritime Center of Excellence at Long Beach City College*

*Based on availability and student qualifications.

AGL and Student Presenters



AGL and Student Presenters

AGL and Student Presenters

News Details

Air District Honors Port's Innovative Education Program

Students studied development of clean technology for goods movement

October 7, 2019

The Port of Long Beach collected a prestigious Clean Air Award on Friday for an education outreach program that connected local high school students to a project developing non-polluting, zero-emissions cargo-moving technology on the docks.

Port of Long Beach staff and Academy of Global Logistics at Cabrillo High School students show off the Port's Clean Air Award at the South Coast Air Quality Management District's 31st annual Clean Air Awards on Oct. 4. The Port received SCAQMD's Clean Air Education Outreach award for a learning program connecting high school students to efforts to convert to zero-emission operations.The South Coast Air Quality Management District's Clean Air Education Outreach award for the Port and the Academy of Global Logistics at Cabrillo High School was presented Friday at the SCAQMD's 31st annual Clean Air Awards luncheon at the Grand Hotel in Los Angeles.

Sixty high school students at the West Long Beach campus worked with industry experts and learned about cargo operations at the nation's second-busiest seaport for their "Zero-Emissions Transformation Capstone Project." The students studied the real-world issues of"C-PORT" — the Commercialization of POLB Off-Road Technology project, a demonstration of the use of zero-emissions cargo-handling equipment at two terminals in Long Beach. C-PORT is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment — particularly in disadvantaged communities.

“Connecting our Academy of Global Logistics students together with our work on zero-emissions technology was so gratifying. I’m doubly pleased to see the students and the Port recognized for this groundbreaking collaboration,” said Long Beach Harbor Commission President Bonnie Lowenthal. “Our education outreach programs aim to show our local students the universe of career opportunities in international trade and goods movement, and I think we’ve definitely hit the mark here.”

“I’d like to thank our partners in the California Air Resources Board, labor, the marine terminals, educators and the students, who all share in this recognition,” said Port of Long Beach Executive Director Mario Cordero. “I hope that these students and many more like them will join us as we continue to build the green port of the future.”

CALIFORNIA CLIMATE INVESTMENTS
Cap and Trade
Dollars at Work

The SCAQMD’s Clean Air Education Outreach Award is for outstanding individual or group effort designed to educate the public on air quality issues, promote efforts to improve air quality, or both.

Established in 2016 in partnership with the Long Beach Unified School District, the Academy of Global Logistics at Cabrillo High School is part of the Port of Long Beach’s comprehensive education outreach programs that nurture future industry leaders and experts. About 670 students so far have participated in the four-year Academy program, which combines academic curriculum with industry-relevant training to support educational and career development.

Photo caption: Port of Long Beach staff and Academy of Global Logistics at Cabrillo High School students show off the Port’s Clean Air Award at the South Coast Air Quality Management District's 31st annual Clean Air Awards on Oct. 4. The Port received SCAQMD's Clean Air Education Outreach award for a learning program connecting high school students to efforts to convert to zero-emission operations.

Biz Briefs: Air District Honors Port's Education Program With Clean Air Award

Long Beach Business Journal

Oct. 8, 2019

The South Coast Air Quality Management District (SCAQMD) on Friday honored the Port of Long Beach (POLB) with a 2019 Clean Air Award for its Academy of Global Logistics program at Cabrillo High School.

SCAQMD's Clean Air Education Outreach Award highlights educational efforts around air quality issues. As part of the academy, 60 students at the West Long Beach high school worked with industry experts to learn about cargo operations at the port, with a focus on the Commercialization of POLB Off-Road Technology (C-PORT) project.

The C-PORT project encompasses the demonstration of zero emissions cargo-handling equipment at two of the port's terminals.

"Connecting our Academy of Global Logistics students together with our work on zero emissions technology was so gratifying. I'm doubly pleased to see the students and the Port recognized for this groundbreaking collaboration," Long Beach Harbor Commission President Bonnie Lowenthal stated. "Our education outreach programs aim to show our local students the universe of career opportunities in international trade and goods movement, and I think we've definitely hit the mark here."

The academy, which launched in 2016, is part of the port's educational outreach programming. So far, 670 students have participated in the four-year program.

Air District honors Port’s innovative education program

By: American Journal Of Transportation | Oct 08 2019 at 09:20 AM | Ports & Terminals

Students studied development of clean technology for goods movement

The Port of Long Beach collected a prestigious Clean Air Award on Friday for an education outreach program that connected local high school students to a project developing non-polluting, zero-emissions cargo-moving technology on the docks.

Port of Long Beach staff and Academy of Global Logistics at Cabrillo High School students show off the Port’s Clean Air Award at the South Coast Air Quality Management District’s 31st annual Clean Air Awards on Oct. 4. The Port received SCAQMD’s Clean Air Education Outreach award for a learning program connecting high school students to efforts to convert to zero-emission operations.The South Coast Air Quality Management District’s Clean Air Education Outreach award for the Port and the Academy of Global Logistics at Cabrillo High School was presented Friday at the SCAQMD’s 31st annual Clean Air Awards luncheon at the Grand Hotel in Los Angeles.

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The Port of Long Beach is one of the world’s premier seaports, a gateway for trans-Pacific trade and a trailblazer in goods movement and environmental stewardship. With 175 shipping lines connecting Long Beach to 217 seaports, the Port handles $200 billion in trade annually, supporting more than 575,000 Southern California jobs.

Zero-emissions equipment deployed to port terminals

ajot.com/news/zero-emissions-equipment-deployed-to-port-terminals

By AJOT

In recognition of California Clean Air Day, the Port of Long Beach on Wednesday announced the demonstration of hydrogen- and electric-powered cargo handling equipment at two shipping terminals, in pursuit of its goal to become the world's first zero-emissions seaport.

The new equipment was purchased through a $5.3 million grant from the California Air Resources Board as part of the "C-PORT," or Commercialization of POLB Off-Road Technology Project. The Port has several ongoing clean-air technology demonstrations in partnership with labor, marine terminal operators and regulatory agencies.

The CARB grant falls under the umbrella of California Climate Investments, a statewide initiative that puts billions of cap-and-trade dollars to work by reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment – particularly in disadvantaged communities similar to those adjacent to the Port.

"Today, you see some of the equipment with the potential to take us to the next level – zero emissions," said Long Beach Harbor Commission President Bonnie Lowenthal. "The equipment, which will be operated by our longshore partners at the Port, will help us reduce our impact on our neighborhoods and contribute to the Port's ability to increase trade."

Five vehicles will be demonstrated as part of C-PORT: two battery-electric top handlers at SSA Marine's Pacific Container Terminal at Pier J; and one fuel cell yard tractor, one battery-electric top handler and one battery-electric yard tractor at Long Beach Container Terminal at Pier E.

As part of the project, information about the demonstration was recently integrated into the coursework at the Port-sponsored Academy of Global Logistics at Cabrillo High School to support education and workforce development for new port technologies.

"Projects like these are designed to take us down the road to being the world's first zero-emissions seaport," said Port of Long Beach Executive Director Mario Cordero. "We have our labor partners of the ILWU, our terminal operators SSA and LBCT, and our regulatory agencies all working together to find the right technologies to reach our zero-emissions goals. With teamwork and cooperation like that, I think we can look forward to many more innovative projects to demonstrate new technologies."

Port of Long Beach showcases hydrogen equipment

h2-view.com/story/port-of-long-beach-showcases-hydrogen-equipment

Molly Burgess

October 4, 2019

The Port of Long beach showcased its hydrogen-powered cargo handling equipment in recognition of California Clean Air Day on Wednesday.

To achieve the Long Beach's goal of being the world's first zero emission seaport, the port purchased the zero-emission equipment through a $5.3m grant from the California Air Resources Board as part of the 'C-PORT' or Commercialisation of POLB Off-Road Technology Project.

Commenting on the event, Bonnie Lowenthal, Long Beach Harbour Commission President, said, "Today, you see some of the equipment with the potential to take us to the next level – zero emissions."

"The equipment, which will be operated by our longshore partners at the port, will help us reduce our impact our neighbourhoods and contribute to the port's ability to increase trade."

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Zero-Emissions Equipment Deployed to Port Terminals

Hellenic Shipping News

Oct. 4, 2019

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Source: Port of Long Beach

Ports of Long Beach, L.A. unveil new zero-emission vehicles

presstelegram.com/2019/10/02/ports-of-long-beach-l-a-unveil-new-zero-emission-vehicles

Chris Haire

October 3, 2019

The ports of Long Beach and Los Angeles will soon deploy new zero-emissions vehicles at some of their terminals, as they continue testing technology that will help them become more eco-friendly, officials at the twin port complex announced separately Wednesday, Oct. 2.

Both ports have made it their goal to fully transition from diesel-powered to zero-emission cargo-handling equipment by 2030.

The Port of Long Beach unveiled a new battery-electric yard tractor during an evening ceremony at the Civic Center. That tractor — the term for the vehicle portion of tractor-trailer big rigs that commonly roam freeways — will carry cargo containers from the Long Beach Container Terminal, in Pier E, to the rail yard. It is one of five vehicles the port will deploy over the next month for a two-year testing period, thanks to a $5.3 million grant from the California Air Resources Board, officials said.

Pier E will also have a fuel-cell yard tractor. (A fuel cell generates power from an energy source, while a battery stores energy.) The other vehicles, according to port officials, are battery-electric top handlers, which look like a mix between a fork lift and a crane; the top handlers will place them onto tractors. Pier E will get one top handler and Pier J will get two.

Officials will determine the long-term future of the vehicles after the testing period, which will include accessing how long the batteries last and how much power they have, said Long Beach port spokesman Lee Peterson.

“Those who said the technology wouldn’t be green for many years,” said Long Beach port Executive Director Mario Cordero, “you see before you that it is available.”

The Port of Los Angeles, meanwhile, announced that it will begin a one-year demonstration of two battery-electric top handlers as well. The two zero-emission vehicles are prototypes that cost $1.8 million each, said port spokesman Phillip Sanfield.

Related links

The top handlers, according to a statement from the port, can operate up to 18 hours between charges and can load containers weighing as much as 75,000 pounds onto trucks. They will begin operating at the Everport Container Terminal by the end of the year.

The demonstration of the top handlers, Sanfield said, will help move them from prototypes to commercial-ready — with the expectation that Everport and other terminal operators will eventually deploy newer versions on a more widespread scale.

“We’re excited to power up these battery-electric top handlers,” said L.A. port Executive Director Gene Seroka, “and test them under the real-world conditions of a working container terminal.”

31st CLEAN AIR AWARDS

South Coast Air Quality Management District

Program

ORDER OF PROGRAM

Please visit our 31st Annual Clean Air Awards webpage for detailed information regarding all of our recipient clean air heroes at www.aqmd.gov/caa or you can point your phone camera to the QR code to connect directly.

MUSICAL ENTERTAINMENT

Beyond The Bell Jazz Ambassadors

INTRODUCTION OF EMCEE

Derrick J. Alatorre, Deputy Executive Officer

WELCOME BY MISTRESS OF CEREMONIES

Christina Sanchez, Mistress of Ceremonies

PRESENTATION OF THE FLAG

Color Guard, Blair High School Junior Reserve Officers' Training Corps (JROTC) of Pasadena Unified School District, under direction of First Sergeant Hicks

PLEDGE OF ALLEGIANCE

Michael Cacciotti, South Coast AQMD Governing Board Member and South Pasadena Council Member

INVOCATION

Father Christopher Kolentsas, St. Sophia's Church

INTRODUCTIONS

Christina Sanchez

CHAIRMAN'S REMARKS

Chairman Dr. William A. Burke of the South Coast AQMD Governing Board

*20-MINUTE BREAK TO SERVE LUNCH

AWARDS

CLOSING REMARKS

Emcee Christina Sanchez

AWARD WINNERS:

S. ROY WILSON LEADERSHIP IN GOVERNMENT AWARD

Gina McCarthy

Former United States Environmental Protection Agency Administrator, Professor of the Practice of Public Health at the Harvard T.H. Chan School of Public Health and Director of the Center for Climate, Health and the Global Environment (Harvard C-CHANGE)

THE ROBERT M. ZWEIG, M.D. MEMORIAL AWARD

Dr. Jill Johnston

Assistant Professor of Preventative Medicine and Director of Community Outreach & Engagement in Environmental Health, University of Southern California

YOUTH LEADERSHIP IN AIR QUALITY

Pacoima Beautiful's Youth United Toward Environmental Protection (YUTEP)

YOUTH LEADERSHIP IN AIR QUALITY

Youth Leadership Institute, Coachella Valley Estamos Aquí: A Community Documentary

CLEAN AIR EDUCATION AND OUTREACH AWARD

California Safe Schools

CLEAN AIR EDUCATION AND OUTREACH

Port of Long Beach's Academy of Global Logistics at Cabrillo High School

MODEL COMMUNITY ACHIEVEMENT

San Bernardino Council of Governments with Partners BYD, Daylight Transport, CALSTART, BNSF and the California Air Resources Board

CLEAN AIR BUSINESS LEADERSHIP AWARD

Total Transportation Services, Inc.

INNOVATIVE CLEAN AIR TECHNOLOGY

Daimler Trucks North America

Friday, October 4, 2019 · The L.A. Grand Hotel Downtown

General Outreach Report

Attachment F

Green Education, Inc.

The Future at POLB...
Zero Emissions
Off-Road Technology

Community Engagement Program

Port of LONG BEACH
The Green Port

Community Workshops

- **Our Goals:**
- **Share how POLB is investing in zero-emissions equipment.**
- **Discuss the Port's Clean Air Action Plan goals and future zero-emissions projects.**
- **Provide community with a "birds eye view" of Zero-Emissions Off Road Technology & C-PORT demos**
- **Identify the positive impacts from ZE technology for residents and the city**

Green Education, Inc.

Port of
LONG BEACH
The Green Port

POLB: Clean Air Action Plan

- 2017: CAAP update called for transition to zero-emissions cargo handling equipment by 2030 & zero-emissions trucks by 2035.
- POLB has received over $75M in grants from CA Energy Commission (CEC) & CA Air Resources Board (CARB) to deploy ZE and NZE technologies

Green Education, Inc.

Port of LONG BEACH
The Green Port

C-PORT Investments

- **CARB awarded a $5.3 million grant to fund the first ZE demonstration at POLB, known as the Commercialization of POLB Off- Road Technology Demonstration, or C-PORT. Over $3 million in cost match as well.**

- **C-PORT will advance commercialization of ZE cargo handling equipment, a direct benefit to disadvantaged communities (DACs) heavily burdened by Port-related airborne emissions**
  - **Supports the CAAP:**
    - Advance new technologies
    - Air quality and emission improvements
    - Energy/Fuel efficiency improvements

CALIFORNIA CLIMATE INVESTMENTS
Cap and Trade Dollars at Work

Port of LONG BEACH
The Green Port

Green Education, Inc.

C-PORT

- **Design, manufacture, and demonstrate 5 zero-emissions pre-commercial cargo handling vehicles.**
- **Demo will include three never before tested battery electric top handlers at two terminals.**
- **Conduct a head-to-head comparison of a hydrogen fuel cell yard truck VS. battery electric yard truck.**

Green Education, Inc.

Port of LONG BEACH
The Green Port


TAYLOR
TAYLOR
TAYLOR


HOVA
CNHTC

COMMITMENTS

- Install electric charging stations and fueling infrastructure
- International Longshore & Warehouse Union workers will be properly trained to operate the new technology and equipment
- Community engagement, outreach and education
- LBUSD and CITT at CSULB coordination. AGL at Cabrillo HS sponsoring student ZE capstone project
- Demonstrate the proposed equipment in 2019/2020. Determine what has success in real-world operations and measure emission reductions.

Green Education, Inc.

Emission Reductions

- **0.690 tons per year (t/y) of NOx**
- **0.0212 t/y of PM10**
- **347 t/y of GHG**

Partners

- AGL at Cabrillo HS
- Air Products
- BYD
- CA Air Resources Board
- CNHTC/Sinotruk UQM
- Grant Farm
- Green Education Inc.
- Int'l Longshore & Warehouse Union
- Kalmar Transpower
- Long Beach Container Terminal
- Loop Energy
- SCAQMD
- SSA Marine
- Taylor Machine Works
- Tetra Tech

Green Education, Inc.

Port of
LONG BEACH
The Green Port

POLB at the Forefront

- Extensive experience implementing projects that demonstrate advanced technology across the goods movement sector, to reduce environmental and community health
- Millions of dollars in federal, state and local funding secured to replace and upgrade older diesel equipment ahead of state regulations
- POLB and POLA funds the development and demonstration of promising emission-reduction technologies through their Technology Advancement Program (TAP)

Green Education, Inc.

Port of
LONG BEACH
The Green Port

How will the pilots help you & our communities?

- **Reduction in greenhouse gas and toxic emissions**
- **More awareness for zero-emissions technology status**
- **Workforce development and potential jobs in zero-emissions technology**
- **Determine what has most success in real-world operations and reducing GHG & emissions**

Green Education, Inc.

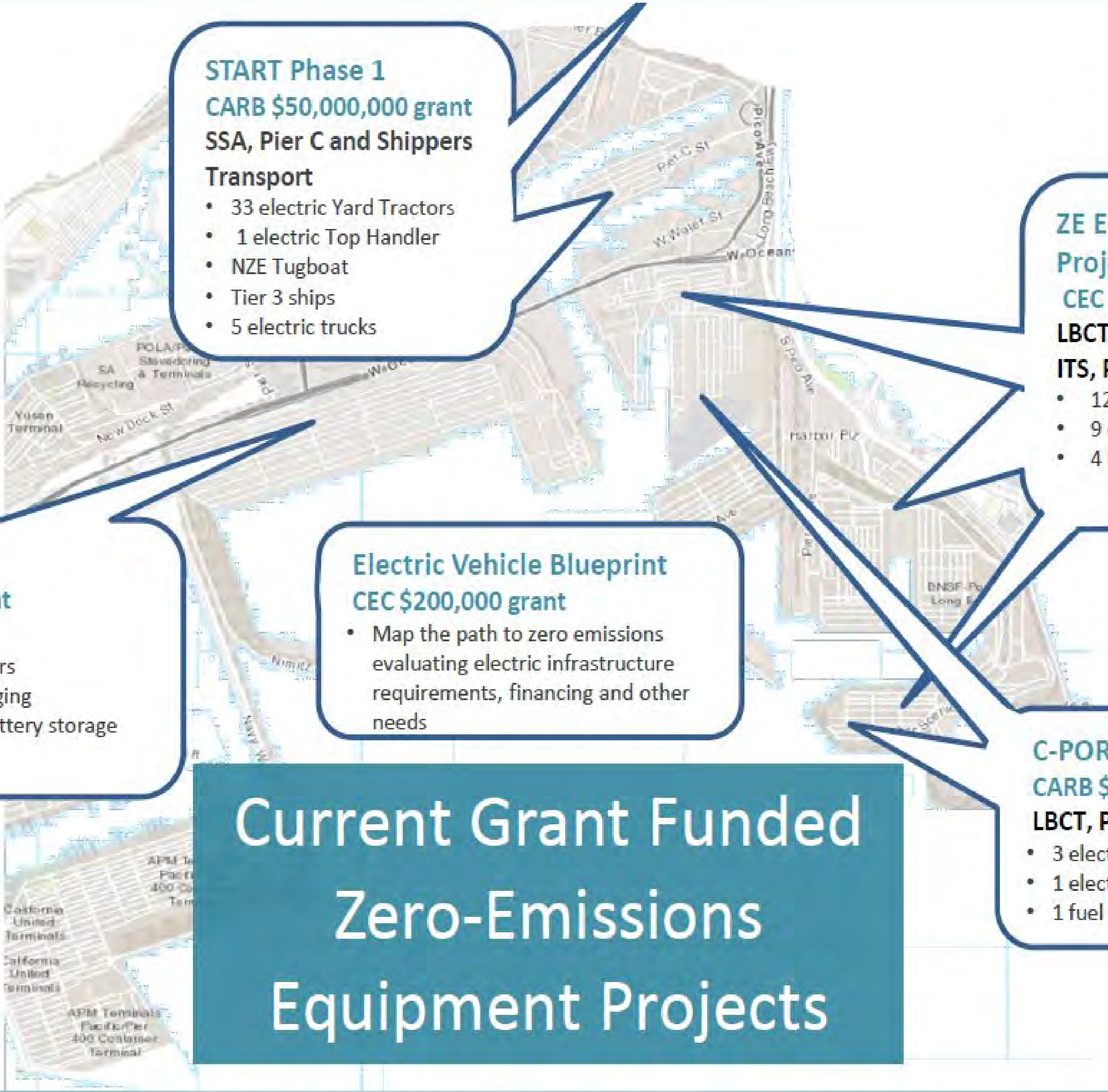
Port of
LONG BEACH
The Green Port

POLB Demonstrations

CALIFORNIA CLIMATE INVESTMENTS
Cap and Trade Dollars at Work

STATE OF CALIFORNIA ENERGY COMMISSION

Port of LONG BEACH
The Green Port



START Phase 1
CARB $50,000,000 grant
SSA, Pier C and Shippers Transport
- 33 electric Yard Tractors
- 1 electric Top Handler
- NZE Tugboat
- Tier 3 ships
- 5 electric trucks

ZE Equipment Transition Project
CEC $9,755,000 grant
LBCT, Pier E and SSA, Pier J and ITS, Pier G
- 12 electric Yard Tractors
- 9 electric RTG
- 4 LNG Hybrid Electric Trucks

PAVE Project
CEC $8,000,000 grant
TTI, Pier T
- 6 electric Yard Tractors
- Install electrical charging infrastructure and battery storage

Electric Vehicle Blueprint
CEC $200,000 grant
- Map the path to zero emissions evaluating electric infrastructure requirements, financing and other needs

C-PORT Project
CARB $5,339,820 grant
LBCT, Pier E and SSA, Pier J
- 3 electric Top PickS
- 1 electric Yard Tractor
- 1 fuel cell Yard Tractor

Current Grant Funded Zero-Emissions Equipment Projects

Education Outreach and Workforce Development Programs

Port of
LONG BEACH
The Green Port

Wrap Up...Questions?

- **More workshops to follow in most impacted neighborhoods.**
- **Please share with your friends, families, schools, churches...what you learned today.**
- **Contact Green Education if you want a workshop for your group.**
- **stella@greeneducationinc.org**
- **THANK YOU FOR YOUR TIME & YOUR INTEREST!**

Green Education, Inc.

Port of
LONG BEACH
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Port of
LONG BEACH
THE PORT OF CHOICE