

KANSAS CITY AREA TRANSPORTATION AUTHORITY

Invitation for Bids (IFB) #F23-5003-39A
Traction Power Substation – KC Streetcar Riverfront Extensions (Package 3)

ADDENDUM #2

Issue Date: February 7, 2023

This Addendum is hereby made a part of the Invitation for Bid and Project Documents to the same extent as if it were originally included therein and is intended to modify and/or interpret the bidding documents by additions, deletions, clarifications, or corrections. The Contractor shall acknowledge receipt of this Addendum on the “Receipt of Addenda” form (herein attached) and shall include the form in their Bid Submittal documents.

The following specifications and plans have been updated. The updated specification include red-line modifications. The updated plans include a “for-information” set showing the changes as well as clean updated plan sheets.

Specifications	Remove	Replace
SECTION 34 21 14P TES MEDIUM-VOLTAGE AC CIRCUIT-BREAKER SWITCHGEAR	302624 - 302635	304505 – 304516
SECTION 34 21 16P TES SUBSTATION ENCLOSURES	302636 - 302646	304517 – 304527
SECTION 34 21 18P TES LIGHTING	302665 - 302669	304528 – 304532
SECTION 34 21 19P TES DC SWITCHGEAR	302670 - 302683	304533 - 304546
SECTION 34 21 23P TES TRANSFORMER-RECTIFIER UNIT	302684 - 302699	304547 - 304562
SECTION 34 21 25P TES DC CONTROL POWER	302704 - 302709	304563 - 304568
SECTION 34 22 33P TES RACEWAY AND BOXES	302726 - 302731	304569 – 304575
Plans – Informational Only (Green Digits 304449 – 304476) Showing Comparison. Red is old version, green is updated.		
Plans	302794 - 302821	304477 - 304504

Other Changes in the Document:

Numerous locations in the document:

Bid Close Date is changed from 2/8/2023 2:00 PM Local Time to 2/21/2023 2:00 PM Local Time.

Bid Opening Date is changed from 2/8/2023 2:15 PM Local Time to 2/21/2023 2:15 PM Local Time.

AIA 101, Page 7 of 128 §3.3.2

Change “Within fourteen (14) months of NTP” to “Within sixteen (16) months of NTP”

Change “Deliver fabricated material within 14 months of NTP” to “Deliver fabricated material within 16 months of NTP”

Change “terrorism; strikes; any acts,” to “terrorism; strikes, epidemic, pandemic; any acts”

Change “1. Guarantee parts availability for a period of 10 years from Contract award.” to “1. Not used.”

Change “2. Provide detailed manufacturing drawings to the Owner at the end of the 10-year period or when the availability of parts ceases after that date.” to “2. Not used.”

Q1.1 General Conditions Article 11.1.2.2 requires the general liability policy to contain Products and Completed Operations Insurance for one (1) year after final payment. 11.1.1.5 requires the policies to contain two (2) years of Products and Completed Operations following project completion. Please advise which duration is correct.

Response: Article 11.1.2.2.d requires 1 year after final payment. Article 11.1.2.5 (not 11.1.1.5 as asked) requires a duration of warranty items or at least two (2) years following the project completion, longer, or as otherwise noted. For the purposes of this contract "project completion" shall take on the same meaning as "Substantial Completion."

Q1.2 General Conditions Article 11.1.1.5 requires the Automobile Liability policy to cover subcontractor's vehicles. Contractor has no insurable interest in the subcontractor's vehicles. Contractor will however require subcontractors to maintain their own Auto Liability coverage. Please amend:

The policy(ies) shall include Comprehensive Automobile Liability coverage for all vehicles, licensed or unlicensed, on or off KCATA premises, whether the vehicles are owned, hired or non-owned, covering use by or on behalf of the Contractor ~~and any subcontractors~~ during the performance of work under this Agreement.

Response: The Contractor shall not maintain insurance over subcontractor's vehicles provided the Contractor passes contractual requirements from the prime contract through to the subcontractor.

Q1.3 General Conditions Article 11.3.1 requires the Contractor's builders risk policy to continue in force until the earlier of final payment or when no other entity has an insurable interest in the covered property. Builders risk insurance ends upon Substantial Completion or at the point the Work is put to its intended use by the Owner, whichever is earlier. Please amend to recognize insurance industry practices:

Such property insurance shall be maintained, unless otherwise provided in the Contract Documents or otherwise agreed in writing by all persons and entities who are beneficiaries of such insurance, until ~~final payment has been made as provided in Section 9.10~~ **Substantial Completion** or until no person or entity other than the Owner has an insurable interest in the property required by this Section 11.3 to be covered, whichever is later.

Response: No change shall be made.

Q1.4 Please modify Agreement Article 4.5 (Liquidated Damages) as follows:

The Contractor acknowledges and agrees that if the Contractor fails to timely complete the project within the time set forth for Substantial Completion, as may be amended pursuant to the Agreement, the Owner will sustain extensive damages and loss as a result of such delay. The Parties agree that the exact amount of such damages and loss is not readily ascertainable at the time of the execution of this Agreement. Therefore, the Owner and the Contractor agree that, if the Contractor fails to achieve Substantial Completion of the Work, the Owner shall be entitled to retain or recover from the Contractor, as liquidated damages, and not as penalty, the following amounts:

Liquidated damages will be assessed at a rate of \$3,200 per calendar day for that work is not Substantially Complete within the dates and parameters established in Section 3.3.2.

The liquidated damages rate will continue to accrue until the actual date of Substantial Completion. The amount of liquidated damages assessed by the Owner shall be deducted from any sums due the Contractor and, in the event that such liquidated damages exceed amount owed, the Contractor shall promptly pay Owner, upon demand, the amount of such excess. **Contractor's maximum aggregate liability for unexcused delay shall not exceed ten percent (10%) of the Contract price. Payment of such damages shall be Owner's sole and exclusive remedy for Contractor's unexcused delay.**

Response: No change shall be made to this article.

Q1.5 Please modify General Conditions Article 15.1.7 (Waiver of Claims for Consequential Damages) as follows:

To the fullest extent allowable by law and notwithstanding anything herein to the contrary, the Contractor and Owner waive Claims against each other for consequential, incidental, special, or punitive damages arising out of or relating to this Contract whether under contract, tort, strict liability, or any other theory of liability. This mutual waiver includes but is not limited to

1. damages incurred by the Owner for rental expenses, for downtime costs, losses of use, income, profit or revenue, financing, business and reputation, ~~and for~~ loss of management or employee productivity or of the services of such persons, or any other loss;
2. damages incurred by the Contractor for principal office expenses including the compensation of personnel stationed there, for losses of financing, business and reputation, and for loss of profit, except anticipated profit arising directly from the Work; and
3. the negligent acts of the Contractor or his subcontractors which cause additional expense to the Owner for rental, for loss of use, **downtime costs**, income, profit **or revenue**, financial business, and representation and for loss of management or employee productivity or of the services of such persons are exempt from this mutual waiver.

This mutual waiver is applicable, without limitation, to all consequential damages due to either party's termination in accordance with Article 14. Nothing contained in this Section 15.1.7 shall be deemed to pre liquidated damages, when applicable, in accordance with the requirements of the Contract Documents.

Response: No change shall be made to this article.

Q1.6 Please modify General Conditions Article 16.22 (Force Majeure) as follows:

16.22.1 Both Parties shall be excused from performing its obligations under this Contract during the time and to the extent that it is prevented from performing by an unforeseeable cause beyond its control ("Excusable Delays") including, but not limited to: any incidence of fire, flood; acts of God or the

public enemy; commandeering of material, products, plants or facilities by the federal, state or local government; national fuel shortage; acts of war; terrorism; strikes; epidemic, pandemic, quarantine restrictions, cost escalation, any acts, restrictions, regulations, by-laws; prohibitions or measures of any kind on the part of any KCATA; freight embargoes; delays of Contractor's suppliers for like causes; contractual acts of either Party or a material act of omission by either Party; when satisfactory evidence of such cause is presented to the other Party, and provided further that such nonperformance is unforeseeable, beyond the control and is not due to the fault or negligence of the Contractor or KCATA. Contractor and KCATA shall use its best efforts to remove the cause of delay and resume work as soon as possible.

Response to 1.6.- 16.22.1 Epidemic and pandemic are acceptable to add to the definition of Force Majeure. Quarantine and Cost Escalation are not acceptable to add.

16.22.2 If at any time, Contractor concludes that any of the Work hereunder will become subject to a delay beyond Contractor's control, including but not limited to any of the aforementioned causes, Contractor shall notify KCATA of the nature and detailed reasons and foreseeable extent of such delay and shall, once every seven (7) calendar days thereafter, notify KCATA whenever, to the best of Contractor's knowledge and belief, the nature or foreseeable extent of such delay shall change. Contractor shall provide this written notice within five (5) business days of Contractor's becoming aware of the facts or matters giving rise to such Excusable Delay. Both Parties shall keep in contact with each other as to the status of such Excusable Delay and shall agree in writing to a restart date when the facts or matters giving rise to such Excusable Delay have concluded and further delays are not foreseen. Upon reengagement of work, Contractor and KCATA will formulate and agree upon an equitable adjustment update project schedule, taking into account the timeframe that has passed and incurred costs since the work stoppage, necessary time and cost to resume or re-create any previously completed tasks due to damaged or missing equipment and any associated time periods and/or costs for shipment and/or manufacture of equipment.

Response to 16.22.2: No change will be made to this section.

Q1.7 Please modify Sec. 16.30.4.1 Indemnification as follows:

To the fullest extent permitted by law, Contractor agrees to and shall indemnify, defend and hold harmless KCATA, its Commissioners, officers and employees from and against any and all claims, losses, damages, causes of action, suits, liens and liability of every kind, (including all expenses of litigation, expert witness fees, court costs and attorney's fees whether or not suit be commenced) for personal injury (including death) and real property damage by or to any person or entity (collectively the "Liabilities") arising out of, caused by, or resulting from the acts or omissions of Contractor, subcontractors, or sub-subcontractors, their respective agents or anyone directly or indirectly employed by any of them in performing work under this Contract, regardless of whether or not such claim, damage, loss or expense is caused in part by a party indemnified hereunder, so long as such Liabilities are not caused by the sole negligence or willful misconduct of a party indemnified hereunder. Such obligation shall not be construed to negate, abridge, or otherwise reduce other rights or obligations of

indemnity which would otherwise exist as to a party or person described in this paragraph. Contractor shall also indemnify, hold harmless and defend the KCATA for any contractor or subcontractor action, tort, or violation of federal or state law or city ordinance.

Response: No change shall be made to this section.

Q1.8 The Special Provisions 02.03.03 states that fabricated materials are to be delivered within 14 months of NTP. Please confirm that when the substation is delivered and inspected, KCATA will issue a notice of Substantial Completion, and that such notice will not be dependent on any work that is outside the scope of this contract, such as installation of external cables, utility connections, or field testing.

Response: See Book 1, section 02.03.12 (2) for the definition of Substantial Completion. When the TPSS is delivered, inspected, and accepted, the Owner will issue notification that the work is 95% complete. However, the Fabricator shall be still be required to attend to the Testing, Commissioning, and Training required elsewhere in the contract. See §3.3 of AIA 101.

Q1.9 Section 02.03.12 in “02 Information for Bid” states that the Date of Substantial Completion is a written notice that the work is 95% or more complete. Similar to our previous question, please confirm that substantial completion will be reached when the substation is delivered and inspected, and will not be dependent on any work that is outside the scope of this contract, such as installation of external cables, utility connections, or field testing.

Response: See Response to Q1.8 above.

Q1.10 Special Provisions 03.11.05 calls for providing test equipment for System Integration Testing. Please confirm that neither system integration testing nor any equipment required is included in the scope of work for this bid.

Response: While the System Integration testing is a part of the Construction Contractor, the Fabricator shall be included in this Work and shall be available to troubleshoot problems and issues that may be related to the fabrication of the TPSS.

Q1.11 Liquidated damages are listed as \$3,200 per calendar day (02.02.02 in 02 Invitation for Bid and 4.5 in the Agreement) for each day that the work is not complete beyond the completion date listed in 02.02.01 (NTP + 450 calendar days). Please confirm that this date is the same date as the substantial completion date mentioned in Section 3.3.2 of the Agreement (Delivery and Acceptance of Fabricated Material within fourteen (14) months of NTP).

Response: Substantial Completion is defined in §3.3 of AIA 101 and revolves around the delivery, acceptance, etc. of the TPSS. NTP+450 is the date by which the contract shall be closed out. Failure to close out the contract by NTP+450 shall not be subject to Liquidated Damages. Also, see modification to change in delivery time of 14 months above.

Q1.12 Section 4.5 of the Agreement says that liquidated damages will be assessed at a rate of \$3,200 per calendar day for work that is not Substantially Complete within the dates and parameters

established in Section 3.3.2. In addition to the delivery of the material, Section 3.3.2 also includes a milestone for submittal of detailed shop drawings (4 months after NTP). Please confirm that this milestone is not subject to the \$3,200 per calendar day liquidated damages, and only the milestone for delivery and acceptance of fabricated material (14 months after NTP) is subject to LDs.

Response: See updated Section 3.3.2 above. Also see updated Book 3, Section 02.03.03 (1) (b) (PDF page 196 of 460) above.

Q1.13 Section 04.01, the list of forms required for bid submission, states that all firms (prime contractors, subcontractors, and suppliers) doing business with KCATA must complete a vendor registration process. However, is there anything that must be submitted with the bid to document this process? If there is a form, is it only required from the Prime Contractor? If a document is required from others (i.e. subcontractors and suppliers), we request that they only be required from the apparent low bidder after the bidder is notified of KCATA's intent to award

Response: There is not a separate form to indicate that the registration process has been completed.

Q1.14 The bid form calls for a price for storing the substation 180 days. For pricing purposes, should the bidder assume that the substation must be delivered by the substantial completion date (14 months after NTP), and that if KCATA decides to store the substation instead, a change order will be issued based on the unit price provided in Bid Item 2?

Response: The intent of the storage costs is to pay the Fabricator for each day the equipment is stored. Should the TPSS be stored for only a portion of the days, the Fabricator will be paid for only those days. Additionally, see changes to 14 month duration above.

Q1.15 For pricing purposes, will the 180 days of storage start on the expected delivery date, the substantial completion date mentioned in our previous question?

Response: The 180 days is intended to begin on the date of Substantial Completion. If the delivery site or TPSS foundation (work site) is not prepared to receive the TPSS and storage is required. The Owner will provide transportation to the Contractor (not Fabricator) to inspect the interior and exterior of the TPSS.

Q1.16 If KCATA decides to store the substation for up to 180 days, will the substantial completion date (along with the liquidated damages tied to it) be adjusted accordingly?

Response: See response to Q1.8 for the definition of Substantial Completion. Liquidated Damages are not intended to apply to the 180 days of storage.

Q1.17 The TPSS Responsibility Matrix in the back of the IFB file indicates that the TPSS Supplier will be paid 75% of contract value before delivery and 5% upon inspection following delivery, with the remaining 20% paid when external cables are connected and tested (by others) and test reports and results are submitted (also by others). Please confirm that although the final 20% of payments to the TPSS Supplier are dependent on the work of others, which is largely out of the control of the TPSS

Supplier, there are no TPSS Supplier contract milestones with liquidated damages tied to these events, and the final milestone for which the TPSS Supplier might be assessed liquidated damages is the delivery of the substation to the jobsite.

Response: Within 30 days of delivery of the TPSS to the delivery site, with all other items on the Responsibility Matrix met, and with a written request from the Fabricator, the Fabricator will be paid in full less retainage (if applicable) and also less \$30,000 for Final Contractor/Fabricator close out indicated in Item 4 of the TPSS Responsibility Matrix. The \$30,000 fee shall be paid only in full (no partial payment) when all items in the Matrix are met.

Q1.18: As shown in our previous question, the TPSS Supplier will only be paid 80% of contract value after delivering the substation. Practically all of our cost will be incurred before TPSS delivery, therefore this payment schedule will put us in a very negative cash position for an undefined duration, as we have no control over the installation of external cables and the field testing. We would have to include finance costs in our bid, which will raise the bid price. We propose that the payment milestone for Assembly is increased from 25% to 45%, getting us fully paid (less the 5% retainage) when the TPSS is delivered to site and accepted.

Response: See response to Q1.17. See response to Q1.17.

Q 2.1 Due to Current Supply Chain challenges and the vast specifications provided for review. Please extend the bid timeline by a minimum 10 weeks in order to bid. Please extend the RFI deadline to 2 weeks prior to bid closing to allow proper time to evaluate and ask quotes for all sub supplied items within the substation.

Response: See "Other Changes to the Document" section above.

Q 2.2 Due to defectiveness of the specification against current commercially available equipment and in comparison to the current IEEE standards, please modify this request to an RFQ. Being an IFB would force a no bid due to the many clauses that cannot be met, or contradict within the specification

Response: No change shall be made to the status of RFQ or IFB.

Q 2.3 Due to the scope of contract being a material supply to go into storage, the Liquidated damages timeline is not realistic. Current market conditions will not allow for materials to be ready within NTP+450 days. It is estimated it will take 20 - 24 months to deliver a substation due to long lead time items of AC Switchgear, Transformers, and solid state devices (MFPRs and PLCs) requiring a delivery period of 12 - 14 months from design approval. Please modify the Liquidated damage clauses to align with a penalty period that would be implemented for when the installation needs to occur.

Response: See "Other Changes to the Document" section above.

Q 2.4 34 21 14P clause 2.3.A Sheet Steel, minimum 11 gage IEEE standard indicated 14 ga steel in standard. This is also industry standard. 11 ga cannot be complied. Please allow for AC Switchgear

structure that comply to all gaging requirements that align with IEEE and industry commercially available products

Response: The successful bidder may propose alternate methods to meet these requirements – alternative methods have been accepted. If cubicles are proposed to be 14 gauge then it is anticipated that there would be two layers between adjacent MV areas resulting in excess of #11 ga steel. Front and rear doors will be required to be min #12 gauge.

Q 2.5 34 21 14P clause 2.11.A Factory Design Tests Please waive all factory design test requirements for AC Switchgear, and allow proven industry standard designs as per IEEE, or previous design test reports on similar rating switchgear in lieu of performing new tests. Design test laboratories are booking out well over 1 year from receiving an order

Response: The successful bidder may request to waive these tests subject to providing acceptable test reports for identical or similar equipment with substantive comparison to the proposed equipment. Prior to receiving such accepted documentation, the test requirement shall remain.

Q 2.6 Buy America 49 CFR part 661 Please confirm the rolling stock provision of 661.11 is the provision that applies to this contract. 70% of all components must be of American content

Response: 49 CFR 661.11 Rolling Stock Procurements does apply to this contract since this is considered "Traction Power Equipment". The Contractor should review all of the requirements of the Buy America requirements 49 CFR 661 in order to meet the applicable requirements and submittals.

Q 2.7 34 21 16P clause 1.5 H Factory Design Tests Please remove all factory design test clauses from the Substation enclosure specification as no such standard or test exists. All testing to be production tests only

Response: The specification shall apply as related to the equipment. Within the Contract the successful bidder shall identify where specified tests are not applicable for concurrence by the Agency/Engineer. Please note that NEMA 250 does identify a section on design tests.

Q 2.8 34 21 16P clause 2.2 E.1 NEMA 250 Type 4 Prefabricated buildings cannot comply to this NEMA 250 Type 4 rating. If there are ventilations, HVAC , fans, or any other penetration in the building a NEMA 4 enclosure rating cannot be met. Please revise to NEMA 3R standard Prefabricated enclosure rating

Response: The successful bidder may propose this deviation in Contract, however resistance to hose-directed water (that being the difference between NEMA 3R and NEMA 4) should be achievable.

Q 2.9 34 21 16P 2.6 clause A.3.a minimum 11 gauge 11 gauge is not industry standard for prefabricated buildings and is a significant additional costs to this item. Given the structure must be designed and certified to Structural and seismic ratings in MO and certified by a structural engineer, please allow for 14 ga external wall panels with interior wall sheets to aid in rigidity of structure

Response: No change shall be made to the specification.

Q 2.10 34 21 16P 2.6 clause B.3.a minimum 14 gauge Most prefabricated buildings do not have a separate internal and external walls. They are generally composed of a formed panel exterior wall with 14 ga panels, and an internal wall sheet of 16 - 18 ga. Please allow Manufacturers construction design to be accepted as long as certified by a structural engineer

Response: No change shall be made to the specification.

Q 2.11 34 21 16P clause 2.14 A Factory Design Tests No such testing exists. Please remove and allow for factory production tests only

Response: See response to Q2.7.

Q 2.12 34 21 17P clause 2.1F.1 Design Conference within 60 days NTP The items to be discussed in the design conference cannot be provided within a short duration of 60 days NTP due to internal and 3rd party designs needed to be started, and in many cases completed for submission prior to a design conference. This duration does not allow for these items to be discussed. It is requested that this conference happens 120 days from NTP. Also, test procedure cannot be provided in this time. Test procedures are developed after design is frozen and is closer to the time testing is to occur. Generally test procedures are discussed and reviewed 20 to 60 days prior to when the testing it to commence.

Response: Upon written request, the design conference timing will be extended up to 90 days. It is intended to establish a true initial basis to facilitate the fabrication and avoid rejected submittals. An early opportunity to present the approach and intended products supports this goal. An additional design conference may be requested by the successful bidder to provide additional information and details not available at the initial one.

Q 2.13 34 21 19P clause 2.3 A&B 11 gage minimum steel As per IEEE C37.20.1, 14 ga is industry standards. 11 gage cannot be complied. Since this equipment exists within an indoor environment of the prefabricated building 11 ga should not be required. DC equipment supplier do not provide DC switchgear with 11 ga. Please allow all enclosure designs to comply with IEEE and industry standard of commercially available products. 11 gage design would force a no bid decision

Response: See Q 2.4 response above.

Q 2.14 34 21 19P clause 2.4 C.3 Silicon Bronze Manufacturer cannot provide silicon bronze hardware as all hardware is metric in their proven standard design. This request of silicon bronze cannot be complied and would force a no bid decision

Response: See updated specification section 34 21 19P (BATES 304538) included in this addendum where "Zinc plated teal bolts may also be used."

Q 2.15 34 21 19P clause 2.11 A Factory Design Tests Factory Design tests on DC Switchgear, Breaker, and Protection relays/control devices cannot be provided for this contract. To design test both of these items would add a minimum of 12 months to overall project duration as well as significant costs since equipment utilized in the design test cannot be supplied to owner and must be discarded. Please allow

manufactures who have proven DC Switchgear in service throughout the United States for decades to provide their standard gear without design tests.

Response: See response to Q2.5 above.

Q 2.16 34 21 23P clause 2.4.C.4.c Stainless Steel Hinges Manufacturer does not utilize stainless steel hinges and in order to provide this design would require a complete re-design to the frame and structure as the hinge type and style does affect the overall construction. Please allow manufactures to use their standard hinge design and finish. Given the Rectifier is installed in an indoor climate-controlled environment stainless steel hinges should not be required

Response: A substitution will be accepted and shall be submitted as an RFI by the successful bidder.

Q 2.17 34 21 23P clause 2.9.A Factory Design Tests for Transformer-Rectifier Units, Rectifier, Rectifier Transformer Please remove the design test requirement from contract as current design test labs are booking out over 1 year from receipt of order. It is estimated to perform the TRU design test would add 14 to 16 months of lead time to this contract. Transformer design test would add additional time from what is indicated above. Also, rectifiers cannot be design tested independently and would need to be performed as part of TRU test. Design testing would also add significant costs to the overall contract

Response: See response to Q2.5 above.

Q 2.18 34 21 31P clause 1.6 H. 1.a & 2.a Factory Design test There is no such standard for a factory design test on an SAS. Please remove from the contract requirements

Response: See response to Q2.7 above regarding applicability of tests. Note that while the SAS system as a whole may not have applicable design tests, equipment utilized within the system shall have met specific equipment standards.

Q 2.19 34 21 31P clause 1.8 B&C UL Label Not all components within manufacturers Standard SAS can be offered UL labelled, nor is a field evaluation of the SAS is a feasible request. Please allow manufacturers standard IEEE design for SAS that is utilized all over North America to be accepted without a UL label

Response: IEEE design vs UL listing is acceptable.

Q 2.20 34 21 31P clause 2.16 A Factory Design Test No such standard exists to perform a factory design test on an SAS. In addition, it would be unclear what the test procedure would need to encompass for such test. Given the lack of standard, and test requirements, and the fact that design test laboratories are booking over 12 months out, this clause is requested to be removed

Response: See response to Q2.18 above.

Q 2.21 34 21 33P clause 1.5 F.1 & G.1 Design test There is no standard or test procedure for a factory design test on Rail-voltage monitor and grounding system. Please remove this requirement for design tests.

Response: This specification shall apply as related to the equipment. Within Contract, the successful bidder shall identify where specified tests are not applicable for concurrence by the Agency/Engineer.

Q 2.22 34 21 50P 2.3.A Design test DC Surge arrester design tests cannot be performed within enclosures as they are designed to fail within free air, and installing within an enclosure not only voids the warranty, but is in contradiction to a free air outdoor rated DC Surge arrester. please remove the requirement to design test, and to design test within an enclosure. Sub suppliers will not guarantee their product installed within an enclosure

Response: The design test requirement within the required enclosures shall be waived. Provision of surge arrester design test certification in free-air however shall still apply.

Q 2.23 34 21 08P clause 2.1.A.3 Unit Price for spare parts Please confirm that unit pricing for spare parts is to be provided during execution, however the mandatory spare parts requested in each section is to be included in overall pricing with bid.

Response: Confirmed.

Q 2.24 34 21 08P clause 2.1.C.1 Spare part Guarantee of 10 years No supplier nor sub supplier can guarantee spare parts available for 10 years. Obsolescent equipment cannot be forecasted and guaranteed available for 10 years. Please remove this clause. Purchase of spare parts with this contract will mitigate the risk to owner of obsolescence.

Response: Section 24 34 80P 2.1.C.1 (not 24 34 08P as asked) shall be struck – see “Other Changes in the Document” section above.

Q 2.25 34 21 08P clause 2.1.C.2 provide detailed manufacturing drawings at the end of the 1-year period of when the availability of part ceases after that date Drawings for parts can be provided with initial contract design, but providing at 10 years or when availability ceases cannot be offered. Please remove this clause from the specification

Response: Section 24 34 80P 2.1.C.2 (not 24 34 08P as asked) shall be struck – see “Other Changes in the Document” section above.

Q 2.26 34 21 90P clause 2.2 Factory Design Test Due to the duration of project, the additional costs, and the request of design testing that is not defined for testing requirements, please remove all design test requests for this contract. Also, design tests need to be performed at an independent laboratory, thus factory design tests should not apply.

Response: See responses to Q2.7 and Q2.18.

Q 2.27 34 21 97P clause 2.2 Training course Please confirm since this is a supply only contract that field training does not apply. Supplier can provide classroom training. It would be up to the installer to perform field training under their contract and the timeline that aligns with their project schedule with owner.

Response: Confirmed. Training shall be arranged via the Installation Contractor. The Supplier shall provide all O&M and training materials needed to operate, install and maintain the equipment provided.

Q 2.28 34 21 97P clause 2.2 C Supplemental Training Please confirm if supplemental training is requested by Engineer that this would be an additional cost to owner upon request. Supplier cannot offer additional training as deemed necessary for no additional costs

Response: Supplemental training (and associated costs) shall be negotiated with Owner, if required.

Q 2.29 Storage If TPSS Supplier is to offer storage in scope, please confirm the date to when storage is required.

Response: An accurate date for storage is not yet known, but is currently estimated to start Quarter 1 of 2024

Q 2.30 TPSS Responsibility Matrix. Please confirm why installation checks, mechanical tests, equipment functional tests, equipment integration tests are to be handled by an independent test company? The manufacturers can provide these tests at the factory.

Response: The Independent Test Company role shall be to confirm that the manufacturer's tests and documentation have been completed. The ITC is not within the bidder's scope.

Q 2.31 TPSS Responsibility Matrix System Testing Please confirm since this is a supply only contract (into Storage) that system testing is not part of scope for this contract. Supplier cannot support these tests if it's a supply contract to storage. If supplier is to support. Please give a clear timeline of when these tests are to occur

Response: This is confirmed. Field tests are not part of the scope of work. However, factory test of complete operating systems within the TPSS (or simulation of external interfaces) is required by the TPSS Supplier. Support during field tests will be request by Installation Contractor if required.

Q 2.32 TPSS Responsibility Matrix Handover to Agency for further train tests Please confirm since this is a supply only contract (into Storage) that further train tests is not part of scope for this contract. Supplier cannot provide these tests if it's a supply contract to storage. This is the responsibility of the installing contractor and system designer.

Response: This is confirmed. Field tests are not part of the scope of work. However, factory test of complete operating systems within the TPSS (or simulation of external interfaces) is required by the TPSS Supplier. Support during field tests will be request by Installation Contractor if required.

Q 2.33 34 21 17P Clause 2.18 Corrosion Control Junction Box Please provide specifications and drawings for this corrosion control junction box in order to provide

Response: The enclosure is expected to be approximately 12" wide x 18" high x 12" deep. There shall be two terminal jacks provided as described within the specification with connections to earth ground and to negative bus. Terminals shall provide for testing between the two systems. No additional requirements are available at this time. The successful bidder shall have the opportunity to observe the existing system corrosion control test junction box at an existing location to obtain additional information.

Q 3.1 In the general requirements page 27 03.09.01 provided material (eight sections of 39' tram rail). Is this required for the procurement of the TPSS?

Response: No. This was a mistake. 39' sections of Tram Rail are not a part of this project

Q3.2 Section 34 21 05P are we to provide and or connect the blue lights on remote OCS poles as part of this procurement bid?

Response: No, there is no longer a requirement for a blue light on the nearest OCS pole.

Q3.3 Is any grounding required upon placement of the TPSS to be included as part of the procurement bid?

Response: All field installation work including providing, installing and connecting the substation ground grid will be by the Installation Contractor. Connections would be made per the TPSS Supplier recommendations.

Q4.1 DC Switchgear, ISO 9000 certification is required. Will ISO 9000 equivalent Procedures & Standards be acceptable?

We follow ISO 9000 Standards, but are not ISO 9000 Certified

Response: Verification of following ISO 9000 Standards shall be permitted.

Q4.2 Due to late start to the project, time constraints and resources, we are requesting a minimum of two week extension to the bid date.

We need that time to receive & compare vendor quotes and properly prepare a competitive proposal.

Response: See the Addendum cover page for change in times.

KANSAS CITY AREA TRANSPORTATION AUTHORITY (KCATA)

Invitation for Bids (IFB) #F223-5003-39A
Traction Power Substation – KC Streetcar Riverfront Extension (Pkg 3)

RECEIPT OF ADDENDA

Proposers shall return this form when submitting their Bid Submittal. The form shall be signed and dated by an authorized representative of the firm. Failure to submit this form may deem the Bidder non-responsive. As additional addenda are issued, please notate date received below.

We hereby acknowledge that the Addenda noted below was received all information has been incorporated into the Bid as required.

Addendum #1 dated January 26, 2023

Date Received _____

Addendum #2 dated February 7, 2023

Date Received _____

Company Name _____ Date _____

Address/City/State/Zip _____

Authorized Signature _____ Printed Name _____

Telephone _____ Fax _____ Email _____

SECTION 34 21 14P
TES MEDIUM-VOLTAGE AC CIRCUIT-BREAKER SWITCHGEAR
SUBSTATION PROCUREMENT ONLY

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Metal-clad, medium-voltage ac circuit breaker switchgear for TES substation primary protection.
 - 2. Incoming fusible, load break disconnect switch.
 - 3. Utility metering equipment.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 01 43 00 – Systems Quality Assurance
- C. SECTION 01 60 01 – Buy America Requirements
- D. SECTION 34 21 06P – TES Common Work Results for Metals
- E. SECTION 34 21 17P – TES Substation Design and Assembly
- F. SECTION 34 21 18P – TES Lighting
- G. SECTION 34 21 31P – TES Substation Automation System (SAS)
- H. SECTION 34 21 80P – TES Spare Parts and Special Tools
- I. SECTION 34 21 90P – TES Testing
- J. SECTION 34 21 95P – TES Operation and Maintenance Data

1.3 DEFINITIONS

- A. Intelligent Electronic Device (IED): Refers to any digital or numerical-based protection, metering, control, or monitoring device that has processing, recording and reporting capabilities and a local human machine interface (HMI); used in electrical switchgear.

1.4 REFERENCED STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. American National Standards Institute (ANSI):
 - 1. ANSI C39.1, Requirements for Electrical Analog Indicating Instruments
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. IEEE 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
 - 2. IEEE 1653.2, Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 Vdc Nominal Output
 - 3. IEEE C37.06, Standard for Ac High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V
 - 4. IEEE C37.09, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 5. IEEE C37.12, Guide for Specifications of High-Voltage Circuit Breakers (over 1000 Volts)
 - 6. IEEE C37.20.2, Standard for Metal-Clad Switchgear

7. IEEE C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear
 8. IEEE C37.46, Standard Specifications for High Voltage (> 1000 V) Expulsion and Current-limiting Power Class Fuses and Fuse Disconnecting Switches
 9. IEEE C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus
 10. IEEE C37.90.1, Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
 11. IEEE C57.13, Standard Requirements for Instrument Transformers
- D. Evergy:
1. Evergy S3, Point of Delivery Requirements for Privately Owned Substations, 15 kV Class
 2. Evergy S8, Metering Transformer Installation in Metal-Clad Switchgear – 15 kV and Below
- E. National Electrical Contractors Association (NECA):
1. NECA 430, Standard for Installing Medium-Voltage Metal-Clad Switchgear

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Certification that products submitted meet Buy America requirements of 49 U.S.C. Section 5323(j) and 49 CFR Part 661, as per SECTION 01 60 01 – Buy America Requirements.
- C. Product Data: Catalog data and other pertinent information concerning design and application ratings, service performance, and reliability, including the following:
1. Complete details of circuit breakers, drawout mechanism, manual racking handle, and interface with drawout mechanism.
 2. Relays.
 3. Control switches.
 4. Indicating lamps.
 5. Protective devices.
 6. Surge arresters.
 7. Cubicle heaters and humidistat.
 8. Protection devices with coordination curves and setting procedures.
- D. Spare Parts and Special Tools:
1. Submit a list of spare parts to be provided under this Section.
 2. Submit at the same time as product data.
 3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in Section 34 21 80P, TES Spare Parts and Special Tools.
 4. Submit a list of special tools to be provided under this Section, as defined in Section 34 21 80P, TES Spare Parts and Special Tools.
- E. Shop Drawings:
1. Manufacturer's detailed, dimensioned drawings for each type of switchgear assembly.
 2. Manufacturer's schematic wiring and interconnection diagrams.
- F. Operation and Maintenance Data:
1. Manufacturer's operating and maintenance instructions, parts list, illustrations and diagram for components.
 2. Recommended list of spare parts.
 3. Submit immediately after approval of product data

1.6 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 80P, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section:
1. Ac circuit breaker, complete with truck: Provide 1 spare.
 2. Circuit breaker operating mechanism charging motor: Provide 1 spares.

3. Circuit breaker operating mechanism spring: Provide 1 spare assemblies.
4. Circuit breaker solenoids: Provide 1 spare sets.
5. Metering current transformers: Provide 1 spare set.
6. Protection current transformers: Provide 1 spare set.
7. Potential transformers: Provide 1 spare set.
8. Potential transformer primary and secondary fuses: Provide 1 spare set.
9. Ac protective relays (non-IED): Provide 1 spare set.
10. Ac switchgear IEDs: Provide 1 spare set.
11. Ac ammeter and voltmeter: Provide 1 spare set if separate from IEDs.
12. Ac switchgear control circuit mini-breakers: Provide 1 spare sets.
13. Transducers: Provide 1 spare set.
14. Indicating LEDs, including those for trip circuit monitor: Provide 1 spare set.

1.7 QUALITY ASSURANCE

- A. Quality Assurance/Quality Control shall be carried out in accordance with the requirements of SECTION 01 43 00 Systems Quality Assurance.
- B. The ac metal clad switchgear shall be UL labeled or shall be furnished with a Field Evaluation label in accordance with Section 34 21 17P, TES Substation Design and Assembly.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, storage, and handling shall be carried out in accordance with the requirements of 26 05 00-13, Systemwide Electrical General Requirements for Systems, except as modified herein.
- B. Obtain written permission from the Engineer before shipping substation.

1.9 WARRANTY

- A. Comply with warranty requirements in accordance with the General Conditions, Article 6.20.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Ac switchgear shall form a line-up of dead-front, totally enclosed, free-standing switchgear suitable for indoor service, and include an incoming disconnect switch, utility metering, and a circuit breaker to feed rectifier transformer.
- B. Switchgear shall be metal-clad and conform to the requirements of IEEE C37.20.2, except as otherwise indicated.

2.2 RATINGS

- A. Ac switchgear shall have the following ratings:
 1. Nominal Voltage: 13.2 kV.
 2. Maximum Voltage: 15 kV rms.
 3. Frequency: 60 Hz.
 4. Insulation Level, 60 Hz Withstand: 36 kV.
 5. Insulation Level, Impulse Withstand: 95 kV.
 6. Continuous Current: 1200 A.
 7. Rated Short Circuit Current: 25 kA.
 8. Maximum Dimensions: 36 inches wide, 96 inches deep, 95 inches high or as indicated.

2.3 AC SWITCHGEAR STRUCTURE

- A. Construction:
 1. Rigid, self-supporting, and self-contained.
 2. Structural elements electrically welded or bolted together.
 3. Sheet steel, minimum 11 gage.

4. Shall support equipment under normal loads, short-circuit conditions, and specified seismic conditions.
 5. Ac switchgear enclosure shall be divided, barriered, and partitioned into separate vertical sections.
 6. Finish: Powder coat in accordance with Section 34 21 06P, TES Common Work Results for Metals.
- B. Circuit Breaker Compartments:
1. Design to allow draw-out circuit breakers to be easily drawn in or out of their housing.
 2. Provide guide rails or cradles for positioning the removable elements as an integral part of the equipment. Guides shall ensure proper alignment.
 3. Provide self-aligning, self-coupling, primary and secondary disconnecting devices that allow the draw-out breakers to connect or disconnect from the buses and auxiliary circuits.
 4. Connection of control wiring to the ac breaker shall be by sliding contacts. A plug-style disconnect is acceptable, provided the breaker cannot be mechanically racked into the connected position with the plug disconnected.
 5. Provided automatic protective shutters to cover live medium-voltage terminals and prevent accidental contact with live parts as the removable element of breaker is drawn out of the cubicle.
 6. Provide a manual racking mechanism for horizontal draw-out of each circuit breaker:
 - a. Mechanism shall have three circuit breaker positions: Disconnected, test, and connected.
 - b. Provide positive stops to prevent over-travel at each position with labels clearly identifying the breaker's position.
 - c. Mechanism shall be designed for racking of circuit breaker in and out of connected and disconnected position with the compartment front door in the closed and latched position.
 - 1) With door closed and latched, the socket for insertion of manual racking handle shall be within 1 inch of face of door for ease of use. An extension on the socket may be provided to satisfy this requirement.
 - 2) An arrangement that makes it difficult to align the manual racking handle with the socket without opening the door is not acceptable.
 - d. Manual racking handle:
 - 1) Handle shall be designed such that it does not require a user with special skills to insert or operate.
 - 2) Provide a universal joint if necessary to prevent the user from knocking his knuckles on the floor while racking a breaker.
 - 3) Engineer may reject manual racking handle after delivery if it has not been designed for ease of use. If rejected, provide a handle that addresses the use issues at no additional cost to the City.
 - 4) Provide one at each switchgear location.
 7. Breaker case and frame shall be grounded when the breaker is in the connected and test positions by means of positive contact with a copper ground bus.
 8. Provide the following interlocks:
 - a. Prevent either electrical or manual operation of the breaker unless it is in the connected or test position.
 - b. A positive mechanical interlock shall prevent racking in or out unless the breaker is in the OPEN position.
 - c. Circuit breaker, complete with the operating mechanism shall be capable of being removed from the enclosure only in the disconnected position.
- C. Control/ Terminal Board Compartment:
1. Controls, including programmable controllers, instrumentation, control relays, terminal boards, control wiring and control devices shall be housed in a separate control/terminal board compartment.
 - a. Compartment shall be barriered from the power wiring and buswork compartments.

- b. Exception: Where controls and terminal boards are dedicated to circuit breaker function, they may be located in the circuit breaker compartment.
 - 2. Protective relays, meters, instruments and control devices shall be mounted on front compartment doors and shall be located such that meters and displays can be operated and read by a person standing at floor level.
- D. Access Doors:
- 1. Access to all components shall be from the front and the rear.
 - 2. Equipment access panels located on the side or top of the enclosures are prohibited.
 - 3. Provide each compartment with separate hinged front and rear access doors for servicing.
 - 4. Opening of any front door shall not expose circuits in adjacent compartments.
 - 5. Construction:
 - a. Sheet steel, 11 gage minimum.
 - b. Reinforce against distortions using suitable flanges and stiffening members.
 - 6. Hinges: Stainless steel heavy-duty type.
 - 7. Latches:
 - a. Doors shall be securely fastened in the closed position with a three point latch easily opened without the use of tools.
 - b. Two latches will be allowed if front panel consists of more than one full-length door.
 - 8. Handles: Provide each door with a heavy duty-handle with provisions for a padlock.
 - 9. Door Stops: Provide each door with a heavy-duty stop to hold it securely in the open position.
- E. Heaters: Provide two strip-type heaters in each switchgear cubicle to prevent condensation.
- 1. Operating voltage for heating strips shall not exceed 50 percent of heater rated voltage.
 - 2. Provide an individual humidistat in each cubicle to control heaters.
 - 3. Locate humidistat in an area of each cubicle so that it can measure the average humidity in the cubicle.
 - 4. Provide a digital heater ammeter on the front of each cubicle enclosure to indicate current and operation of heaters.
- F. Lights: Provide a light in each cubicle in accordance with Section 34 21 18P, TES Lighting.
- G. Warning Signs:
- 1. Front Access Doors: Sign on each stating "DANGER: LIVE PARTS" and "DANGER: HIGH VOLTAGE."
 - 2. Rear Access Doors: Sign on each stating "DANGER: LIVE PARTS" and "DANGER: HIGH VOLTAGE."

2.4 BUSES AND CONNECTIONS

- A. Power Bus:
- 1. Material: Silver-plated, electrical grade copper.
 - 2. Continuous current rating: Minimum 1200 A for main bus and circuit breaker connections.
- B. Ground Bus:
- 1. Material: Electrical grade copper.
 - 2. Size: Minimum 2 inch by 1/4 inch.
 - 3. Extend the full length of ac switchgear assembly and bond to each switchgear section by solidly bolting the bus to a non-removable structural member.
- C. Main Bus:
- 1. Extend three-phase horizontal bus the full length of ac switchgear assembly.
 - 2. Insulate entire length of main bus, including joints, with 30 kV, flame-retardant, non-hygroscopic, track-resistant insulation free from internal voids.
 - 3. Corona Prevention:
 - a. There must not be air gaps between the bus and the bus insulation.
 - b. Where bus passes through cubicle barriers, there must not be air gaps between the bus insulation and the opening through which it passes.

- D. Connections:
 - 1. Silver-plated, electrical grade copper bus.
 - 2. Connections include but are not limited to bus taps, circuit breaker connections, CT and PT connections, transformer connections, and surge arrester connections.
 - 3. Join with a minimum of two bolts per joint and Belleville washers. Hardware shall be silicon bronze.
 - 4. Cable connections are not permitted.
- E. Buses and bus connections shall be adequate to withstand thermal and mechanical stresses associated with short-circuit currents equal to the momentary and three-second rating of the circuit breaker.

2.5 INCOMING DISCONNECT SWITCH SECTION

- A. Description: Load break, fusible, airbreak disconnect switch, meeting the requirements of Every S3.
- B. Switch Cubicle:
 - 1. Mechanical Interlock:
 - a. The switch must be open before the door can be opened.
 - b. The door must be closed before the switch can be closed.
 - 2. Observation Window: Ample sized, high-impact, gasketed, positioned so that position of all three switches can easily be seen through the closed door.
 - 3. Safety Barrier: Metal, grounded, bolted closed in front of switch to prevent inadvertent contact with live parts; barrier must allow full-view inspection of the switch blade position.
 - 4. Operating Mechanism Cover: Hinged, with quarter turn nylon latches, to discourage casual tampering.
 - 5. Switch Position Indicators:
 - a. Green LED with label "OPEN"
 - b. Red LED with label "CLOSED"
 - 6. Locking Provisions: Suitable for padlocking switch in the open or closed position.
- C. Switch:
 - 1. Switching mechanism:
 - a. Three-pole, gang-operated.
 - b. Manual quick-make, quick-break over-toggle type not requiring use of chain or cable
 - c. Heavy-duty coil spring to provide opening and closing energy.
 - d. Normal Operation: Opening and closing speed independent of the operator; not possible to tease switch into intermediate position.
 - e. Maintenance Operation: Slow closing possible to check switch blade engagement; slow opening possible to check operation of arc-interrupting contacts.
 - 2. Contacts: Separate main and break contacts for maximum endurance during fault-close and load-interrupting duty.
 - 3. Barriers:
 - a. Insulating barriers between each phase and between the outer phases and the enclosure.
 - b. Isolating barrier between operating chain and switch blades.
 - 4. Grounds:
 - a. Positive beryllium copper grounds on each phase with switch in open position.
 - b. Grounds shall be visible through viewing window.
 - 5. Switch shall be removable from the structure as a complete operational component.
- D. Fuses:
 - 1. Provide fault protection using fuses with continuous ratings as determined based on load served.
 - 2. Provide UL certification for fuse/switch integrated momentary and fault close ratings.
- E. Service Entrance:

1. Make provisions for bottom (underground) service entrance and termination of the 13.2 kV incoming service cables. Conductors will be installed and terminated by Evergy during field installation.
2. Verify conduit entry locations to ensure proper termination of utility incoming cables.
3. Provide a copper ground conductor equivalent to 2/0 copper minimum around the inside of the enclosure walls in the cable termination compartment and solidly ground to the ac switchgear ground bus. Provide a grounding horn for use with portable grounds.

2.6 UTILITY METERING SECTION

- A. Section shall meet requirements of Evergy S8, referenced codes and standards, and additional requirements of Evergy, whether published or not.
- B. Coordinate with Evergy via the Engineer to verify requirements before preparing shop drawings.
- C. Submit switchgear shop drawings to Evergy via the Engineer in accordance with Evergy S8 and as directed by Evergy. If clarification of submittal requirements is needed, contact Evergy directly.
- D. Submit shop drawings to Engineer at the same time as submittal to Evergy and obtain approval from both Evergy and Engineer before starting manufacturing.
- E. Obtain Evergy-furnished PTs and CTs from Evergy and install in switchgear in accordance with Evergy S8 and as directed by Evergy.
- F. Furnish and install terminal blocks and PT and CT secondary wiring in accordance with Evergy S8 and as directed by Evergy.
- G. Enclosure access doors:
 1. Interior and exterior: Hinged on one side except as otherwise indicated with a two-point latch mechanism padlockable by Evergy.
 2. Access doors on enclosures containing revenue metering equipment shall be labeled, "UTILITY METERING CUBICLE: NO CUSTOMER EQUIPMENT."

2.7 MEDIUM-VOLTAGE CIRCUIT BREAKER SECTION

- A. General:
 1. Circuit breaker shall be a draw-out type and utilize vacuum interrupters having load and fault break capabilities and shall conform to or exceed the requirements of IEEE C37.06 and IEEE C37.12.
 2. Circuit breakers shall be identical and physically and electrically interchangeable.
 3. Circuit breaker frame shall be provided with a full front metal shield to prevent access to any live primary bus or load terminals when the circuit breaker is in the connected position.
 4. Provide a truck or fifth wheel at each switchgear location to facilitate one-person breaker removal and turning.
 5. Provide means for padlocking the ac breaker in the open position.
 6. Circuit breaker insulation:
 - a. Noncombustible, non-hygroscopic and track-resistant.
 - b. Mechanical strength and physical characteristics shall match the stresses imposed by the circuit breaker rated momentary current.
- B. Minimum ratings:
 1. Nominal System Voltage: 13.2 kV 3-phase.
 2. Maximum Voltage: 15 kV rms.
 3. Frequency: 60 Hz.
 4. Insulation Level, 60 Hz: 36 kV, rms.
 5. Insulation Level, impulse: 95 kV, crest.
 6. Continuous Current: 1200 A.
 7. Short Circuit Current at Maximum Voltage: 25 kA rms.
 8. Fault Clearing Time: Five cycles max.

- C. Circuit Breaker Operating Mechanism:
 - 1. Motor-charged and spring-operated unless otherwise approved by Engineer.
 - 2. Mechanism shall be designed to prevent overcharging.
 - 3. The mechanism shall ensure that the release of stored energy for closing the circuit breaker main contacts is prevented unless the mechanism has been fully charged.
 - 4. The stored-energy closing mechanism shall automatically charge itself within 15 seconds after closing of the breaker.
 - 5. Energy storage shall be sufficient for an open-close-open cycle at maximum rated short circuit current.
 - 6. Provide manual cranking capability to permit spring charging in the event motor power is unavailable. Provide one manual crank at each switchgear location.
 - 7. Provide manual trip and close buttons on front of circuit breaker.
 - 8. Withdrawal of circuit breaker from enclosure:
 - a. Provide an interlock to prevent withdrawal when the mechanism is fully charged.
 - b. Alternately, provide automatic controlled discharge of the stored energy when the circuit breaker is withdrawn from or inserted into the enclosure.
 - 9. Circuit breaker shall be electrically and mechanically trip free. The operating mechanism shall be non-pumping.
 - 10. Operation counter: Four-digit, non-resettable, register-type mechanical operations counter. Provide on each circuit breaker to record each close/open cycle.
- D. Circuit Breaker Control Voltage:
 - 1. Control voltage: 125 Vdc.
 - 2. Closing mechanism voltage range: Plus or minus 15 percent of the nominal dc control voltage.
 - 3. Tripping mechanism voltage range: Plus or minus 25 percent of the nominal dc control voltage.
- E. Circuit Breaker Control Switches:
 - 1. Open/Close: Switch located on breaker HMI and SAS HMI touch screen (see Section 34 21 31, Substation Automation System (SAS)).
 - 2. SAS HMI control switch shall permit open and close operations when the circuit breaker is in the connected position.
 - 3. Breaker HMI control switch shall permit open and close operations when the circuit breaker is in the test position.
 - 4. Provide a switch for resetting the circuit breaker after a trip and provide a mechanical trip indication at the control switch.
- F. Auxiliary contacts:
 - 1. Provide a minimum of six electrically separate sets of reversible auxiliary contacts, in addition to those required for the circuit breaker control circuit.
 - 2. Auxiliary contacts shall be operated by the breaker mechanism in both the "connected" and "test" positions.
 - 3. Spare auxiliary contacts shall be wired to the outgoing terminal blocks.
- G. Indicating LEDs:
 - 1. Provide indicating LEDs on the front of the circuit breaker enclosure to indicate the state of the circuit breaker:
 - a. Closed breaker: Red LED.
 - b. Tripped or open breaker: Green LED.
 - 2. Provide an amber LED above each local/remote switch which shall be illuminated when switch is in local position.
 - 3. Provide a white LED indicating light on the front of the circuit breaker enclosure to indicate the stored-energy closing mechanism is charged.

2.8 PROTECTIVE RELAYS

- A. General Requirements:

1. Conform to the applicable sections of IEEE C37.90.
 2. Cases: Rustproof metal or high-impact plastic rectangular cases with test switches, panel-mount form factor.
 3. Contacts: Silver-to-silver non-welding.
 4. Non-IED Relays: Self-resetting with seal-in, hand-resetting targets indicating relay operation.
 5. Arrangement:
 - a. Devices including switches, relays, indicating lights and test plugs shall be conveniently accessible and easily visible.
 - b. The grouping shall be modular and place related functions in proximity.
 - c. Devices of the same general type shall be manufactured by the same company and shall be similarly arranged and mounted.
 6. Mounting:
 - a. Flush mounted, plumb and square with the lines of the panels and as recommended by the manufacturer, with wiring connections on the back of the relay.
 - b. Mount on hinged or removable panels and not on a fixed portion of the switchgear.
 7. Color: Match color of switchgear. See Section 34 21 06P, TES Common Work Results for Metals for color.
- B. Provide the following protective and monitoring devices at a minimum, as shown in the Contract Drawings. Additional protective devices recommended by Vendor or equipment manufacturers may be installed with Engineer approval.
- C. Ac Protective Relay - Intelligent Electronic Device (IED):
1. For each medium-voltage ac breaker provide a multi-function protective relay IED and related transducers:
 - a. IED must capture real-time voltage and current for a triggered event with pre- and post-trigger sampling data useful for analyzing trip information, and store in non-volatile memory.
 - b. IED shall communicate with the SAS via protocol specified in Section 34 21 31P, TES Substation Automation System (SAS).
 2. Provide the following functions, at minimum:
 - a. Ac undervoltage (ANSI Device 27):
 - 1) Primary function: Trip and annunciate when the ac input voltage drops to 80 percent of nominal voltage.
 - 2) Relay shall also trip and annunciate upon loss of voltage due to utility outage.
 - 3) Relay shall contain field adjustable time delay.
 - b. Phase sequence relay (ANSI Device 47):
 - 1) Three-phase voltage protective relay connected to provide open phase protection.
 - 2) This relay shall contain a field adjustable time delay.
 - c. Ac overvoltage (ANSI Device 59):
 - d. Phase fault time overcurrent (ANSI Device 50/51).
 - 1) Primary function shall be to provide overload and fault protection for loads served.
 - 2) Relay shall be designed to compile a composite time overcurrent characteristic curve which shall best match the normal and overload requirements of the load and to match the thermal and mechanical withstand of transformers.
 - 3) Relay shall provide for both instantaneous and time delay overcurrent protection.
 - e. Ground fault time overcurrent (ANSI Device 50N/51N):
 - 1) A residual instantaneous and time delay relay connected to provide sensitive ground fault detection.
 - 2) This relay shall be field adjustable.
 - f. Control/Position of ac breaker (ANSI Device 52).
 - g. Reverse Power (Device 32):
 - 1) Provide in incoming feeder cubicle connecting to utility service switchgear.

- 2) This device shall trip and lock-out associated circuit breaker when it detects a flow of power from substation back toward the utility.
 - h. Local/Remote control (Device 43)
 3. Device shall have chart recording features with PC software used for downloading and analyzing faults. Transient fault recording function shall capture analog and digital pre-fault and post-fault waveforms and data.
- D. Provide the following additional ac protective relay:
1. Lockout (Device 86H/86):
 - a. Provide on the ac circuit breaker compartment.
 - b. Reset switch handle:
 - 1) Heavy-duty switchboard type pistol-grip handle.
 - 2) Acceptable Manufacturer: Electroschalt or approved equal.
 - c. Provide indication of "lockout" and "normal" at the reset switch.
 - d. When the main ac circuit breaker is tripped by the lockout relay, the following sequence of events shall occur:
 - 1) Dc feeder circuit breakers shall be opened for TES substations.
 - 2) Ac breaker shall remain locked out until manually reset.
- E. Trip Circuit Monitors:
1. Provide a trip circuit monitor for monitoring the trip coil on each of the following:
 - a. Medium voltage ac circuit breaker.
 - b. Lockout relay.
 2. Indication and Operation:
 - a. Green LED that illuminates when the trip coil is energized and turns off when the coil is de-energized.
 - b. NO and NC Form C contacts for indication of a failed trip coil.
 - c. Red LED that illuminates upon failure of the trip coil.
 - d. 200 millisecond delay to allow for auxiliary contacts to transfer.
 - e. LEDs: Plug-in replaceable with a life of 100,000 hours; protected against reverse polarity by a diode.
 - f. Control Power: 125 Vdc.
 - g. Manufacturer: E-max RAW-1D or approved equal.
- F. Protective device coordination: Installation Contractor shall be required to perform a coordination study for the ac system in accordance with Section 34 21 73, TES Studies.

2.9 INSTRUMENTS AND METERS

- A. Analog instruments and meters ANSI C39.1.
1. Provide analog switchboard type ammeter and voltmeter, with 250 degree scales, rated for use with corresponding transformer.
 2. Cases shall be dust proof and covered with a non-reflecting glass window.
 3. The accuracy of all indicating instruments shall be within 1 percent of full scale reading.
 4. Voltmeters and ammeters shall be rated for use with the corresponding transformer.
 5. Scales shall be of a suitable range, equal to the associated potential or current transformer primary rating.
 6. Provide incoming line phase selector switches for connection to the line transformers for the ammeter and voltmeter.

2.10 INSTRUMENT TRANSFORMERS

- A. Instrument transformers shall conform to IEEE C57.13, with the additional requirements indicated below.
- B. Current transformers:
1. Shall be capable of withstanding thermal and mechanical ratings of the circuit breaker.
 2. Molded-rubber or epoxy construction, wound-type or bushing-mounted.
 3. Wound-type current transformers:

- a. Provide separate compartment isolated from the control panel and all other equipment.
 - b. Provide a mounting frame which bolts securely to the switchgear frame.
 - c. Full-wave impulse insulation level: 125 kV.
 - d. Secondary terminal blocks shall have covers with integral shorting bars and secondary wiring shall be run to readily identifiable terminal block points in the control compartment.
 - e. Terminal block points shall also have integral shorting bars for the current transformer leads.
- 4. Bushing-type current transformers: Low-voltage, ring-core, high-accuracy type designed for secure mounting on the primary contact support bushings.
 - 5. Accuracy: Relaying accuracy classification, under the burdens imposed by the specified devices.
- C. Potential transformers (PTs):
- 1. Drawout-type, molded-rubber or epoxy construction.
 - 2. Transformers shall have full-wave impulse insulation level of 125 kV.
 - 3. Primary and secondary circuits of potential transformers shall be fused by means of non-renewable cartridge-type fuses meeting requirements of IEEE C37.46.
 - 4. Grounding of trunion: Trunion or other conveyance mechanism on which drawout PTs are mounted shall be continuously grounded in the fully inserted position, while being withdrawn, and when in the fully withdrawn position.
 - 5. Grounding of PT: Primary of PT shall be grounded, as soon as the primary circuit is disconnected, while the PT is being withdrawn and in the fully withdrawn position.
 - a. Grounds shall be beryllium copper.
 - b. Provide a viewing window in the PT drawer for viewing grounds. Grounding in the fully withdrawn position shall be visible from the exterior of the switchgear, without removing panels or parts, by a person standing on the floor.
 - 6. Fuses:
 - a. Primary fuses shall be completely disconnected before a person can access the transformer or its high-voltage fuses.
 - b. Secondary circuit fuses shall be installed in the low-voltage circuits and shall be located to permit replacement when the switchgear is in operation.
 - 7. Rating: Adequate for the burden requirements of the accuracy classification and capable of carrying rated load continuously without excessive heating or damage.

2.11 SOURCE QUALITY CONTROL

- A. Factory Design Tests:
- 1. Tests shall consist of all Design Tests as specified in IEEE C37.20.2.
 - 2. Perform tests on the ac switchgear assembly and each component of the ac switchgear.
 - 3. The main ac circuit breaker test shall be performed in accordance with the design tests as described in IEEE C37.09.
- B. Factory Production Tests:
- 1. Ac Circuit Breaker: Prior to mounting inside ac switchgear, perform the following on each ac circuit breaker in accordance with IEEE C37.09:
 - a. Nameplate check.
 - b. Control and secondary wiring checks.
 - c. Clearance and mechanical adjustment check tests.
 - d. Mechanical operation tests.
 - e. Timing tests.
 - f. Stored energy system tests.
 - g. Conductivity of the current path test.
 - h. Low-frequency withstand voltage tests on major insulation components.
 - i. Current transformer.
 - j. Resistors and coils.

2. Ac switchgear: Perform production tests as part of TES Substation Factory Acceptance Tests, as specified in Section 34 21 90P, TES Testing.

2.12 MANUFACTURE

- A. Manufacture switchgear in accordance with the referenced ANSI and IEEE standards.

2.13 INSTALLATION

- A. Install switchgear in TES substation enclosure in accordance with manufacturer's installation instructions and NECA 430.

2.14 SURGE ARRESTERS

- A. Provide surge arresters in Service Switchgear.
- B. Connect the surge arrester ground terminals directly to the switchgear ground bus connected to the station grounding electrode (by Installation Contractor).

2.15 TRANSFER TABLE

- A. Provide transfer table at each substation for removing and lowering PTs and draw-out fuse trunions.
- B. Table shall be capable of being raised and lowered hydraulically from floor to trunion levels.

PART 3 - EXECUTION

3.1 INSTALLATION

1. Install ac switchgear in accordance with Section 34 21 17P, TES Substation Design and Assembly, and Contract Drawings.

PART 4 - MEASUREMENT

4.1 MEASUREMENT

- A. The quantities of accepted work will be measured in the following units. All measurements will be plan measure except for authorized changes:
 1. Description: Lump Sum.

PART 5 - PAYMENT

5.1 PAYMENT

- A. Payment will be made at the respective unit or lump-sum price listed in the proposal and shall be full compensation for all labor, materials, and equipment necessary to complete the respective unit in place. There will be no separate measurement or payment for any item of work not specifically identified and listed in the proposal, and all such work shall be considered a subsidiary item with all costs pertaining thereto included in the prices for other items listed in the proposal. At the Engineer's option, partial payment may be made for any lump sum item listed in the proposal, providing that the Vendor is diligently and satisfactorily pursuing full completion of such partially complete item in accordance with the approved job progress schedule.

END OF SECTION

SECTION 34 21 16P
TES SUBSTATION ENCLOSURES
SUBSTATION PROCUREMENT ONLY

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Prefabricated enclosures for TES substations.
 - 2. HVAC for prefabricated enclosures.
 - 3. Testing of prefabricated enclosures.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 01 43 00 – Systems Quality Assurance
- C. SECTION 01 60 01 – Buy America Requirements
- D. SECTION 34 21 05P – Common Work Results for TES
- E. SECTION 34 21 06P – TES Common Work Results for Metals
- F. SECTION 34 21 08P – TES Dielectric Epoxy Flooring
- G. SECTION 34 21 17P – TES Substation Design and Assembly
- H. SECTION 34 21 31P – TES Substation Automation System (SAS)
- I. SECTION 34 21 80P – TES Spare Parts and Special Tools
- J. SECTION 34 21 90P – TES Testing
- K. SECTION 34 22 26P – TES Grounding and Bonding

1.3 DEFINITIONS

- A. Galvanneal: As defined in Section 34 21 06P, TES Common Work Results for Metals.

1.4 REFERENCED STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. American Institute of Steel Construction (AISC):
 - 1. AISC 303, Code of Standard Practice for Steel Buildings and Bridges
 - 2. AISC 360, Specification for Structural Steel Buildings
- C. ASTM International (ASTM):
 - 1. ASTM A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot Dip Galvanizing of Steel Assemblies
 - 2. ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - 3. ASTM E136, Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
- D. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. IEEE 1653.2, Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 V DC Nominal Output
 - 2. IEEE C37.20.1, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

- E. International Code Council (ICC):
 - 1. International Building Code
 - 2. International Mechanical Code
 - 3. International Energy Conservation Code
- F. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
 - 2. NEMA ICS 6, Industrial Control and Systems: Enclosures
- G. National Fire Protection Association (NFPA):
 - 1. NFPA 70, National Electrical Code

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Certification that products submitted meet Buy America requirements of 49 U.S.C. Section 5323(j) and 49 CFR Part 661, as per SECTION 01 60 01 – Buy America Requirements.
- C. Product Data:
 - 1. Seam caulking.
 - 2. Thermal and acoustical insulation, including weather stripping.
 - 3. Entry doors, including material, construction, and sealing gasket material.
 - 4. Door hardware, including hinges, handles, locks, panic bars, and door closer.
 - 5. Exterior equipment access door hardware including latches, hinges, gaskets, and door stops.
 - 6. HVAC units.
 - 7. HVAC control unit and thermostat.
- D. Spare Parts:
 - 1. Submit a list of spare parts to be provided under this Section.
 - 2. Submit at the same time as product data.
 - 3. Provide part numbers for each part, including a detailed break-down of each spare part assembly and set, as defined in Section 34 21 80P, TES Spare Parts and Special Tools.
- E. Shop Drawings:
 - 1. Structural and architectural plans to scale including the following:
 - a. Plans, elevations, and sections, including HVAC, door frames and openings, equipment mounting, lifting and anchorage details, and lighting.
 - 2. Drawings for fabrication including the following:
 - a. Floor plan showing framing and floor plate; equipment outlines and weights; floor openings; and welds and bolted connections.
 - b. Wall plans including framing, posts, beams, and other structural members; welds and bolted connections; interior and exterior wall panel details including interlocking, assembly of wall panels, and caulking; and connection of wall panel to base showing required z-type channel and wall panel lapped over floor seam.
 - c. Roof plan showing framing; welds and bolted connections; roof panel details including interlocking and rain cap, assembly of roof panels, and caulking; details of roof penetrations and the means used to prevent ingress of water; and connection of roof to walls.
 - d. Details of construction of doors, frames, welds, bolted connections and the means used to prevent ingress of water.
 - e. Penetrations for cable, conduit, ventilation, or other purposes.
 - f. Clear indication on each drawing of each type of material, including type of galvanized finish, if any; and dimensions, gauge or thickness.
 - 3. Enclosure equipment grounding details, including proposed ground grid connections.
- F. Compliance Certificates: For enclosure materials and performance.
- G. Calculations:
 - 1. Structural:

- a. Design calculations for the enclosure including analysis calculations for equipment, roof, wind, and seismic loadings, and for any temporary supports, certified by a structural engineer registered in the State of Missouri.
 - b. Design calculations for anchorage and supports, certified by a Professional Engineer registered in the State of Missouri.
- 2. HVAC:
 - a. Sizing of heating, ventilating, and air conditioning units, including tabulation of interior equipment heat gains, infiltration gains/losses, conductive gains/losses and solar gains, certified by a mechanical engineer registered in the State of Missouri.
- H. Testing:
 - 1. Submit test procedures that meet the requirements of Section 34 21 90P, TES Testing for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.
 - 2. Submit test reports that meet the requirements of Section 34 21 90P, TES Testing for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.
- I. Operations and Maintenance Data:
 - 1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following requirements:
 - a. Repair procedure for powder coat finish.
 - 2. Submit immediately after approval of product data.

1.6 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 80P, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
 - 1. Lock cylinders: Keyed for TES substation doors; provide 1 spare.
 - 2. Padlocks: Keyed for TES substation equipment access doors: Provide 2 spare.
 - 3. HVAC:
 - a. Complete units, including all sub-assemblies; Provide 1 spare.
 - b. HVAC fan; Provide 1 spare.
 - c. HVAC controller; Provide 1 spare.

1.7 QUALITY ASSURANCE

- A. Quality Assurance/Quality Control shall be carried out in accordance with the requirements of SECTION 01 43 00 – Systems Quality Assurance.
- B. Qualifications:
 - 1. Manufacturer of the pre-fabricated metal buildings shall be a company regularly engaged in the production of pre-fabricated galvanized steel buildings with a powder coat finish, and as approved by Engineer.
 - a. Manufacturer shall have constructed at least 50 similar buildings in the last 10 years.
 - b. Manufacturer shall be experienced in forming galvanneal conforming to ASTM A653/A653M with minimum coating weight A25.
 - c. Once a manufacturer is approved, it shall not be discharged or otherwise replaced by the Vendor without the written approval of Engineer.
 - d. Personnel working on metal buildings shall be experienced, skilled, and familiar with building construction, including installing air conditioning, heating and ventilation systems.
 - 2. Where engineering calculations are called out, they shall be performed by a professional engineer registered in the State of Missouri.

3. Welding shall be performed by Certified Welders. Refer to Section 34 21 06P, TES Common Work Results for Metals, for detailed requirements.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, storage, and handling shall be carried out in accordance with the requirements of 26 05 00-13, Systemwide Electrical General Requirements for Systems, except as modified herein.
- B. Obtain written permission from the Engineer before shipping substation.

1.9 WARRANTY

- A. Comply with warranty requirements in accordance with the General Conditions, Article 6.20.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Each substation enclosure shall be a shop assembled, free-standing, self supporting, steel building, utilizing channel perimeter framework and rigidly braced with channel and angle cross members.
- B. Completed assembly shall be designed for shipment for installation at site.
- C. The enclosure shall be a totally integrated weatherproof unit that houses the indicated substation equipment. The enclosure shall provide a dry, vermin proof, condensation free, stable internal ambient temperature environment.
- D. Provide a false brick façade for substation enclosure. Provide samples/colors for KCMO final selection. Vendor to propose material meeting the following requirements:
 - Resistant to fade or discoloration
 - Brick façade not required on doors
 - Shall not impede access or door/equipment operation
 - Fire resistant
 - Secured in a suitable manner for the TPSS service lifespan

2.2 ENCLOSURE DESIGN

- A. Design enclosures and components for the service life specified in Section 34 21 17P, TES Substation Design and Assembly.
- B. Design enclosure in accordance with AISC 303, AISC 360, International Building Code, and local building codes to withstand live roof loading, wind loading, and seismic loading based on the service conditions specified in Section 34 21 17P, TES Substation Design and Assembly, and the stresses caused during loading, transportation, unloading and installation.
- C. Access to the substation equipment will be from the sides and the rear. Enclosure design must allow the removal of all major equipment from outside or inside of the substation enclosure without disassembly of the equipment.
- D. Design enclosure for securing to a reinforced concrete slab as indicated on the Contract Drawings.
- E. Ratings:
 1. Complete enclosure shall have a NEMA 250 Type 4 rating.
 2. Doors, removable panels, joints, walls, roofs, floors, vents, louvers and outdoor accessories shall be weatherproof under environmental conditions specified in 34 21 17P, TES Substation Design and Assembly.

- F. Structural design engineering calculations and drawings shall be sealed by a professional engineer registered in the State of Missouri.

2.3 BASE

- A. Fabricate from welded structural steel beams, rigidly braced with steel cross members to provide adequate strength for lifting the complete assembly, including all equipment.
- B. Structural steel:
 - 1. Hot-dip galvanized before welding in accordance with Section 34 21 06P, TES Common Work Results for Metals.
 - 2. Avoid using structural steel members with nonsymmetrical sections to minimize warpage and distortion during hot-dip galvanizing, as recommended by ASTM A384/A384M.
- C. Welds:
 - 1. Mask steel in weld areas before galvanizing in accordance with Section 34 21 06P, TES Common Work Results for Metals.
 - 2. Touch up welds as required in Section 34 21 06P, TES Common Work Results for Metals.

2.4 ACCESS STEP

- A. Provide a single fabricated steel step assembly at each entry door.
- B. Design:
 - 1. Design such that water may not become trapped on or in the structure.
 - 2. Comply with the IBC and 29 CFR 1910.24.
 - 3. Include in structural design engineering calculations sealed by a professional engineer registered in the State of Missouri.
 - 4. If design includes bolted attachment, bolt heads must be on the interior and nuts on the exterior, with bolt heads tack welded on the interior so they cannot turn if tightening is required.
- C. Dimensions:
 - 1. Step depth: Minimum 10 inches, measured from outer edge of door threshold.
 - 2. Step width: As indicated on drawings.
 - 3. Height: 7 inches below interior finished floor height, plus or minus 1/2 inch.
- D. Material:
 - 1. Support structure: Steel.
 - 2. Step: Steel grating, non-skid.
- E. Finish:
 - 1. Hot-dip galvanized after fabrication in accordance with Section 34 21 06P, Common Work Results for Metals.
 - 2. If step is welded to base, mask steel in weld areas before galvanizing in accordance with Section 34 21 06P, TES Common Work Results for Metals.
 - 3. Coat welds made after hot-dip galvanizing in accordance with Section 34 21 06P, TES Common Work Results for Metals.

2.5 FLOOR

- A. Fabricate from steel plate stitch-welded to the base, with cutouts as indicated or required.
- B. Steel plate: Minimum 1/4 inch.
- C. The floor shall withstand the weight of the heaviest circuit breaker, rectifier transformer or other equipment item which may have to be moved along the floor, without significant deflection.
- D. Indicate in engineering calculations the piece of equipment that may be moved along the floor that was used for floor calculations.
- E. Cutouts:

1. Provide access to cables or conduits that penetrate floors as indicated on Contract Drawings or as otherwise necessary.
2. Provide insulated protection on edges for cable penetrations to prevent damage to cable insulation.
3. Provide removable cover plates for openings:
 - a. Ac switchgear: 11 gage steel with stainless steel hardware to latch it in place.
 - b. Dc switchgear: 1/4-inch glastic with non-metallic hardware to latch it in place.
 - c. Other penetrations: 1/4-inch glastic with non-metallic hardware to latch it in place.

2.6 WALLS

- A. Exterior walls:
 1. Material: Sheet steel panels, of a grade to be determined by Vendors structural design engineer.
 2. Coating:
 - a. Galvanneal meeting the requirements of ASTM A653/A653M with minimum coating weight A25.
 - b. Galvanneal shall not be quenched by the steel manufacturer or galvanizer or chemically treated in a way that inhibits powder coating.
 3. Thickness:
 - a. Minimum 11-gauge.
 - b. The specified minimum thickness shall apply to the base metal only.
 4. Interlock adjoining panels with J-type interlocking, as indicated in Figure 1, below.
 5. Seal seams with manufacturer recommended caulking.

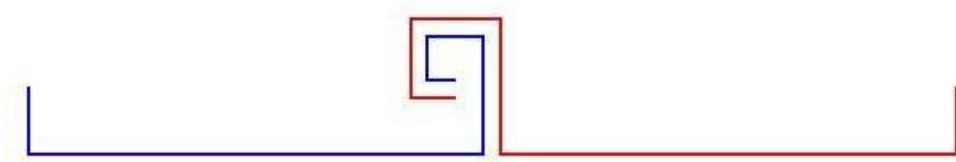


Figure 1: Cross Section Wall Panels J-Type Interlocking

6. At wall-panel base, provide Z-type channel and lap exterior wall panel over the floor seam to prevent drain back, as illustrated in Figure 2, below.

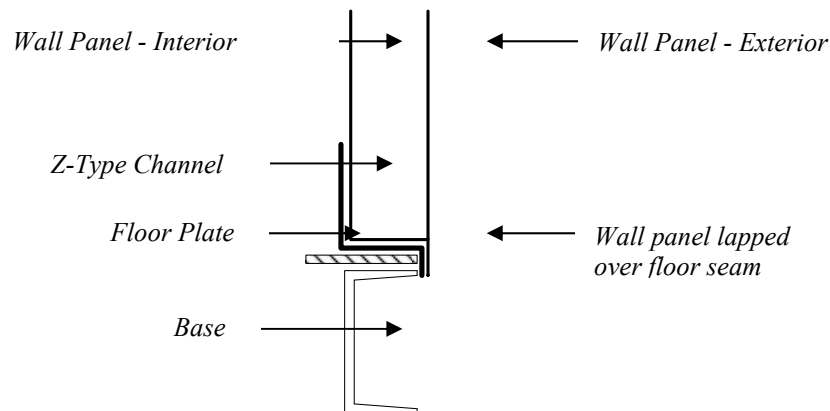


Figure 2: Cross Section Wall-Panel Base Z-Type Channel

- B. Interior walls:
 - 1. Material: Same as exterior walls, above.
 - 2. Coating: Same as exterior walls, above.
 - 3. Thickness:
 - a. Minimum 14-gauge.
 - b. The specified minimum thickness shall apply to the base metal only.

2.7 ROOF

- A. Shed type, with pitch as shown on Contract Drawings, fabricated from interlocking sheet steel panels.
 - 1. Material: Same as exterior walls, above.
 - 2. Coating: Same as exterior walls, above.
 - 3. Thickness: Same as exterior walls, above.
 - 4. Interlocking: J-type, with standing seams and rain caps over seams, as indicated in Figure 3, below.
 - 5. Seal seams with manufacturer recommended caulking.

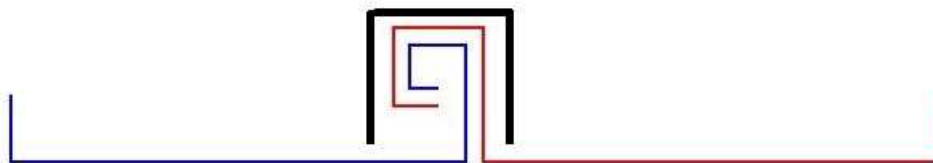


Figure 3: Cross Section Roof Panels Standing Seams With Rain Cap

- B. Roof penetrations:
 - 1. Shall be used only with approval of the Engineer.
 - 2. If used, shall be minimal, with each flashed and waterproofed.

2.8 THERMAL AND ACOUSTICAL INSULATION

- A. General Requirements:
 - 1. Insulating materials shall have a certified classification of "non combustible" as defined by ASTM E136.
 - 2. Flame proofing of insulating materials will not be acceptable. Proof of certification shall be by one of the following:
 - a. UL label or listing.
 - b. National Bureau of Standards test results.
 - c. Certified test report from a nationally recognized testing laboratory.
- B. Thermal Insulation:
 - 1. Enclosure thermal insulation shall comply with International Energy Conservation Code.
 - 2. Floor: Solid insulating panels.
- C. Acoustical insulation: Provide where needed to control continuous sound levels outside substations.

2.9 ENTRY DOORS

- A. Provide a minimum of two entry doors, located as indicated on the Contract Drawings.
- B. Material: Minimum 14 gauge sheet steel, galvanized in accordance with ASTM A653/A653 with minimum coating weight A40.
- C. Insulation: R value in accordance with applicable energy code.
- D. Size: Not smaller than shown on Contract Drawings.
- E. Door Hardware:
 - 1. Hinges: Stainless steel with stainless steel hinge pins.
 - 2. Panic hardware: One or three point crash-bar safety latches to permit opening doors from within under all conditions.
 - 3. Door Handles: Shaped such that they are easy to grasp with one hand and do not require tight grasping, pinching, or twisting of the wrist to operate. Door knobs are not acceptable.
 - 4. Locks: Self-locking, tamper proof, integrated with entry handles.
 - a. Locks all keyed alike.
 - b. Owner to provide keying requirements.
 - c. Provide two keys for each substation enclosure.
 - 5. Door Closer:
 - a. Heavy duty, highly corrosion resistant; all external body components of aluminum, zinc alloy or stainless steel material with stainless-steel fasteners.
 - b. Shall close door firmly and have hold-open position.
- F. Sealing:
 - 1. Doors shall be tightly sealed with neoprene gaskets.
 - 2. Secure seals to the doors so as to allow easy replacement.
 - 3. Design of doors shall prevent intrusion of water around the seams.

2.10 EXTERIOR EQUIPMENT ACCESS DOORS

- A. Provide hinged doors where shown on Contract Drawings:
 - 1. Equipment doors shall allow access to the rear of the ac switchgear, rectifier transformer, rectifier, and dc switchgear from the outside of the substation for regular maintenance.
 - 2. Opening the rectifier transformer rear double doors shall allow removal of the transformer as a unit from the outside of the substation.
- B. Material: Minimum 11 gauge sheet steel, galvanized in accordance with ASTM A653/A653M with minimum coating weight A25.
- C. Provide stiffening members as required.

- D. The exterior equipment access doors shall meet or exceed the requirements of NEMA ICS 6 for weatherproof NEMA 250 Type 4 enclosures.
- E. Latches:
 - 1. Three-point, padlockable, heavy-duty stainless steel switchgear type.
 - 2. Handle shall be located at working height referenced to actual final grade elevation at site.
- F. Hinges:
 - 1. Stainless steel, with stainless steel hinge pins and hardware.
 - 2. Provide a minimum of three concealed hinges.
- G. Door gaskets: Neoprene. Secure seals to doors to allow easy replacement.
- H. Door stop: Provide one for each door to hold it in the open position
- I. Padlock: Provide one padlock complying with Section 34 21 05, Common Work Results for TES, for each external door.

2.11 GROUNDING PADS

- A. Provide four copper grounding pads, bonded to the steel base of the enclosure at the corners as indicated on the Contract Drawings, for connection of 2-hole cable lugs.
 - 1. Grounding pads shall be on the interior of the base.
 - 2. Coordinate location of ground pads with location of access holes and adjust location of ground pads on switchgear side of the enclosure, if necessary, to make them accessible.
- B. Provide openings in floor for access, with removable cover plates as described above in Article titled "Floor."
 - 1. Size: Minimum 10 inches x 12 inches.
 - 2. Location: Coordinate access openings with equipment layout such that no part of the minimum size opening will be obstructed by the equipment. Openings in equipment provided for cable entrance may also be used for access to grounding pads.
- C. Connect enclosure grounding pads to enclosure interior perimeter ground specified in Section 34 22 26, TES Grounding and Bonding.

2.12 HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

- A. Interior Environment: Provide thermostatically controlled HVAC system to prevent condensation and maintain the interior temperature between 65 degrees F and 77 degrees F under all operating conditions.
- B. General Requirements:
 - 1. HVAC system shall comply with the International Mechanical Code.
 - 2. HVAC units shall be controlled by the same thermostat and control unit.
 - 3. High Temperature Alarm:
 - a. If substation interior temperature reaches 85 degrees F send alarm to SAS. See Section 34 21 31, TES Substation Automation System (SAS).
 - b. Alarm temperature set point shall be field adjustable.
 - 4. Supply voltage: Either 120/~~208~~ Vac ~~single or three phase~~ or ~~208~~120/240 Vac, single-phase.
 - 5. Finish color: Match finish color of substation enclosure.
 - 6. HVAC Units: Unitary, packaged, wall-mounted type, hermetically-sealed compressors, UL listed, AHRI performance certified, with economizer cycle, meeting minimum efficiency requirements of the International Energy Conservation Code.
- C. Ventilation and Air Conditioning: Design system for heat gain in the substation under the following simultaneous conditions.
 - 1. Maximum loading of the rectifier transformer per IEEE 1653.2 for Heavy Duty Traction Service.
 - 2. Exterior design conditions per International Energy Conservation Code.
 - 3. Maximum solar heat gain.

- D. Ventilation system shall provide sufficient air changes to prevent battery-evolved hydrogen gases from exceeding a 1 percent concentration level.
- E. Heating: Design based on conduction and infiltration heat loss with exterior design conditions per International Energy Conservation Code and substation de-energized (no heat gain from interior equipment).
- F. Air Intakes:
 - 1. Grill: Provide over filter to prevent entrance of foreign objects.
 - 2. Filters: Provide micro-glass, high-efficiency disposable filters in filter frames.
 - 3. Exterior: Provide tamper-proof hardware for filters located on exterior of enclosure.
- G. Provide two HVAC units for each substation enclosure with each unit capable of maintaining the interior environment specified above.
- H. Economizer Cycle Cooling:
 - 1. Provide HVAC units in conjunction with an exhaust fan to allow cooling using only exterior air when that air is less than 60 degrees F.
 - 2. Equip inlet and exhaust ducts for economizer cooling with gasketed, motorized dampers to seal the enclosure when economizer cooling is not possible.
 - 3. Economizer design shall maintain zero or slightly positive pressure within the substation enclosure at maximum ventilation rate.
- I. Redundant Operation:
 - 1. HVAC units shall operate with one unit on standby.
 - 2. Failure of the operating unit shall cause the other unit to commence operation automatically.
 - 3. Provide controls to manually and automatically alternate the units to minimize wear on each unit.

2.13 FINISHES

- A. Exterior metal surfaces:
 - 1. Roof and walls: Powder coat in accordance with Section 34 21 06P, TES Common Work Results for Metals.
 - 2. Floor bottom and support structure: Shop-applied paint coating system in accordance with Section 34 21 06P, TES Common Work Results for Metals.
 - 3. Color: See Section 34 21 06P, TES Common Work Results for Metals.
- B. Interior metal walls and ceiling:
 - 1. Powder coat in accordance with Section 34 21 06P, TES Common Work Results for Metals.
 - 2. Color: See Section 34 21 06P, TES Common Work Results for Metals.
- C. Interior floor surfaces:
 - 1. Shop-applied paint coating system in accordance with Section 34 21 06P, TES Common Work Results for Metals.
 - 2. Dielectric epoxy floor, where indicated on Contract Drawings, in accordance with Section 34 21 08P, TES Dielectric Epoxy Flooring.
 - 3. Floor shall have a non-skid finish.
 - 4. Color: Shop-applied paint coating system shall match color of dielectric epoxy flooring. See Section 34 21 08P, TES Dielectric Epoxy Flooring.

2.14 SOURCE QUALITY CONTROL

- A. Factory Design Tests:
 - 1. Coating qualification test: Perform in accordance with IEEE C37.20.1.
- B. Factory Production Tests:
 - 1. Rain test for outdoor LV switchgear:
 - a. Perform on each substation in accordance with IEEE C37.20.1. An existing design test will not be accepted; this test will not be waived.
 - b. In addition to IEEE C37.20.1 requirements, address HVAC systems as follows:

- 1) Test first with HVAC systems installed but not operating.
 - 2) If HVAC systems have louvered openings that open when the system is in operation, retest with all such openings in the fully open position.
- C. Replace IEEE C37.20.1 satisfaction of test requirements with the following: the enclosure shall have satisfactorily met the requirements of this test if during the visible inspection no water is found.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. As necessary, installation of HVAC units after substation delivery shall comply with the following:
1. International Mechanical Code.
 2. NFPA 70.
- B. Provide condensate drain pipe for HVAC units.

PART 4 - MEASUREMENT

4.1 MEASUREMENT

- A. The quantities of accepted work will be measured in the following units. All measurements will be plan measure except for authorized changes:
1. Description: Lump Sum.

PART 5 - PAYMENT

5.1 PAYMENT

- A. Payment will be made at the respective unit or lump-sum price listed in the proposal and shall be full compensation for all labor, materials, and equipment necessary to complete the respective unit in place. There will be no separate measurement or payment for any item of work not specifically identified and listed in the proposal, and all such work shall be considered a subsidiary item with all costs pertaining thereto included in the prices for other items listed in the proposal. At the Engineer's option, partial payment may be made for any lump sum item listed in the proposal, providing that the Vendor is diligently and satisfactorily pursuing full completion of such partially complete item in accordance with the approved job progress schedule.

END OF SECTION

SECTION 34 21 18P
TES LIGHTING
SUBSTATION PROCUREMENT ONLY

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Interior substation overhead and emergency lighting.
 - 2. Exterior substation lighting.
 - 3. Lighting inside equipment enclosures.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 01 43 00 – Systems Quality Assurance
- C. SECTION 01 60 01 – Buy America Requirements
- D. SECTION 34 21 17P – TES Substation Design and Assembly
- E. SECTION 34 21 25P – TES DC Control Power

1.3 REFERENCED STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE C62.41, Guide on Surge Voltages in AC Power Circuits Rated up to 600V
- C. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code
- D. Underwriters Laboratories Inc. (UL)
 - 1. UL 8750, Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Certification that products submitted meet Buy America requirements of 49 U.S.C. Section 5323(j) and 49 CFR Part 661, as per SECTION 01 60 01 – Buy America Requirements.
- C. Product Data:
 - 1. Document that proposed luminaires, ballast and lamps fully comply with Contract Documents.
 - 2. Indicate luminaire construction, photometric performance, installation, and maintenance requirements.
 - 3. Include clear and legible product specifications, drawings and illustrations of sufficient detail to describe the following:
 - a. Luminaire housing, hardware, and finishes.
 - b. Light controlling elements.
 - c. Electrical components, including lampholders, ballast, and provision for conduit entry.
 - d. Support details. Indicate weight of luminaire, complete with lamps.
 - 4. Include procedures for installation of the complete lighting unit in its final service location.
- D. Shop Drawings: Lighting layout with proposed luminaires indicated by manufacturer and model number.
- E. Calculations: Show that specified lighting levels are achieved with proposed luminaires.

- F. Operations and Maintenance Data:
1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Materials and components clearly indicated in the parts list.
 - b. Relamping methods.
 - c. Special tools required.
 - d. Frequency of inspection, tightening, or other service recommended for preventative maintenance.
 2. Submit immediately after approval of product data.

1.5 QUALITY ASSURANCE

- A. Quality Assurance/Quality Control shall be carried out in accordance with the requirements of SECTION 01 43 00 Systems Quality Assurance.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, storage, and handling shall be carried out in accordance with the requirements of 26 05 00-13, Systemwide Electrical General Requirements for Systems.

1.7 WARRANTY

- A. Comply with warranty requirements in accordance with the General Conditions, Article 6.20.

PART 2 - PRODUCTS

2.1 PERFORMANCE CRITERIA

- A. Each substation shall have interior and exterior lighting to provide the specified minimum light levels.
- B. Minimum Lighting Levels:
1. Interior: 70 footcandles at 30 inches horizontal above the aisle floor, unless otherwise approved by the Agency.
 2. Exterior: 2 footcandles, measured at ground level.
 3. Emergency Lighting: Minimum 2 footcandles at floor level.
 4. Minimum lighting levels shall be maintained throughout the substation. Average lighting level shall not be used to meet this requirement.

2.2 COMPONENTS

- A. Drivers:
1. Mount drivers securely inside luminaire to obtain the necessary heat dissipation.
 2. Drivers for LED-lamps shall match the characteristics of the lamps, and have the following characteristics:
 - a. Operate lamps at a frequency of 20 kHz or higher without visible flicker.
 - b. Listed Class P.
 - c. Total Harmonic Distortion: Less than 10 percent at 277 V.
 - d. Current crest factor: Less than 1.5.
 - e. Power factor: 0.98 minimum.
 - f. Audible noise rating: Class A or better.
 - g. Contain no Polychlorinated Biphenyls (PCBs).
 - h. Transient protection: IEEE C62.41, Category A.
 - i. Inherent thermal protection.
 - j. Provide constant light output with input voltage fluctuation of plus or minus 5 percent.
 - k. Provide instant-start for parallel wiring connection of lamps. Allow remaining lamps to maintain full output, in the event of lamp failure on multiple lamp luminaire.
 - l. Provide reliable lamp starting at 50 degrees F for interior luminaires and 0 degrees F for exterior luminaires.

- B. Lamps:
 - 1. Provide lamps used in the illumination system of standard manufacture, readily available, and of the highest efficiency and life consistent with other requirements of the illumination system.
 - 2. Ensure all lamps of each type are provided by a single manufacturer.
 - 3. LED Lamps:
 - a. Life: Ensure lamps have a rated minimum average life of 50,000 hours.
 - b. Color Temperature: Minimum 3500 degrees K Correlated Color Temperature (CCT).
 - c. Color Rendering Index (CRI): Minimum 80.
- C. Reflector Material: Prefinished, copper-free aluminum alloy, minimum thickness 0.032 inch, Architectural Type 1 with Class M1 anodic coating providing 83 percent reflectivity.

2.3 LUMINAIRES

- A. Interior of Substation Enclosure
 - 1. Ceiling mounted, industrial LED luminaire with clear, prismatic diffuser complying with UL 8750.
 - 2. Acrylic lens: Manufactured from virgin-acrylic extrusion or injection molding pellets.
- B. Exterior of Substation Enclosure:
 - 1. Wall-mounted, vandal-resistant, LED luminaire, full cut-off type.
 - 2. UL listed for 40 degrees C. maximum ambient and wet locations with IP66 ingress rating. Luminaire shall comply with IES LM-79 and LM-80 and be DLC (Design Lights Consortium) qualified.
 - 3. Housing: Die-cast aluminum, with a hinged door secured by captive stainless steel, tamper-resistant screw. Housing shall incorporate cooling fins specifically design for cooling LED light source and driver. Approximate dimensions of complete luminaire: 6"Wx7"Hx4"D including back-box. Provide with wire guard.
 - 4. Finish: Epoxy or polyester powder-coat paint, white.
 - 5. Optical: Sealed LED compartment with anodized, mirror-finish, forward-throw reflector, high-output bright-white (5000K CCT) LED, impact resistant tempered glass lens and silicone sealing gaskets. Luminaire shall deliver at least 1400 lumens, be rated full-cutoff with BUG rating B1-U0-G0 or better, and be suitable for wall-mounting 8 feet or greater above surrounding surface.
 - 6. Electrical: Integrated electronic LED driver with integral surge protection shall be mounted to housing for effective cooling. Provide luminaires with integral photocontrol or a single NEMA-style, aimable photocontrol wired in luminaire circuit.
 - 7. Acceptable Product: Lumark XTOR2A-WT-WG or approved equal.
- C. Emergency Lighting:
 - 1. Self-contained units containing lamps, battery, battery charger, controls, test switch, and status indicator.
 - 2. Lighting Heads: High-output 4.5 W LED MR16 lighting heads; minimum two lamps per unit.
 - 3. Battery:
 - a. Nickel-cadmium, 12 V, rechargeable, sealed, maintenance-free.
 - b. Capacity: Shall supply rated lamp load for 1-1/2 hours, minimum.
 - c. Life expectancy: 10 years.
 - 4. Battery charger:
 - a. Solid-state, current-limited, temperature-compensated, short-circuit proof, and reverse-polarity protected with plus-or-minus 1 percent regulation.
 - b. Charger shall automatically maintain battery in fully-charged float condition and be capable of providing full recharge in 12 hours.
 - 5. Unit controls shall energize the lamps automatically upon failure of the ac power supply and disconnect load before battery low-voltage limit is reached.

6. Housing: UV-stabilized, high impact, clear 0.120-inch polycarbonate or 18-gage steel, with a baked enamel finish.
7. Listing: UL listed for emergency lighting.
8. Acceptable Product: Kenall METEL-series LED or approved equal.

2.4 LIGHTING INSIDE EQUIPMENT ENCLOSURES

- A. Luminaire:
 1. Ceiling and side mounted, LED strip luminaire with clear, prismatic diffuser complying with UL 1570.
 2. Minimum illuminance: 30 fc at 1.5 feet.
 3. Color Temperature: 6000 K
 4. Minimum Length: 6 inches less than cubicle width.
 5. MTBF: 40,000 Hours
 6. Acceptable Product: LBFA Lux Bar LED light bar, or approved equal.
- B. Power Supply:
 1. UL listed, sized for load.
 2. Input: 125 Vdc
 3. Output: Compatible with luminaire voltage.

2.5 FACTORY ASSEMBLY

- A. General:
 1. Luminaires shall be supplied from the substation ac panelboard.
 2. Comply with NFPA 70.
 3. Luminaire quantities and locations shown on Contract Drawings are for illustration purposes only and may not be adequate to achieve specified lighting levels. Locate luminaires and provide a quantity sufficient to achieve specified lighting levels.
- B. Interior Luminaires:
 1. Locate to illuminate the vertical surfaces of equipment.
 - a. Coordinate to avoid interference with overhead raceways or other major wiring or blocking of the light.
 - b. Luminaires shall not be mounted directly above equipment.
 2. Switches:
 - a. Provide 3-way switches complying with requirements for switches in Section 34 21 17P, TES Substation Design and Assembly.
 - b. Mount inside by each entry door.
- C. Exterior luminaires: Locate on substation exterior walls to light all four sides of substation.
- D. Emergency lighting:
 1. Provide luminaires complete with lamps in place.
 2. Wire unswitched.
- E. Lighting inside equipment enclosures:
 1. Comply with NFPA 70.
 2. Supply luminaire power supplies from 125 Vdc power specified in Section 34 21 25P, TES Dc Control Power.
 3. Power supplies shall not be wired in series. Luminaires shall not be wired in series.
 4. Provide lighting for control and power cubicles within the ac switchgear, transformer, rectifier, and dc switchgear cubicles.
 5. Locate on ceiling and sides to light the interior of each equipment enclosure.
 6. Control cubicles: Provide two top or side mounted light bars directed towards the component and terminal mounting panel.
 7. Transformer/rectifier enclosure: Provide two top mounted light bars for every 2 feet of enclosure width.
 8. Switching:

- a. For each cubicle door, provide door switch as specified in Section 34 21 17P, TES Substation Design and Assembly.
- b. For each cubicle door with a viewing window, provide an external switch as specified in Section 34 21 17P, TES Substation Design and Assembly, in addition to door switch.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.

PART 4 - MEASUREMENT

4.1 MEASUREMENT

- A. The quantities of accepted work will be measured in the following units. All measurements will be plan measure except for authorized changes:
 1. Description: Lump Sum.

PART 5 - PAYMENT

5.1 PAYMENT

- A. Payment will be made at the respective unit or lump-sum price listed in the proposal and shall be full compensation for all labor, materials, and equipment necessary to complete the respective unit in place. There will be no separate measurement or payment for any item of work not specifically identified and listed in the proposal, and all such work shall be considered a subsidiary item with all costs pertaining thereto included in the prices for other items listed in the proposal. At the Engineer's option, partial payment may be made for any lump sum item listed in the proposal, providing that the Vendor is diligently and satisfactorily pursuing full completion of such partially complete item in accordance with the approved job progress schedule.

END OF SECTION

SECTION 34 21 19P
TES DC SWITCHGEAR
SUBSTATION PROCUREMENT ONLY

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. DC switchgear for TES substations, including the following:
 - a. Negative switch (89N) and positive switch (89P) sections
 - b. Feeder breaker sections
- B. Number of DC circuit breakers and the configuration of each TES substation are shown on the Contract Drawings.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 01 43 00 – Systems Quality Assurance
- C. SECTION 01 60 01 – Buy America Requirements
- D. SECTION 34 21 06P – TES Common Work Results for Metals
- E. SECTION 34 21 08P – TES Dielectric Epoxy Flooring
- F. SECTION 34 21 17P – TES Substation Design and Assembly
- G. SECTION 34 21 18P – TES Lighting
- H. SECTION 34 21 25P – TES Dc Control Power
- I. SECTION 34 21 31P – TES Substation Automation System (SAS)
- J. SECTION 34 21 80P – TES Spare Parts and Special Tools
- K. SECTION 34 21 90P – TES Testing

1.3 DEFINITIONS

- A. Intelligent Electronic Device (IED): See definition in Section 34 21 17P, TES Substation Design and Assembly.

1.4 REFERENCED STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE C37.14, Standard for Low-Voltage Dc Power Circuit Breakers Used in Enclosures
 - 2. IEEE C37.16, Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Ac (635 V and below) and Dc (3200 V and below) Power Circuit Breakers
 - 3. IEEE C37.20.1, IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
 - 4. IEEE C37.30.1, Standard Requirements for AC High-Voltage Air Switches Rated Above 1000 V
 - 5. IEEE C37.41, Standard Design Tests for High-Voltage (>1000 V) Fuses, Fuse and Disconnecting Cutouts, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Fuse Links and Accessories Used with These Devices
 - 6. IEEE C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus

- C. International Electrotechnical Commission (IEC)
 - 1. IEC 60077-1, Railway applications - Electric equipment for rolling stock - Part 1: General service conditions and general rules
 - 2. IEC 60077-3, Railway applications - Electric equipment for rolling stock - Part 3: Electrotechnical components - Rules for d.c. circuit-breakers

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Certification that products submitted meet Buy America requirements of 49 U.S.C. Section 5323(j) and 49 CFR Part 661, as per SECTION 01 60 01 – Buy America Requirements.
- C. Product Data: Complete manufacturer's product descriptions and catalog data, including information on the following:
 - 1. Design and application ratings.
 - 2. Details of circuit breaker, internal components, arc chute, contacts, and closing and tripping mechanisms.
 - 3. Details of switchgear, drawout mechanism, interlocks, and shutters.
 - 4. Relays, controls, switches, indicators, load measuring devices, resistors and cubicle heaters.
 - 5. Key Operated Mechanical Interlock: Kirk key catalog data.
 - 6. Bus insulating material.
 - 7. Certified service performance, reliability and 5-year proven service history record, including a complete device history of the following:
 - a. Multi-function relays.
 - b. Circuit breakers.
- D. Spare Parts and Special Tools:
 - 1. Submit a list of spare parts to be provided under this Section.
 - 2. Submit at the same time as product data.
 - 3. Provide part numbers for each part, including a detailed breakdown of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
 - 4. Submit a list of special tools to be provided under this Section, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
- E. Shop Drawings:
 - 1. Arrangement drawings.
 - 2. Schematic wiring diagrams.
 - 3. Interconnection diagrams.
 - 4. Bus insulating drawings.
- F. Complete details of transfer trip scheme.
- G. Kirk key scheme, including description, and detailed arrangement drawings.
- H. Testing:
 - 1. Submit test procedures that meet the requirements of Section 34 21 90P, TES Testing, for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.
 - 2. Submit test reports that meet the requirements of Section 34 21 90P, TES Testing, for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.
- I. Operations and Maintenance Data:
 - 1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Manufacturer's operating and maintenance instructions, parts list, illustrations and diagram for components.

- b. Wiring diagram.
- 2. Submit immediately after approval of product data.

1.6 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 73P, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section:
 - 1. Dc circuit breaker: Complete with truck and accessories. Provide 1 spares.
 - 2. Main contacts for dc circuit breaker: Provide 1 spare assemblies.
 - 3. Secondary contacts for dc circuit breaker: Provide 1 spare assemblies.
 - 4. Dc circuit breaker charging motors: Provide 1 spares.
 - 5. Dc circuit breaker solenoids: Provide 1 spares.
 - 6. Dc circuit breaker springs: Provide 1 spares.
 - 7. Dc protective relays (non-IED): Provide 1 spare set.
 - 8. Dc switchgear IEDs: Provide 1 spare set.
 - 9. Dc ammeter and voltmeter: Provide 1 spare set, if separate from IEDs.
 - 10. Dc switchgear control and auxiliary relays: Provide 1 spare set.
 - 11. Transducers: Provide 1 spare set.
 - 12. Dc switchgear control circuit fuses (if used): Provide 1 spare sets.
 - 13. Dc mini circuit breakers (if used): Provide 1 spare of each rating.
 - 14. Mechanical interlocks: Provide 1 spare set.

1.7 QUALITY ASSURANCE

- A. Quality Assurance/Quality Control shall be carried out in accordance with the requirements of SECTION 01 43 00 Systems Quality Assurance.
- B. DC Switchgear:
 - 1. UL labeled or furnished with a Field Evaluation label in accordance with Section 34 21 17P, TES Substation Design and Assembly.
 - 2. DC switchgear including circuit breaker shall have 5 years successful operation in service at a transit application.
- C. Manufacturers of dc switchgear and components used in the dc switchgear shall be ISO 9001 certified.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, storage, and handling shall be carried out in accordance with the requirements of 26 05 00-13, Systemwide Electrical General Requirements for Systems.

1.9 WARRANTY

- A. Comply with warranty requirements in accordance with the General Conditions, Article 6.20.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Dc Switchgear: Dead-front, self-ventilated, metal enclosed, free standing, sheet steel enclosures suitable for indoor service.
- B. Circuit Breakers: Provide switchgear with individually enclosed, draw out type, high speed, power circuit breakers rated for use with the transformer-rectifier unit.
- C. Rear Access:
 - 1. Prefabricated TES Substation: Provide through exterior equipment doors and design such that positive feeder cables and negative return cables can be landed from the rear.
- D. Front Access:

1. Prefabricated TES Substation: Provide access to removable components of the switchgear from the front.
- E. Bus and Power Wiring:
 1. Prefabricated TES Substation: Locate in rear.
- F. Complete Assembly: Include dc buses and connections, positive and negative feeder cable terminal connections, indicating lights, terminal blocks, protective and auxiliary relays, control circuitry, wiring and all other devices necessary to make a complete and operable switchgear assembly.
- G. Workmanship: Avoid wiring congestion, train wires neatly, protect wiring from sharp edges.
- H. Standards: Design, materials, construction, and tests shall be in accordance with IEEE C37.14, IEEE C37.20.1, and as further described or modified in this Section.
- I. Finish: Powder coat and color in accordance with Section 34 21 06P, TES Common Work Results for Metals.

2.2 RATINGS

- A. The switchgear assembly and circuit breakers shall have the following minimum ratings in accordance with IEEE C37.14 and IEEE C37.16:

Full-Load Voltage	750 Vdc (Nominal Voltage 800Vdc)
Maximum Voltage	1000 Vdc
Continuous Current	2000 A
Minimum Frame Size	2000 A
Insulation Level:	
60 Hz withstand	3.7 kV rms
Short circuit rating	30 kA, peak

2.3 SWITCHGEAR ENCLOSURE

- A. Switchgear Structure:
 1. Steel, rigid, self-supporting, self-contained, conforming to IEEE C37.20.1 and to requirements indicated below:
 2. Fabricated of electrically welded or bolted sheet steel, 11 gage minimum.
 3. Provide enclosures sufficiently rigid to support equipment under normal loads, short-circuit conditions, and specified seismic conditions.
 4. Apply coating to switchgear assembly in accordance with Section 34 21 06P, TES Common Work Results for Metals.
- B. Doors: Sheet steel, 11 gage minimum, properly reinforced against distortion by suitable flanges and stiffening members.
 1. Hinges: Heavy duty stainless steel.
 2. Latches: Minimum of three latches shall securely fasten door in the closed position and shall be easily opened without the use of tools.
 3. Handle: Heavy duty, padlockable, opens all three latches, easily operated with one hand-motion, one for each door.
 4. Door stops: Heavy duty to hold door securely in the open position. Not easily bent if an attempt is made to close door without releasing door stop.
- C. Heaters: Provide two thermostatically-controlled strip-type heaters in each switchgear cubicle to prevent condensation.
 1. Operating Voltage: Shall not exceed 50 percent of heater rated voltage.
 2. Thermostat:

- a. Provide an individual thermostat for each cubicle.
 - b. Locate thermostat in a general area of each cubicle so that cool air at the lower portion of the enclosure can be sensed by the thermostat.
- 3. Digital Heater Ammeter: Provide on the front of each cubicle enclosure to indicate current and operation of heaters.
- 4. Power Source: 120 Vac auxiliary power system; use an isolation transformer.
- D. Lights: Provide inside equipment enclosures, as specified in Section 34 21 18P, TES Lighting.
- E. Warning Signs:
 - 1. Comply with requirements for warning signs in Section 34 21 17P, TES Substation Design and Assembly.
 - 2. Provide signs on front, rear, and side access doors of cubicles where 600/750 Vdc wiring is present: "DANGER: LIVE PARTS" and "DANGER: HIGH VOLTAGE."
 - 3. Provide signs on removable rear access doors: "DANGER: HIGH VOLTAGE."
- F. Dc circuit breaker cubicle:
 - 1. Suitable for accommodation of drawout circuit breakers.
 - 2. Supporting Guide Rails: Provide for positioning removable elements as an integral part of equipment.
 - 3. Design such that circuit breakers are easily drawn in or out of their housings.
 - 4. Include stationary disconnecting device contacts for the circuit breakers.
 - 5. Breakers shall connect or disconnect from buses and auxiliary circuits by means of self-aligning, self-coupling, primary disconnecting devices.
 - 6. Provide self alignment mechanisms such that misalignment of contact is not possible when circuit breaker elements make contact with stationary contacts.
 - 7. Control Wiring: Connection to the dc breaker may be by movable contacts or by a plug-style disconnect.
 - a. Plug style disconnect:
 - 1) It shall not be mechanically possible to rack breaker into the connected position with the plug disconnected.
 - 2) Locate where easily accessible. Engineer will make final determination whether location is easily accessible.
 - 3) Provide heavy-duty connection hardware not easily bent or broken due to mishandling.
 - 8. Provide suitable shrouds or automatic safety shutters on devices to prevent accidental contact with live parts.
 - 9. Provide each enclosure with protective shutters that cover live high-voltage terminals when the access door is opened or a dc feeder breaker is racked out of the cubicle.
 - 10. Provide each compartment with a hinged door or full width drawout panel for front access to the circuit breakers, instruments and terminal blocks.
 - 11. Provide rear access doors in prefabricated substations to facilitate access to the dc power bus. Doors shall swing fully open against the adjacent door or enclosures.
 - 12. Provide connections to the dc feeder cables in the rear compartment.
 - 13. Construct switchgear enclosures to allow for the dissipation of ionized gas from the circuit breaker arc chutes without hazard to personnel from the discharge of hot gas or other materials.
 - a. Release gas from the units to the outside of the switchgear enclosure by means of suitable stacks, louvered vent openings, or vent openings covered with grilles.
 - b. Provide adequate clearance to ground to prevent the possibility of establishing a conducting path to grounded structure or objects when interrupting maximum short-circuit energy at rated maximum voltage.
 - c. Line enclosure surfaces exposed to arcs or ionized gases with flame resistant, high dielectric insulating materials.
 - d. This paragraph is not intended to require the use of arc-resistant switchgear.
 - 14. Stacking of dc circuit breakers in cubicles is not permitted.

- G. Negative and Positive Switch Cubicles:
 - 1. Mount positive and negative switches in separate isolated cubicles, either stacked or side by side.
 - 2. Negative switch may be provided as part of rectifier but must be isolated from rectifier.
 - 3. Cubicles shall have a hinged door with a clear window for viewing negative or positive switch position.
- H. Separate high voltage devices from low voltage controls:
 - 1. If high voltage devices and low voltage controls are located in the same cubicle, identify high and low voltage by color coding mounting panels.
 - 2. No controls are allowed in rear cable and bus compartment.
- I. The control devices can share the same compartment with the protection devices.
 - 1. Control/protection compartment shall be dead-front and shall consist of hinged swinging panels mounted on the switchgear frame.
 - a. Construct swinging panel doors to support flush and semi-flush mounted devices.
 - b. Swinging panel doors shall not distort from a plane surface in any position.
 - c. Swinging panel doors of control/protection compartment shall be supported by stainless steel hinges.
 - d. Panel doors shall swing open and provide free access to the area behind the panel, the rear of the devices mounted on the panels, wiring, terminal blocks, and auxiliary devices mounted within the compartment.
 - e. Secure swinging panel doors in the closed position with two positive latching or screwed fasteners that can be operated by hand without tools.
 - f. Swinging panel doors shall open 90 degrees and be held with heavy duty stops.

2.4 BUS AND BUS CONNECTIONS

- A. Main horizontal dc switchgear bus shall be an extension of the rectifier bus, run the length of the dc switchgear. Tap to serve each circuit breaker.
- B. Bus: Electrical grade copper with high electrical conductivity, rated 2000 A.
- C. Bolted bus connections: Silver-plated copper.
 - 1. All connections to the bus shall be bolted.
 - 2. Applies to bus taps, circuit breaker connections, cable connections, and connections of devices such as transducers and shunts.
 - 3. Bolts: Silicon bronze of sufficient number and size for application. Minimum two bolts per joint. Zinc plated steel bolts may also be used.
 - 4. Washers: Provide a Belville washer for each bolt, properly sized for the application.
 - 5. Conductivity: Each joint shall have conductivity at least equal to that of the bus bar and shall be so clamped that no loss of conductivity will occur during the life of the switchgear.
- D. Insulation:
 - 1. Insulate main bus and feeder bus from each other by one of the following means:
 - a. Electrical insulating laminate barrier that completely encloses bus on both sides and both edges.
 - b. Insulating boot.
 - c. Insulated coating.
 - d. Other approved means.
 - 2. Insulate connections to the bus using a boot.
 - 3. Mount bus bars on barrier-type insulation or post-type insulators.
- E. Strength: Bus, bus connections, and bus insulation shall withstand thermal and mechanical stresses resulting from maximum available short-circuit current or rms interrupting rating of circuit breakers whichever is greater, without damage or permanent distortion.

2.5 POSITIVE AND NEGATIVE DISCONNECT SWITCHES

- A. Provide a negative dc disconnect switch (Device 89N) and a positive dc disconnect switch (Device 89P) in each substation dc switchgear assembly, as shown in Contract Drawings. Each switch shall meet the following requirements:
 - 1. Type: Manually-operated, single-pole, bolted-pressure type, solid copper blade with silver plated contacts.
 - 2. Rating: 2000 A continuous current at 1000 Vdc and withstand twice the expected rms bolted short circuit currents.
 - 3. Insulation level: Sufficient to pass 1 minute 60 Hz dry withstand test at 3.7 kV, rms.
 - 4. Handle: Provide an insulated operating handle.
 - 5. Switch Position Indication:
 - a. Provide a green and a red indicating light on the front panel of cubicle for each switch:
 - 1) Green illuminated: Switch open.
 - 2) Red illuminated: Switch closed.
 - b. Provide indication to SAS; see Section 34 21 31P, TES Substation Automation System (SAS).
 - c. See Section 34 21 17, TES Substation Design and Assembly, for requirements for Device 33 position switch.
 - 6. Instructions: Provide a simple operation instruction nameplate on each cubicle door.
- B. Negative Disconnect Switch - 89N:
 - 1. Connection: Install between the negative return cable and the rectifier negative pole.
 - 2. Interlock with Positive Switch:
 - a. Provide key interlock with positive disconnect switch to ensure negative switch can be opened only when positive switch is open.
 - b. Key removal from the negative disconnect switch shall be possible only when the negative disconnect switch is closed.
 - c. Opening of negative disconnect switch shall require the key to be inserted in the negative disconnect switch.
 - 3. Interlock with Dc Circuit Breakers:
 - a. If negative switch is in the open position it shall not be possible to close a dc circuit breaker.
- C. Positive disconnect switch - 89P:
 - 1. Connection: Install between the rectifier output and the dc feeder breakers.
 - 2. Interlock with Negative Switch:
 - a. Key interlock with the negative switch to prevent positive switch from closing when the negative disconnect switch is open.
 - b. Key shall not be removable from the positive switch when the negative disconnect switch is closed.
 - c. With the key removed from the positive switch it shall be mechanically locked open.
 - 3. Interlock with Ac Switchgear: Key interlock to ensure no-load opening.

2.6 CIRCUIT BREAKERS

- A. Dc circuit breakers: Single-pole, air-break, high-speed, removable type.
 - 1. Manufacture in accordance with IEEE C37.14, and rate according to the preferred ratings listed in IEEE C37.16, except as indicated in this Section.
 - a. As an alternate, provide dc circuit breakers tested according to IEC 60077-1 and IEC 60077-3.
 - 2. Suitable for local and remote supervisory control.
 - 3. Electrically operated and electrically and mechanically trip-free with the mechanism insuring full contact pressure until time of opening.
 - 4. Insulated to withstand 3.7 kV, rms at 60 Hz for 1 minute.
 - 5. Peak rated momentary current: 30 kA, minimum.

- B. Instantaneous (Device 76): Provide each dc feeder circuit breaker with a direct-acting, bi-directional, instantaneous overcurrent tripping device adjustable between 150 percent and 350 percent of the breaker rating.
- C. Contacts:
 - 1. Surfaces of the moving and stationary contact members of the main contacts shall be silver, non-welding silver alloy, or equivalent that combines high conductivity and necessary arc-resistant properties.
 - 2. Main and secondary contacts of breaker shall be removable for replacement.
- D. Operating mechanism:
 - 1. Solenoid-operated or motor-charged stored-energy, spring-operated type.
 - a. Connect solenoid operated mechanisms such that the control voltage is removed from the closing coil after a preset time.
 - b. In the event the breaker does not close or the closing control circuit is not opened, a trip sequence shall be initiated to open the closing control circuit and restore all closing sequence relays to their normal position.
 - c. Motor-charged and spring-operated mechanisms:
 - 1) Mechanism shall be designed to prevent overcharging.
 - 2) The mechanism shall ensure that the release of stored energy for closing the circuit breaker main contacts is prevented unless the mechanism has been fully charged.
 - 3) The stored-energy closing mechanism shall automatically charge itself within 15 seconds after closing of the breaker.
 - 4) Energy storage shall be sufficient for an open-close-open cycle at maximum rated short circuit current.
 - 2. Mechanism shall be non-pumping.
 - 3. Design shall ensure positive opening of the moving contacts and circuit interruption when the tripping impulse is received at the fully closed or any partially open position.
 - 4. Provide control with a shunt trip device with the necessary auxiliary control equipment.
- E. Breaker Position: Make provisions for moving each breaker to a "connected", "test" and "disconnected" position with positive stops in each position.
 - 1. "Connected" position: Both the primary disconnecting devices and the secondary disconnecting devices shall be in full contact and the breaker shall be in position for normal operation.
 - 2. "Test" position: Primary disconnecting devices shall be open and separated by a safe distance and the secondary disconnecting devices shall be in full contact.
 - 3. "Disconnected" position: Both primary and secondary disconnecting devices shall be open and separated by a safe distance and shutter closed.
 - 4. Position Indicator: Provide an indicator to show the location of the circuit breaker in "connected," "test," or "disconnected" positions.
- F. Mechanical and Electrical Interlocks:
 - 1. Mechanical:
 - a. Provide interlock to prevent moving circuit breaker in or out of the "connected" position when circuit breaker main contacts are in the closed position.
 - b. Provide interlock to prevent closing the circuit breaker manually unless the breaker is in the "test" or "disconnected" position.
 - 2. Electrical: Provide interlock to prevent closing circuit breaker electrically, unless the circuit breaker is in the "connected" position with the primary disconnecting devices in full contact, or in the "test" position.
- G. Breaker Control:
 - 1. Breaker control switch: Incorporate into SAS HMI and dc breaker protective IED. For additional information on SAS HMI see Section 34 21 31, TES Substation Automation System (SAS), .
 - a. Breaker in Connected Position: Breaker control by SAS HMI.

- b. Breaker in Test Position: Breaker control by dc breaker IED HMI.
 - c. Request to close a dc feeder breaker shall be governed by the load measure reclose system. See Protective Devices article, below, for details of the load measure reclose system.
 - d. Provide sufficient logic to ensure that a response to an HMI or remote supervisory closure request will not result in an unsafe condition or cause damage to the substation or any of its components.
 - 2. Bypass Load Measuring:
 - a. Provide control on SAS HMI that allows an authorized operator to bypass load measure system when closing breaker.
 - b. See Section 34 21 31P, TES Substation Automation System (SAS) for details of operation.
 - 3. Manual trip:
 - a. Provide each circuit breaker with mechanical means for manually tripping the circuit breaker in the "test" and "connected" positions.
 - b. This function shall be available with the compartment door closed.
 - 4. Control power: Provide from 125 Vdc control power system per Section 34 21 25P, TES Dc Control Power.
- H. Indication:
- 1. Electrical:
 - a. Provide red and green indicating lights on each breaker unit for electrical closing and opening of the breaker while in the "test" or "connected" positions.
 - 1) Red light illuminated: Breaker closed.
 - 2) Green light illuminated: Breaker open.
 - 3) Provide long life, high brightness and high visibility, LED array lights.
 - b. Provide indication to SAS; see Section 34 21 31P, TES Substation Automation System (SAS).
 - 2. Mechanical: Provide a mechanical indicator, visible when the door is closed, to show when the circuit breaker is in the "open" and "closed" condition.
- I. Auxiliary Contacts:
- 1. Provide a minimum of four electrically separate sets of reversible auxiliary contacts, in addition to those required for the circuit breaker control circuit.
 - 2. Auxiliary contacts shall be operated by the breaker mechanism in both the "connected" and "test" position.
 - 3. Spare auxiliary contacts shall be wired to the outgoing terminal blocks.
- J. Arc chutes:
- 1. Metal plate or magnetic coil type.
 - 2. Suitable for bidirectional current flow.
 - 3. Designed for positive interruption of currents from 0 A to circuit breaker maximum rating.
 - 4. If required, provide circuit breaker Provide with an air puffer device to extinguish low-current arcs.
- K. Operations Counter: Provide four digit, non-resettable, register type mechanical operations counter on each circuit breaker to record tripping operations.
- L. Lockout Provisions:
- 1. Provide means to permit padlocking the dc breaker in the open position to prevent inadvertent closure without having to withdraw the breaker element.
 - 2. Padlocking means shall not allow breaker to be inserted further than the test position.
- M. Breaker Truck Wheels:
- 1. Provide circuit breakers with approved wheels to remove element from cubicle.
 - 2. Fifth Wheel:
 - a. If breaker truck cannot be easily turned when outside the breaker cubicle, provide a fifth wheel.

- b. Engineer will make the determination whether breaker truck can be easily turned.
 - c. Wheels shall not damage epoxy floor coating.
- N. Interchangeability:
 - 1. Removable elements of the same type and rating shall be completely physically and electrically interchangeable.
 - 2. Removable elements not of the same type of rating shall not be physically interchangeable.

2.7 TES SUBSTATION DC CABLE CONNECTIONS

- A. Bottom or top feed for negative and positive dc feeders, as required.
- B. Provide ample space for pulling and terminating the feeder cables entering or leaving the switchgear without requiring a less than specified cable bending radius.
- C. Provisions shall be made for the termination of up to four 250 kcmil, 2 kV dc positive cables in each feeder breaker section.
- D. Provide for the termination of up to eight 250 kcmil, 2 kV dc negative return cables on load side of the negative disconnect switch.

2.8 PROTECTIVE DEVICES

- A. General Requirements:
 - 1. Protective relays and multifunction relays provided in dc switchgear shall be Intelligent Electronic Devices (IED) equipped with communication function.
 - 2. Built-in Functions:
 - a. Control.
 - b. Measurement.
 - c. Fault recording: Capture real-time voltage and current for a triggered event with pre- and post-trigger sampling data useful for analyzing trip information, and store in non-volatile memory.
 - 3. Alarm Communication: Send alarms to SAS via protocol specified in Section 34 21 31P, TES Substation Automation System (SAS).
 - 4. Screens: LCD.
 - 5. Time Synchronization: Protective IEDs shall synchronize time with SAS.
 - 6. Protective Device Coordination: Installation Contractor shall perform a coordination study for the dc system in accordance with Section 34 21 73P, TES Studies, to obtain preliminary relay settings.
 - 7. Final Settings: Installation Contractor shall make final adjustments to relaying systems and protective devices during TES Substation Field Acceptance Testing and Integrated Testing specified in Section 34 21 90P, TES Testing.
 - 8. Contact Wire Thermal Rise: Set instantaneous and sustained current curves to limit the contact wire thermal rise to less than 165 degrees F.
 - 9. Complete Installation: Provide additional components such as auxiliary relays, isolating diodes and similar devices not shown in the Contract Drawings, but required for a complete installation.
- B. Arrangement and Appearance:
 - 1. Arrange devices such as auxiliary relays, indicating lights and test plugs to be conveniently accessible and easily visible.
 - 2. IED meters and displays shall be located such that they are easy for a person standing at floor level to operate and read.
 - 3. The grouping shall be modular and place related functions in proximity.
 - 4. Mount devices plumb and square with the lines of the panels and mount as recommended by the manufacturer and approved by Engineer.
 - 5. Auxiliary devices shall match the general appearance as far as possible with frames of a compatible approved color and finish.

6. Devices of the same general type shall be manufactured by the same company and shall be similarly arranged and mounted.
 7. Refer to substation one-line diagram in the Contract Drawings for arrangement of protective relays and devices.
- C. At a minimum, provide the following protective functions/devices as shown below and on the substation one-line diagram in the Contract Drawings. Additional protective functions/devices recommended by equipment manufacturers may be installed with Engineer approval.
1. Dc Feeder Multifunction Relay IED:
 - a. Acceptable Manufacturer/Product: Siemens Sitras Pro, or approved equal.
 - b. Functions: Include the following at minimum:
 - 1) Overcurrent: At minimum, provide the following overcurrent protection functions, which shall operate in the forward and reverse current directions:
 - a) Instantaneous Overcurrent Trip ([Device 150](#)).
 - b) Low Level Fault Trip and associated time delay ([Device 151](#)).
 - c) Timed Overcurrent Trip:
 - (1) Provide timed overcurrent trip function with inverse time characteristic that can be graphed with the set current, I_{tmd} , as the y-axis, and the time delay, T_{mdDel} , as the x-axis.
 - (2) Tripping shall be initiated when the load current exceeds the set current during the period of time t such that (t/T_{mdDel}) and (I_{load}/I_{tmd}) correspond to a point on the curve.
 - 2) Rate of Rise Trip ([Device RoR](#)): Shall be initiated if all of the following conditions are met:
 - a) Current di/dt exceeds the trip limit, di/dt .
 - b) Di/dt stays above the trip limit during the delay time, Delay.
 - c) During the delay time current exceeds the current rise limit.
 - c. Load Measure and Reclose:
 - 1) Provide each dc feeder cubicle with a set of automatic reclosing functions and equipment, including the following:
 - a) Load measuring function ([Device 82/182](#)).
 - b) Adjustable time delay reclosing function ([Device 83/183](#)).
 - c) Load measuring resistors mounted on the top of the circuit breaker cubicle;
 - d) Associated accessories.
 - 2) Initiate the load measuring and automatic reclosing cycle when either the dc circuit breaker receives a "close" command (from the local or remote control), or when the circuit breaker is tripped automatically and attempts to reclose.
 - 3) A "lockout" status or intentionally initiated trip of the dc lockout relay shall disable the load measuring and automatic reclosing cycle.
 - 4) Precede initiation of the load measuring cycle by an adjustable time delay to permit the faulted line section to become fully de-energized.
 - 5) At the commencement of the load measurement cycle, a voltage sensor shall determine whether there is no voltage on the section.
 - 6) If the voltage measuring circuit detects potential on the section, it shall reclose the associated circuit breaker immediately, providing that this potential is greater than a preset value.
 - a) The pickup setting shall be adjustable over the range of 60 to 750 Vdc.
 - b) Initially the pickup voltage shall be set to 560 Vdc.
 - 7) If the voltage measuring circuit detects no potential on the section, the load measuring function shall make repeated load measurements at suitable adjustable time intervals.
 - 8) If a load measurement determines that no fault is present, initiate automatic reclosing of the circuit breaker.
 - 9) A successful reclosure with no automatic trip within five seconds shall complete the measurement cycle and reset the devices to their initial state.

- 10) Make provision for selection of up to six attempts to complete a successful load measurement and automatic reclosing cycle at 15 second intervals, within a 3 minute period. Set initially at three attempts.
- 11) If no successful reclosure takes place in the three minute period, the automatic reclosing and load measuring system shall lock out the feeder breaker from closing.
- 12) Provide each automatic reclosing and load measuring function with test facilities that shall check the functioning of all devices.
 - a) Initiate test cycle with a local "test" push-button, which shall be functional only when the circuit breaker removable element is in the "test" position.
 - b) Circuit breaker shall not close until after completing automatic reclosing and load measuring test when the breaker is in the "connected" position.
- 13) Monitor condition of reclosure device.
- d. Incomplete Sequence (Device 148):
 - 1) This function shall detect the failure of a dc circuit breaker to clear a fault within a predetermined time.
 - 2) This function shall actuate the ac lock-out relay (Device 86) when actuated.
 - 3) This function shall actuate the dc lock-out relay (Device 186) when actuated.
- e. Transfer Trip:
 - 1) Provide two types of transfer trip:
 - a) The first type shall be automatically resettable (Device 85/~~185~~). Automatic resetting shall be controlled by the load measure reclose relay and occurs on di/dt faults.
 - b) The second type shall require manual resetting (Device 85L/~~185L~~). It shall trip the dc lockout relay (Device 186~~H~~) in both the originating and receiving substations, and is required for dc instantaneous over-current, frame faults, rail-to-earth potential faults, incomplete sequence faults, and emergency shutdowns.
 - 2) Configure TPSS SAS devices as required for full transfer trip functionality over a fiber optic connected communications network. Transfer trip function and network communications must be fully operational.
 - 3) Provide communication function blocks or other programming required for relays and IEDs to establish relay-to-relay communication between substations.
 - 4) Monitor the condition of the communication continuously.
 - 5) Generate an alarm if a fault condition is detected.
 - 6) Tripping of a dc breaker shall initiate tripping of the remote active breaker feeding the same power section. If a substation is bypassed, the local breaker shall send the transfer trip signal to the substation beyond the bypassed substation to de-energize the power section.
 - 7) Transfer trip shall be integral to protection relays.
 - 8) Communication for transfer trip must be configured using VLAN. See Section 34 21 31P, TES Substation Automation System.
 - 9) Factory test network configuration and transfer trip functionality using fiber connectivity between each TPSS local area network. Testing shall demonstrate actual tripping of breakers between the transmitting and receiving IEDs such that the network and transfer trip functions will be ready upon connecting the fiber optic cable for the WLAN.
2. Reverse Current:
 - a. Provide reverse current detection (Device 32).
 - b. The protection shall detect current flow from the distribution bus into the rectifier unit and trip and lock out the dc feeder breakers and ac circuit breaker.
 - c. The trip level shall be initially set to 15 percent of the rated current or as approved by Engineer.
3. High Resistance Frame Fault:
 - a. Insulate dc switchgear enclosure from ground.

- b. Single-point ground enclosure through a separate high resistance ground IED device 64HS (hot structure) and 64GS (grounded structure).
 - 1) Connect IED with insulated 4/0 AWG copper conductor directly to substation ground mat.
 - 2) The 64HS and GS relay shall be the only ground path to the enclosure.
 - 3) The occurrence of any other ground path must be detected and alarmed.

2.9 INSTRUMENTS AND METERS

- A. Instruments and meters shall be integrated into intelligent electronic devices (IEDs).
 - 1. Voltmeters and ammeters shall be rated for use with the corresponding transducers.
 - 2. Scales shall be of a suitable range, equal to the associated potential or current transformer primary rating.
- B. Provide instrument and metering IEDs with capability of communicating with SAS as specified in Section 34 21 31P, TES Substation Automation System (SAS).
- C. Instruments and metering devices for measuring dc values shall receive their inputs from isolation converters that shall be provided within the bus compartment of the switchgear.
 - 1. Provide auxiliary devices required for operation of the converters.
 - 2. Provide suitable isolation and insulation in order to ensure safe operation in contact with personnel.

2.10 FACTORY ASSEMBLY

- A. Completely insulate dc switchgear enclosure and rectifier from ground and from the rectifier transformer and the ac switchgear.
 - 1. Insulate and isolate dc switchgear and rectifier from the floor using an epoxy floor covering in accordance with Section 34 21 08P, TES Dielectric Epoxy Flooring.
 - 2. Insulate and isolate dc switchgear and rectifier from the transformer using electrical laminate in accordance with Section 34 21 17P, TES Substation Design and Assembly.
 - 3. Insulate walls using electrical laminate in accordance with Section 34 21 17P, TES Substation Design and Assembly, and as shown on Contract Drawings.

2.11 SOURCE QUALITY CONTROL

- A. Factory Design Tests:
 - 1. Dc Switchgear: Perform Design Tests as specified in IEEE C37.20.1:
 - a. Dielectric tests
 - b. Rated continuous current tests
 - c. Short-time withstand current tests
 - d. Short-circuit current withstand tests
 - e. Mechanical endurance tests
 - f. Flame resistance tests
 - g. Rod entry test
 - h. Coating (paint) qualification test
 - 2. Dc Circuit Breaker: Perform Design Tests as specified in IEEE C37.14.
 - 3. Positive and Negative Disconnect Switches:
 - a. Conduct a complete set of design tests on one switch of each type in accordance with IEEE C37.30.1 and IEEE C37.41.
 - b. Tests to be performed with switch(es) in enclosure assembled in closed, final operational configuration.
 - 4. Dc Protection Relays and Control Devices:
 - a. Perform in accordance with Design Tests in IEEE C37.90.
 - b. Frame Fault Relay (Device 64 HS and GS): Following design tests are required.
 - 1) Continuous and maximum short circuit ratings: Demonstrate by test.
 - 2) Response time and maximum trip time: Demonstrate by test.
 - 3) Maximum trip time for this device shall not exceed 50 ms.

- B. Factory Production Tests:
1. Dc Switchgear: Perform during TES Substation Factory Acceptance Tests in accordance with Section 34 21 90P, TES Testing.
 2. Dc Circuit Breaker:
 - a. Prior to mounting inside dc switchgear, perform the following on each dc circuit breaker in accordance with IEEE C37.14:
 - 1) Calibration test
 - 2) Control, secondary wiring and device check test.
 - 3) Dielectric withstand voltage test.
 - 4) No-load operation test.
 - b. Perform additional testing on each dc circuit breaker after mounting in switchgear during TES Substation Factory Acceptance Tests in accordance with Section 34 21 90P, TES Testing.
 3. Positive and Negative Disconnect Switches: Perform during TES Substation Factory Acceptance Tests in accordance with Section 34 21 90P, TES Testing.
 4. Dc Protection Relays, Control Devices and Meters: Perform in accordance with production tests in IEEE C37.90.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Insulate dc switchgear in built-in-place substation as required in Part 2, above, in the article titled "Factory Assembly."

PART 4 - MEASUREMENT

4.1 MEASUREMENT

- A. The quantities of accepted work will be measured in the following units. All measurements will be plan measure except for authorized changes:
1. Description: Lump Sum.

PART 5 - PAYMENT

5.1 PAYMENT

- A. Payment will be made at the respective unit or lump-sum price listed in the proposal and shall be full compensation for all labor, materials, and equipment necessary to complete the respective unit in place. There will be no separate measurement or payment for any item of work not specifically identified and listed in the proposal, and all such work shall be considered a subsidiary item with all costs pertaining thereto included in the prices for other items listed in the proposal. At the Engineer's option, partial payment may be made for any lump sum item listed in the proposal, providing that the Vendor is diligently and satisfactorily pursuing full completion of such partially complete item in accordance with the approved job progress schedule.

END OF SECTION

SECTION 34 21 23P
TES TRANSFORMER-RECTIFIER UNIT
SUBSTATION PROCUREMENT ONLY

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes rectifier-transformers and rectifiers, which are referred to in this Section as the "Transformer-Rectifier Unit," for the TES substations.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 01 43 00 – Systems Quality Assurance
- C. SECTION 01 60 01 – Buy America Requirements
- D. SECTION 34 21 06 – TES Common Work Results for Metals
- E. SECTION 34 21 08 – TES Dielectric Epoxy Flooring
- F. SECTION 34 21 13 – TES Switchboards
- G. SECTION 34 21 17 – TES Substation Design and Assembly
- H. SECTION 34 21 18 – TES Lighting
- I. SECTION 34 21 18 – TES Medium-Voltage Ac Switchgear
- J. SECTION 34 21 31 – TES Substation Automation System (SAS)
- K. SECTION 34 21 80 – TES Spare Parts and Special Tools
- L. SECTION 34 21 90 – TES Testing
- M. SECTION 34 22 10 – TES Low-Voltage Conductors and Cable

1.3 REFERENCED STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. American Society for Testing and Materials (ASTM):
 - 1. ASTM D116, Vitrified Ceramic Materials for Electrical Applications
- C. Institute of Electrical & Electronics Engineers (IEEE):
 - 1. IEEE 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
 - 2. IEEE 1653.2, Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 Vdc Nominal Output
 - 3. IEEE C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear
 - 4. IEEE C57.12.01, General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin Encapsulated Windings
 - 5. IEEE C57.12.91, Standard Test Code for Dry-Type Distribution and Power Transformers
 - 6. IEEE C57.18.10, Standard Practices and Requirements for Semiconductor Power Rectifier Transformers
- D. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA TR 1, Transformers, Regulators and Reactors
 - 2. NEMA SG 6, Power Switching Equipment

1.4 SUBMITTALS

- A. Procedures: SECTION 01 33 00 – Submittal Procedures.
- B. Certification that products submitted meet Buy America requirements of 49 U.S.C. Section 5323(j) and 49 CFR Part 661, as per SECTION 01 60 01 – Buy America Requirements.
- C. Product Data: Manufacturer's product descriptions and catalog data for the following:
 - 1. Transformer-Rectifier Unit:
 - a. Enclosures: Gauge of steel, finish, door hardware.
 - b. Relays, protective devices, control switches, over temperature devices and failed diode indication device.
 - c. Ratings.
 - d. Internal wiring: Wire type and size.
 - e. Information concerning design and application ratings.
 - f. Information concerning service, performance and reliability.
 - g. Documents confirming the substation system rating.
 - 2. Rectifier:
 - a. Bus and bus insulators.
 - b. Diodes
 - c. Fuses
 - d. Dc surge arresters
 - e. Cooling fans
 - 3. Rectifier-transformer:
 - a. Bus and bus insulators.
 - b. Core steel.
 - c. Transformer winding insulation system.
 - d. Transformer Data: Weight, impedance, and primary and secondary BIL
 - e. Transformer temperature monitor.
 - f. Cooling fans
 - 4. Interphase transformer
- D. Spare Parts and Special Tools:
 - 1. Submit a list of spare parts to be provided under this Section.
 - 2. Submit at the same time as product data.
 - 3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in SECTION 34 21 80 – TES Spare Parts and Special Tools.
 - 4. Submit a list of special tools to be provided under this Section, as defined in SECTION 34 21 80 – TES Spare Parts and Special Tools.
- E. Shop Drawings:
 - 1. Transformer-Rectifier Unit:
 - a. Detail drawings for transformer-rectifier unit, including interphase transformer, surge arrester arrangement, and connection between rectifier and transformer.
 - 2. Rectifier:
 - a. Outline drawing showing dimensions, front, back and side elevations of enclosure, overall dimensions, and lifting lugs.
 - b. Detail drawing of connection between rectifier and positive switch
 - c. Rectifier enclosure and door latch details.
 - d. Rectifier nameplate drawing.
 - e. Wiring, schematic, and connection diagrams.
 - f. Rectifier monitoring and protection schematic and wiring diagram.
 - g. Bill of materials.
 - 3. Rectifier-Transformer:
 - a. Outline drawing showing dimensions, front, back and side elevations of enclosure, overall dimensions, and lifting lugs.
 - b. Detail drawing of connection between Ac main breaker and rectifier-transformer.

- c. Transformer enclosure and door latch details.
 - d. Transformer nameplate drawing with nameplate details.
 - e. Wiring, schematic, and connection diagrams.
 - f. Insulation system details.
 - g. Transformer primary and secondary busing arrangements showing bus construction details
 - h. Transformer tap changer arrangement details.
 - i. Bill of materials.
- 4. Transformer temperature monitor/protection device schematic and wiring diagram including the location of the temperature sensor.
- F. Calculations:
 - 1. Transformer design calculations, including hottest spot temperature rise in accordance with IEEE C57.12.01.
 - 2. Transformer calculation of winding temperature during a short circuit in accordance with IEEE C57.12.01.
 - 3. Bus sizing calculations: Rectifier and rectifier-transformer.
 - 4. Proof the transformer-rectifier unit design and construction conforms to IEEE 519.
- G. Submit the following upon completion of transformer manufacture:
 - 1. Measured present worth of transformer energy losses, including the following:
 - a. Table 1, with actual measured losses from the transformer.
 - b. Table 2 calculation, using the new value from Table 1.
 - 2. Comparison of calculated and measured present worth of transformer energy losses, as described in the Article below titled "Transformer Design Optimization."
- H. Submit test procedures that comply with Section 34 21 90, TES Testing.
 - 1. Design Tests.
 - 2. Production Tests.
- I. Submit test reports that comply with Section 34 21 90, TES Testing.
 - 1. Design Tests: Provide design test reports for each type of transformer-rectifier unit within 30 Days after completion of testing.
 - 2. Production Tests: Provide production test reports for each transformer-rectifier unit within 30 Days after completion of testing.
- J. Operations and Maintenance Data:
 - 1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Submit manufacturer's operating and maintenance instructions, parts list, illustrations and diagram for components for products specified in this Section.
 - b. Wiring diagram.
 - c. Diagram showing recommended safety grounding during maintenance.
 - 2. Submit immediately after approval of product data.

1.5 SPARE PARTS

- A. Provide spare parts in accordance with SECTION 34 21 80 – TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
 - 1. Transformer temperature monitor complete with temperature sensors: Provide 1 spare assembly.
 - 2. Rectifier diodes: Provide 2 spare.
 - 3. Rectifier diode protection fuses: Provide 2 spare.
 - 4. Rectifier over-temperature: Provide 1 spare assemblies.
 - 5. Interphase transformer: Provide 1 spare.
 - 6. Rectifier transformer cooling fans; Provide 1 spare.
 - 7. Rectifier cooling fans; Provide 1 spare.

1.6 QUALITY ASSURANCE

- A. Quality Assurance/Quality Control shall be carried out in accordance with the requirements of SECTION 01 43 00 Systems Quality Assurance.
- B. Rectifier-transformer shall be UL labeled or shall be furnished with a Field Evaluation label in accordance with Section 34 21 17, TES Substation Design and Assembly.
- C. Rectifier shall be UL labeled or shall be furnished with a Field Evaluation label in accordance with Section 34 21 17, TES Substation Design and Assembly.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, storage, and handling shall be carried out in accordance with the requirements of 26 05 00-13, Systemwide Electrical General Requirements for Systems, except as modified herein.
- B. Obtain written permission from the Engineer before shipping substation.

1.8 WARRANTY

- A. Comply with warranty requirements in accordance with the General Conditions, Article 6.20, except as modified herein.
- B. Provide an extended warranty of 5 years for rectifier-transformers.

PART 2 - PRODUCTS

2.1 TRANSFORMER-RECTIFIER UNIT - GENERAL REQUIREMENTS

- A. Transformer-rectifier unit shall be manufactured in accordance with the referenced standards.
- B. Transformer-rectifier unit consists of a separate rectifier-transformer and a rectifier, as shown on Contract Drawings.
 - 1. Provide each unit complete with auxiliaries, controls, wireways, interconnecting ac and dc buses, enclosures and necessary hardware, wiring and devices from the high voltage side of the transformer to the dc bus connections to the dc switchgear and negative enclosure.
 - 2. Except as otherwise specified, the transformer-rectifier shall conform to IEEE C57.12.01, C57.12.91, 519, and 1653.2, and NEMA SG 6 and TR 1.
- C. Dc output of the transformer-rectifier unit shall feed the metal enclosed dc switchgear that controls and protects the power supply to the Overhead Contact System (OCS).
- D. Enclosures for Transformer and Rectifier:
 - 1. Construct from sheet steel, 11 gage minimum, properly reinforced against distortion by suitable flanges and stiffening members.
 - 2. Doors:
 - a. Minimum 11 gage sheet steel.
 - b. Doors 36 inches or wider shall include vertical stiffeners, minimum 3 stiffeners for a 36-inch door, with one additional stiffener for each additional 12 inches of door width.
 - 3. Finish: Powder coat in accordance with 34 21 06, TES Common Work Results for Metals.
 - 4. Color: In accordance with Section 34 21 06, TES Common Work Results for Metals.
- E. Design Loading Condition: Transformer-rectifier units shall meet the duty cycle specified in IEEE 1653.2 for heavy traction service.
- F. Efficiency: Overall efficiency of each transformer-rectifier assembly shall be greater than 98 percent at its continuous rating.

- G. Power Factor: Displacement power factor of each transformer-rectifier assembly shall be 0.95 or greater from 25 percent to full load at rated ac voltage.
- H. Voltage Regulation:
 - 1. Minimum 4-1/2 percent between 1 percent and 200 percent load with the nominal ac voltage maintained at the transformer primary and the transformer set at the rated voltage tap.
 - 2. Engineer may allow minor variations in regulation based upon submitted design curve.
- I. Dummy Load:
 - 1. Limit the no-load voltage to the value specified.
 - 2. Provide a bleeder resistance dummy load, if required, to prevent excessive voltage rise at no-load.
- J. Provide protection against transient surge voltages on the dc side of the rectifier. If fuses are used in suppression networks, they shall be monitored by visual indicators and equipped with indication devices wired to local Annunciator.
- K. Short Circuit Ratings:
 - 1. Design transformer, including terminal connections and buswork, to withstand a full short circuit with shorted low-voltage terminals and rated voltage on the high-voltage terminals, in accordance with IEEE C57.12.01. The duration of the short-circuit current shall be minimum 1 second.
 - 2. Design all parts of the rectifier unit, including the terminal connections and buswork, to withstand a maximum dc fault on the dc positive bus, without damage, for the period required for the back-up protection to operate and open the ac circuit breaker.

2.2 TRANSFORMER-RECTIFIER UNIT RATINGS AND CONFIGURATION

- A. Mainline transformer-rectifier units:
 - 1. Rating: 750 Vdc, 500 kW measured at output terminals.
 - 2. Configuration: 12-pulse, double-way, in accordance with IEEE 1653.2, Circuit 31.
 - 3. Convert 13.2 kV, 60 Hz ac, three-phase, three-conductor primary power to 750 Vdc at 100 percent of full load.
 - 4. Ac power source: 13.2 kV switchgear; see Section 34 21 18, TES Medium-Voltage Ac Switchgear.

2.3 PROTECTIVE DEVICES AND RELAYS FOR TRANSFORMER-RECTIFIER UNIT

- A. Coordinate protection to prevent false tripping or malfunction.
- B. Supply an insulating dust cover for each internally-mounted device or the chamber that accommodates these devices.
- C. Compartment: Mount control devices, relays and protective devices within the rectifier and transformer enclosure within a separate barriered compartment in compliance with IEEE C37.20.3.
 - 1. Devices shall be readily accessible without disassembling interior portions of the rectifier assembly.
 - 2. Control wiring shall be contained within the cubicle.
 - 3. Control wiring shall be barriered from and not intermixed with 750 Vdc power wiring.
 - 4. No 750 Vdc devices shall be mounted in control compartment.
 - 5. Locate devices such that heat from other equipment does not affect operation.
- D. Control Power: Power supply for protective devices and relays shall use 125 Vdc auxiliary power system.
- E. Transformer Temperature Monitor (TTM) Device 49:
 - 1. Shall be manufactured for the purpose and have a service proven history.
 - 2. Shall incorporate a hot-spot winding temperature indicator located where the highest temperature reading is obtained during Design testing.

3. Provide with two-step, electrically independent contacts that close on rising temperatures for alarm (first step) and tripping (second step).
 - a. First stage, 49T1:
 - 1) Initiate an alarm on the TTM and SAS. Refer to Section 34 21 31 – TES Substation Automation System (SAS).
 - 2) Set initially at the temperature reached during the 2-hour heat run at 150 percent rated output, and annunciate when this temperature is reached.
 - b. Second stage, 49T2: Initiate an alarm on the TTM and SAS, trip and lock out the main ac breaker, ~~186 and 86 devices~~ and open the main de circuit breaker.
 - c. Temperature set points, T1 and T2, shall be factory-preset when transformer is provided, as recommended by the manufacturer and approved by Engineer, and field adjustable
 4. Display temperature continuously on a digital display mounted on the surface of transformer panel.
 - a. Accuracy: Within 1.5 percent of the full-scale reading.
 - b. Scale: Degrees Celsius.
 - c. Peak Temperature:
 - 1) Peak temperature shall be displayed when requested by the activation of a front panel mounted pushbutton.
 - 2) Peak temperature shall be resettable via a separate front panel mounted pushbutton.
 - 3) TTM shall store the peak temperature reached by the rectifier-transformer.
 5. Enclosure:
 - a. NEMA 1 enclosure for low voltage terminals.
 - b. Cover: Hinged- or screw-type.
 6. Terminal strips: Provide covers and mount on back panel.
 7. Barriers: Provide where necessary to separate conductors with different voltage insulation ratings, such as thermocouple wiring and 125 Vdc control wiring.
 8. Mounting Securely mount enclosure to the transformer frame.
 - a. Mount in a location readily accessible from the front as indicated, but not to restrict access to the transformer coils for maintenance.
 - b. Do not mount the enclosure in removable panels.
 9. Control Wiring:
 - a. Control wiring shall be 600 V switchboard wire. See Section 34 22 10, TES Low-Voltage Conductors and Cable, for switchboard wire requirements.
 - b. Size: Minimum 14 AWG, except for temperature sensor internal wiring.
 10. Contacts: Electrically separate and suitable for operation at 125 Vdc.
- F. Provide the following protective devices for the rectifier. Contacts on these devices shall be electrically separated:
1. Rectifier over-temperature (Device 26):
 - a. Over temperature device shall be factory set, two stages (26R1 and 26R2).
 - b. Shall detect first an abnormal rise in diode heat sink or diode temperature and initiate local and remote annunciation.
 - c. Set-point for the alarm shall be set during the factory systems test to the level recorded during the two hour 150 percent heat run.
 - d. An additional rise in heat sink temperature will trip and lock out the ac main breaker, ~~186 and 86 devices~~ open the main positive circuit breaker and shall alarm on the SAS. Refer to SECTION 34 21 31 – TES Substation Automation System (SAS).
 - e. Devices shall be isolated from the bus voltage.
 2. Frame fault protection for the rectifier: Provide high resistance frame fault protection for the rectifier cubicles.
 3. Provide failed diode indications 98R1 and 98R2.
 4. Refer to Contract Drawings for additional protective devices.

2.4 RECTIFIER

A. General:

1. Provide rectifier assembly as an integral part of the dc switchgear.
 2. Rectifier assembly shall be constructed in accordance with IEEE C37.20.3, except as modified in this Section.
 3. Rectifier shall include silicon diodes, internal buses, terminals for connection to external power and control wiring or buses, shunts, base or bleeder load resistors, protective devices, control wiring, terminal blocks, compartments, cubicles, and all other necessary accessories.
- B. Rating and configuration:
1. IEEE 1653.2 heavy traction service.
 2. Dc Insulation: 1200-Volt Class.
 3. Mainline rectifiers:
 - a. Rated 750 Vdc, 500 kW, with natural convection air cooling.
 - b. Continuous current rating at 100 percent: 666 A.
 - c. Twelve-phase, double-way, 12-pulse rectification.
- C. Enclosure:
1. Mount rectifier assembly in a metal fully-enclosed switchgear section or compartment.
 2. The switchgear section shall be indoor, self-ventilated, metal enclosed structure with barriers, compartments, hinged doors as required by IEEE C37.20.3, except as modified in this Section.
 3. Assemble enclosure with a rigid self-supporting structural steel framework.
 - a. Structural members shall be of sufficient strength to support the buswork under short circuit conditions.
 - b. Principal structural members shall be electrically welded or bolted together.
 - c. Provide lifting eyes for lifting the rectifier unit from the top.
 - d. The completed package shall be capable of being skidded or rolled any direction.
 - e. Provide jacking lugs at each base corner.
 4. Doors:
 - a. Provide convenient access doors on the front and rear of the section for normal maintenance and inspection.
 - b. Latches: Equip each door with a heavy duty latch to hold the door fully and securely closed.
 - c. Hinges: Stainless steel heavy-duty type.
 - d. Door Stops:
 - 1) Provide heavy-duty door stops to hold the door in the open position.
 - 2) Not easily bent if an attempt is made to close door without releasing door stop.
 - e. Window: Provide an ample sized, wired glass, gasketed observation window on each door to observe diode blown fuse indicators.
 - f. Install front-mounted indicating and control devices without damaging the exposed finished surfaces.
 5. Lights: Provide inside equipment enclosures, as specified in Section 34 21 18, TES Lighting.
- D. Bus and Connections:
1. Rectifier buses shall be made of rigid, high conductivity, electrical grade copper.
 2. Buses shall be suitably braced between each other and to the enclosure with high-strength, non-tracking porcelain or fiberglass insulators.
 3. Buses shall be braced to safely withstand the available short-circuit current without damage to the bus or the rectifier.
 4. Where aluminum heat sinks are bonded to a copper bus, coat connection with oxide inhibitor to prevent bimetallic corrosion.
 5. Bus connections shall be bolted using a minimum of four bolts per joint.
 - a. Wherever bolted together, the mating surfaces of copper buses shall be silver-plated.
 - b. Bolted connections shall be made with Belleville washers.
 6. Buses shall extend through the compartment walls to rear bus compartment and connected to the dc switchgear.

7. Rectifier section shall be designed as an integral part of the dc switchgear line up and shall be insulated from the ac and dc switchgear, substation grounds, or other enclosures.
 8. Metal barriers, electrically bonded to the frame, shall be provided between dc positive and negative buses and terminal connections within the rectifier.
- E. Dc surge arrester:
1. Rectifier unit shall be equipped with dc surge arresters.
 2. The arresters shall limit the reverse voltage across rectifier silicon diodes to a value less than 75 percent of the peak-reverse-voltage rating of the diode by limiting the rise of the transient on the positive to negative bus.
 3. Ensure that arresters will fail in a safe manner without damage to equipment and will self extinguish. Install in separate enclosure if necessary.
- F. Silicon Diodes:
1. Silicon diodes shall be hermetically sealed and mounted on adequate heat sinks.
 2. Diodes shall be rated and tested in accordance with IEEE 1653.2 for heavy traction service.
 3. Rectifier shall be able to withstand a bolted fault on the dc switchgear bus without exceeding the safe diode junction temperature on the active diode for the time it takes the ac breaker to clear the fault.
 4. Each diode shall be capable of withstanding, at its maximum operating temperature during blocking periods, repetitive voltages having a value 250 percent of its working peak reverse voltage without a permanent change in diode characteristics.
 5. Each individual diode shall have a peak inverse voltage rating equal to at least 266 percent of the applied peak inverse voltage at no load.
 6. Parallel stacks of diodes, when used, shall be electrically and geometrically similar and as symmetrical as practical to help balance the normal and surge electrical characteristics of each.
 7. Design rectifier to maintain current balance between parallel-connected diodes, if used, in each phase.
 - a. The current for each diode of a parallel-connected stack shall not differ from its proportionate share of the total current by more than plus or minus 10 percent, between 50 percent and 150 percent of the rated capacity.
 - b. Current balancing shall not be achieved by use of selectively matched diodes.
- G. Fuses:
1. Provide one current limiting fuse in series with each phase.
 - a. Each fuse shall have adequate interrupting capacity
 - b. Provide a visual fuse failure indication.
 - c. Fuse failure indication shall be visible from outside rectifier through observation window.
 2. Size fuses to the diode current rating. Diodes shall not open or fail on an external dc fault or rated overload condition.
 - a. Only the fuse connected to a failed (shorted) diode shall open.
 - b. No other rectifier diodes or fuses shall fail or be damaged when one diode fails.
 3. Fuses: 750 V minimum, indicating type, affixed with micro switches for Device 98.
- H. Diode Failure:
1. Diode failure 1 (98R1): If one diode fails, or if one entire leg fails, send alarm to SAS.
 2. Diode failure 2 (98R2): If one leg has failed, and a second leg fails, trip the ac lockout relay (Device 86).
- I. Special Tools: Provide special tools to remove or install the diodes and/or diode fuses and/or hardware with each substation rectifier.
- J. Internal Wiring: 2 kV switchboard wire, per Section 34 22 10, TES Low-Voltage Conductors and Cable.
- K. Heating and Cooling System:

1. Auxiliary heating will be by a thermostatically-controlled space heater within the substation. Heaters mounted within the rectifier enclosure are not necessary.
 2. Rectifier shall be natural convection air-cooled.
 - a. Circulation of ambient air shall do all necessary cooling at the IEEE 1653.2 heavy traction service loading specified.
 - b. Cooling ducts shall not be used.
 3. All rectifiers shall be equipped with fans and thermostats for future forced air cooling.
- L. Maintenance: Heat transfer surfaces and characteristics shall be designed for easy cleaning and to minimize accumulations of dust and other contaminants expected in the operating environment.
- M. In accordance with this Specification, voltages other than 125 Vdc control power are not permitted within the enclosure unless a specific requirement is stated in this Contract.
- N. Nameplate:
1. Provided each rectifier with a corrosion resistant metal nameplate containing the following information at a minimum:
 - a. Name of Manufacturer.
 - b. Descriptive Name.
 - c. Type Designation.
 - d. Serial Number(s).
 - e. Output Rated Power.
 - f. Output Rated Voltage.
 - g. Output Rated Current.
 - h. Overload Currents - Magnitude and Duration.
 - i. Weight.
 - j. Schematic Diagram Number.

2.5 RECTIFIER-TRANSFORMER

- A. Provide dry-type rectifier-transformer of VPI (Vacuum Pressure Impregnation).
- B. Ratings and Configuration:
1. Ventilated, self-cooled Class AA/FA.
 2. Transformer capacity shall be as required to achieve the specified transformer-rectifier unit rating.
 3. IEEE 1653.2 heavy traction service duty cycle.
 4. Transformer shall not suffer loss of life when operated at the specified duty cycle overload.
 5. Insulation Class: 220 degrees C class.
 6. Temperature Rise: Limit winding hottest-spot temperature rise and average winding temperature rise to the values given in IEEE C57.12.01 for the specified insulation class.
 7. Cooling fans:
 - a. Provide fans for forced air cooling, controlled by transformer temperature monitor.
 - b. Fans shall increase the overall rating of rectifier-transformer by 33 percent of its rated output current without exceeding specified temperature rise.
 8. Select the transformer impedance to provide the rectifier output voltage specified.
- C. Windings:
1. Material: Copper.
 2. Windings shall not absorb moisture and shall be suitable for both storage and operation in adverse environments, including prolonged storage in 100 percent humidity at temperature from minus 30 degrees C to 40 degrees C.
 3. Primary windings mainline:
 - a. Delta-connected.
 - b. 95 kV BIL.
 4. Secondary windings mainline:
 - a. Connected for 12-pulse rectification.

- b. 20 kV BIL
- D. Taps:
 - 1. Provide full capacity taps on primary voltage windings:
 - a. Two above rated voltage in 1.25-percent steps;
 - b. Two below rated voltage in 2.5 percent steps;
 - c. One at rated voltage.
 - d. Taps to the nearest turn are acceptable if the exact percentage cannot be achieved.
 - 2. Tap changing shall be by movable silver plated copper bus links for de-energized tap changing.
 - 3. Taps shall be brought out the side of the transformer, not the top.
 - 4. Insulate jumpers from the transformer taps to the tap changer board and primary bus and keep as short as possible so as not to interfere with access to the coils for maintenance.
 - 5. Tap connections shall be accessible through the front hinged enclosure doors.
 - 6. Identify tap connections so that the tap selected is clearly visible through the observation window.
 - 7. Securely bolt the tap-changing bus links in position.
 - 8. Design of links and connectors shall make it impossible to short out sections of windings, or to select taps outside the prescribed range, by incorrectly connecting the links.
- E. Connections:
 - 1. Switchboard: Connect the high-voltage side using electrical grade copper bus with silver plated joints.
 - 2. Rectifier: Connect the low voltage side using electrical grade copper bus with silver plated joints.
- F. Bus supports:
 - 1. Securely support bus from transformer frame using porcelain insulators.
 - 2. Size bus supports for mechanical strength and ability to withstand a bolted fault without distortion.
 - 3. Porcelain insulators: ASTM D116, rated for the line-to-line voltage application, free of imperfections. Insulators that have been re-touched with paint shall not be used. Contractor may propose use of epoxy insulators subject to acceptance by the Agency.
- G. Bus Bars:
 - 1. Size:
 - a. Minimum 1/4-inch by 2-inch, sized for mechanical strength and ability to withstand a bolted fault without distortion.
 - b. Size bus for a current density of 750 A per square inch, or a maximum temperature of 90 degrees C at a 40 degree C ambient, whichever results in a larger size.
 - 2. Bolted connections: Use a minimum of two silicon bronze bolted connections with Bellville washers on high and low voltage ac and dc buses.
- H. Conductors within Transformer Enclosure:
 - 1. Conductors not connected to transformer primary or secondary:
 - a. Voltage rating: 600 V.
 - b. Temperature rating: 105 degrees C.
 - c. Protection:
 - 1) Enclose in GRS conduit securely strapped to the transformer frame or base, or to the enclosure if conduit does not obstruct removable panels or doors.
 - 2) If conduit must be secured to both frame or base and enclosure, insert a short section of liquid tight flexible metallic conduit for vibration isolation.
 - 3) Conductors may be unprotected for a maximum of 8 inches at the point of connection.
 - 2. Cable jumpers from the secondary taps on the coil to the bus:
 - a. Sized for maximum loading for IEEE 1653.2 heavy traction service.
 - b. Temperature rating: 105 degrees C.

- c. Voltage rating: 2 kV.
 - d. Insulation level: 133 percent.
- I. Maintainability:
 - 1. Design transformer so that parts that require maintenance are readily accessible from the front and rear.
 - 2. Ensure that bottom and top of coils are readily accessible for cleaning without removing buswork, panels, or obstructions of any kind.
- J. Transformer Enclosure and Base:
 - 1. Enclosure:
 - a. Enclose transformer in a rigid, self-supporting and self-contained, electrically welded or bolted, indoor, steel enclosure.
 - b. Enclosure shall not rely on transformer frame for support. Avoid attachments to transformer frame.
 - c. Vibration isolation: If enclosure is attached to transformer at any point, provide vibration isolation at attachment points.
 - 2. Front door:
 - a. The entire front of the transformer shall open by padlockable hinged double doors secured by three-point latches.
 - b. Window: Provide an ample sized, wired glass, gasketed observation window in the front hinged doors; position such that the tap connections are readily visible.
 - 3. Ventilation louvers: Design for maximum cooling from the bottom to top.
 - 4. Rear panels:
 - a. The rear of the transformer shall be accessible by removable panels with stainless steel handles and lifting means.
 - b. Secure panels with 3/8-inch minimum stainless steel vandal-proof machine screws tapped into machined bosses.
 - 5. Transformer base:
 - a. Construct from structural steel members suitable for rolling or skidding in any direction.
 - b. Make provisions for pulling along the centerlines perpendicular to each side.
 - c. Provide jacking facilities at each of the four corners of the base to permit insertion of rollers between floor and base.
 - d. Base construction shall firmly secure the core to prevent relative motion of the core during shipment, handling, or seismic shock.
 - 6. Transformer frame:
 - a. Provide lifting hooks or eyes on the transformer frame with a safety factor of four to facilitate lifting the unit.
 - b. The structure shall be sufficiently rigid to withstand maximum transformer short circuit currents without deformation.
 - 7. Transformer Mounting: Design to minimize vibration by using vibration isolation dampers.
 - 8. Lights: Provide inside equipment enclosures, as specified in Section 34 21 14, TES Lighting.
 - 9. Nameplate:
 - a. Provide rectifier-transformer with a corrosion-resistant metal nameplate marked in accordance with IEEE C57.12.01.
 - b. Securely fasten to the front of the enclosure.
- K. Ac Surge Arrester:
 - 1. Provide ac surge arresters on the rectifier-transformer primary side.
 - 2. Provide a separate compartment for ac surge arresters within transformer enclosure.
 - 3. Compartment shall be rigid steel, self-supporting and self-contained, electrically welded or bolted.

2.6 TRANSFORMER DESIGN OPTIMIZATION

- A. Optimize the transformer design and select appropriate materials to provide transformers with the lowest possible life cycle cost.
1. Definition of Life Cycle Cost: The sum of the cost of procurement and the cost of energy losses over the equipment's expected life.
 2. Calculate cost of energy losses over the transformer's expected life by:
 - a. First, calculating annual cost of transformer energy losses (see Table 1, below);
 - b. Second, using the calculated annual cost of transformer energy losses to calculate the present worth of transformer energy losses over the 30-year expected life (see Table 2, below).

table 1 – transformer energy loss schedule			
Column 1	Column 2	Column 3	Column 4
Transformer Load (as percentage of rated power)	Transformer Energy Losses (at Column 1 Loads) (kW)	Estimated Annual Hours (of operation at given loads) (Hours)	Annual Transformer Energy Losses (kWh)
0 percent			
20 percent			
60 percent			
100 percent			
150 percent			
220 percent			
300 percent			
Total Transformer Annual Energy Losses E_L (kWh)			

- B. Using Table 1 - Transformer Energy Loss Schedule:
1. In Column 2, enter transformer energy losses in kW for each indicated transformer load in Column 1. Include energy losses in the transformer windings, steel core, and busbars, and demand requirements of auxiliary equipment such as cooling fans.
 2. In Column 4 calculate the Transformer Annual Energy Losses in kWh by multiplying the Transformer Energy Losses entered in Column 2 by the Estimated Annual Hours provided in Column 3.
 3. Total the numbers in Column 4 and enter in the box at the bottom of Table 1 for the Transformer Annual Energy Losses, E_L .
 4. Use this number to calculate the Present Worth of Transformer Energy Losses in Table 2.

TABLE 2 – PRESENT WORTH OF TRANSFORMER ENERGY LOSSES		
Equation:	$PW = N \cdot E_L \cdot e \cdot [1/(1+i) + (1+k)/(1+i)^2 + \dots + (1+k)^{n-1}/(1+i)^n]$	
Symbol	Description	Value
PW	Present worth of transformer energy losses (Dollars)	\$ _____
N	Number of transformer units	5 (mainline only)
E _L	Transformer annual energy losses (kWh)	from Table 1
E	Utility energy rate (Dollars/kWh)	0.09
I	Interest rate	0.04 (4 percent)
k	Average energy cost escalation factor	0.04
n	Transformer expected life (years)	30

- C. Using Table 2 - Present Worth of Transformer Energy Losses:
1. Calculate the Present Worth of Energy Losses, PW, in dollars over a 30-year period using the equation and values in Table 2.
 2. Insert the calculated Present Worth of Transformer Energy Losses into the Request for Proposal Bid List, where indicated.
- D. Measured Present Worth of Transformer Energy Losses:
1. After transformer is manufactured, measure the actual losses for the transformer at the load levels specified in Table 1.
 2. Update Table 1 with the measured values and recalculate Transformer Annual Energy Losses.
 3. Calculate the Present Worth of Transformer Energy Losses using Table 2, with the new value of Transformer Annual Energy Losses based on measured values.
- E. Comparison of Calculated and Measured Present Worth of Transformer Energy Losses:
1. Compare the Calculated Present Worth of Transformer Energy Losses (entered on the Price Page) with the Measured Present Worth of Transformer Energy Losses (calculated using measured values of a transformer manufactured for this project).
 2. If the Measured Present Worth of Transformer Energy Losses exceeds the Calculated Present Worth of Transformer Energy Losses, the Engineer will issue a unilateral deductive Change Order to deduct the dollar value of the difference between the two.
 3. If the Measured Present Worth of Transformer Energy Losses is equal to or less than the Calculated Present Worth of Transformer Energy Losses, no action will be taken.

2.7 INTERPHASE TRANSFORMER

- A. Design interphase transformer in coordination with transformer-rectifier unit to meet the specified voltage regulation and maximize efficiency, under Kansas City service conditions.
- B. Design, submit product data and shop drawings, and test in accordance with IEEE 1653.2.

2.8 FACTORY ASSEMBLY

- A. Completely insulate rectifier from ground and from the rectifier-transformer and the ac switchgear.
1. Insulate and isolate rectifier from the floor using an epoxy floor covering in accordance with Section 34 21 08, TES Dielectric Epoxy Flooring.
 2. Insulate and isolate rectifier from the transformer using electrical laminate in accordance with Section 34 21 17, TES Substation Design and Assembly.

2.9 SOURCE QUALITY CONTROL

A. Factory Design Tests:

1. Transformer-Rectifier Unit Test:
 - a. General Requirements:
 - 1) Existing test reports will not be accepted in lieu of this test.
 - 2) Transformer-rectifier unit shall be tested as a complete assembly including interconnecting bus and enclosures. AC switchgear is a required part of the assembly only for the short circuit test. DC switchgear is not required.
 - b. Short circuit test:
 - 1) Conduct at a certified laboratory.
 - 2) Power supply shall be minimum 10 MVA.
 - 3) Transformer taps on high-voltage windings shall be connected at the center position of the five available taps.
 - 4) Set ac breaker for the IEEE 1653.2 short-time overload for heavy traction service.
 - 5) Perform in accordance with IEEE C57.12.91, to fully evaluate the capability of all windings.
 - a) Apply fault on the rectifier secondary.
 - b) Make recommended terminal measurements.
 - c. Rated current test:
 - 1) Perform in accordance with IEEE 1653.2.
 - 2) Thermocouple locations shall be indicated in test procedure and approved by the Engineer.
 - 3) Transformer temperature rise determined by any of the thermocouples shall not exceed specified values.
 - 4) Verify efficiency, voltage regulation, and power factor at loads shown in IEEE 1653.2 for heavy traction service.
 - d. Audible sound level test:
 - 1) Perform audible sound level tests in accordance with IEEE C57.12.91 using A-weighting, except apply 3-foot distance.
 - 2) Maximum sound level shall not exceed 60 dBA at 100 percent load measured 3 feet away from assembly.
 - 3) For 12-pulse Circuit 31 rectifier-transformers, include interphase transformer in transformer-rectifier assembly.
 - 4) Measure sound level with rectifier-transformer in its enclosure with all panels bolted closed.
2. Rectifier:
 - a. Dielectric tests: In accordance with IEEE 1653.2.
 - b. Rated voltage test: Subject rectifier to 110 percent of ac rated voltage for 5 minutes with the dc circuit open.
 - c. Current unbalance test:
 - 1) In accordance with IEEE 1653.2.
 - 2) Test may be performed during the design test for transformer-rectifier unit.
 - d. Loss measurement test: Comply with IEEE 1653.2.
 - e. Rated current test:
 - 1) At reduced voltage.
 - 2) After temperature stabilization at rated load.
 - 3) Include the overloads outlined in IEEE 1653.2.
 - 4) Perform with one diode removed from each phase arm. Engineer to select diodes to be removed for test.
 - 5) Shall demonstrate that the maximum safe junction temperature for each diode is not exceeded.
 - 6) Verify efficiency, voltage regulation, and power factor at loads shown in IEEE 1653.2 for heavy traction service.
3. Rectifier-transformer:

- a. Resistance measurements: Take in accordance with IEEE C57.12.91 except that they shall be taken for all tap settings.
 - b. Impedance and load loss: Perform tests in accordance with IEEE C57.18.10 except perform on all windings on all tap settings.
 - c. Commutating reactance: Calculate from load loss tests in accordance with IEEE C57.18.10.
 - d. Impulse test:
 - 1) Perform in accordance with IEEE C57.12.91.
 - 2) Perform after completion of short circuit tests.
 - e. Temperature rise tests: Perform in accordance with IEEE C57.12.91 for heavy traction service.
 - f. Partial discharge test: Perform after completion of all other tests.
 - g. Engineer shall be the sole judge of the serviceability of transformer after completion of design testing.
- B. Factory Production Tests:
- 1. Rectifier:
 - a. Dielectric tests: Perform in accordance with IEEE 1653.2.
 - b. Continuity tests: Perform for all cables and buses.
 - c. Rated voltage test: Perform in accordance with IEEE 1653.2.
 - 2. Rectifier-transformer:
 - a. Dielectric tests: Perform in accordance with IEEE C57.12.91.
 - b. Applied-voltage test: Perform in accordance with IEEE C57.12.91.
 - c. Induced-voltage tests: Perform in accordance with IEEE C57.12.91.
 - d. Resistance measurements: Take for all windings on all taps.
 - e. Ratio tests: Perform on the rated voltage connections and on all taps in accordance with IEEE C57.12.91.
 - f. Polarity and phase relation tests: Perform in accordance with IEEE C57.12.91.
 - g. No-load losses and excitation current: Determine in accordance with IEEE C57.12.91.
 - h. Partial discharge test:
 - 1) Subject transformer to an induced voltage of 1.5 times the rated voltage at a frequency between 100 and 400 Hz.
 - 2) Partial discharge extinction level shall be reached at an induced voltage of not less than 1.2 times the rated line-to-line voltage.
 - 3) Partial discharge extinction level will be defined as the point when the reading at 1.9 MHz is less than 10 microvolts or 13 picocoulombs.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Insulate rectifier in built-in-place substation as required in Part 2, above, in the article titled "Factory Assembly."

PART 4 - MEASUREMENT

4.1 MEASUREMENT

- A. The quantities of accepted work will be measured in the following units. All measurements will be plan measure except for authorized changes.
 - 1. Description: Lump Sum.

PART 5 - PAYMENT

5.1 PAYMENT

- A. Payment will be made at the respective unit or lump-sum price listed in the proposal and shall be full compensation for all labor, materials, and equipment necessary to complete the respective unit in place. There will be no separate measurement or payment for any item of work not specifically identified and listed in the proposal, and all such work shall be considered a subsidiary item with all costs pertaining thereto included in the prices for other items listed in the proposal. At the Engineer's option, partial payment may be made for any lump sum item listed in the proposal, providing that the Vendor is diligently and satisfactorily pursuing full completion of such partially complete item in accordance with the approved job progress schedule.

END OF SECTION

SECTION 34 21 25P
TES DC CONTROL POWER
SUBSTATION PROCUREMENT ONLY

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Battery charger/eliminator and batteries.
 - 2. Enclosed low-voltage switches and fuses.
 - 3. Dc distribution panelboard circuit breakers.
 - 4. Dc control circuit overcurrent protection.
 - 5. Low voltage dc power supply.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 01 43 00 – Systems Quality Assurance
- C. SECTION 01 60 01 – Buy America Requirements
- D. SECTION 34 21 12P – TES Low-Voltage Panelboards
- E. SECTION 34 21 17P – TES Substation Design and Assembly
- F. SECTION 34 21 31P – TES Substation Automation System (SAS)
- G. SECTION 34 21 80P – TES Spare Parts and Special Tools
- H. SECTION 34 21 90P – TES Testing

1.3 REFERENCED STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. Institute of Electrical & Electronics Engineers (IEEE):
 - 1. IEEE 485, Recommended Practices for Sizing Lead Acid Batteries for Stationary Applications
 - 2. IEEE 1115, Recommended Practices for Sizing Nickel-Cadmium Batteries for Stationary Applications
- C. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA FU 1, Low Voltage Cartridge Fuses
 - 2. NEMA KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
 - 3. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
 - 4. NEMA PE 5, Utility Battery Chargers
- D. Underwriters Laboratories (UL):
 - 1. UL 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

1.4 SUBMITTALS

- A. Procedures: SECTION 01 33 00 – Submittal Procedures.
- B. Certification that products submitted meet Buy America requirements of 49 U.S.C. Section 5323(j) and 49 CFR Part 661, as per SECTION 01 60 01 – Buy America Requirements.
- C. Product Data: Manufacturer's product descriptions and catalog data for the following:

1. Submit manufacturers' product data for specified equipment and materials.
- D. Spare Parts and Special Tools:
1. Submit a list of spare parts to be provided under this Section.
 2. Submit at the same time as product data.
 3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in SECTION 34 21 80P – TES Spare Parts and Special Tools.
 4. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in SECTION 34 21 80P – TES Spare Parts and Special Tools and required special tools are described below in Part 2.
- E. Calculations:
1. Battery capacity calculations, including load calculations.
- F. Testing:
1. Submit test procedures that meet the requirements of SECTION 34 21 90P - TES Testing for the following:
 - a. Factory Design Tests.
 2. Submit test reports that meet the requirements of SECTION 34 21 90P - TES Testing for the following:
 - a. Factory Design Tests.
- G. Submit test procedures that comply with Section 34 21 90P, TES Testing.
1. Design Tests.
 2. Production Tests.
- H. Operations and Maintenance Data:
1. Submit manufacturer's operating and maintenance instructions on products specified in this Section.
 2. Submit immediately after approval of product data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts:
1. Deliver spare parts in accordance with SECTION 34 21 80P - TES Spare Parts and Special Tools.
 2. Furnish the following items specified in this Section:
 - a. Battery cells: Provide 4 spares of each type.
 - b. Battery charger/eliminator: Provide 1 spare.
 - c. Mini circuit breakers: Provide 2 spare sets.
 - d. Low voltage dc power supply: Provide 2 spares each type.
- B. Special Tools and Accessories: Submit product data and provide the following accessories for normal operation and maintenance:
1. Cell lifting sling complete with strap and spreader bar.
 2. Battery log book.
 3. Quart of terminal grease, if recommended.
 4. Set of special tools for maintenance.
 5. Micro ohmmeter for testing battery connection resistance.
 6. Set of cell identification numbers.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Ship batteries separate from substation.

1.7 WARRANTY

- A. Comply with warranty requirements in accordance with the General Conditions, Article 6.20, except as modified herein.

- B. Batteries: Furnish warranty of one (1) year from the date the battery is placed in service and additional warranty of 9 years, pro rata, to deliver not less than 90% of its rated capacity.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Batteries and associated charger/eliminators shall operate in parallel, with the charger charging the battery while supplying the continuous connected loads.
- B. Batteries shall supply peak short time current demands and, when the ac supply to the charger is interrupted, supply the entire connect load.
- C. Batteries and charger/eliminators shall be rated for operation within the temperature range specified in SECTION 34 21 31P - TES Substation Automation System (SAS), and shall be capable of operation up to 100 degrees F.
- D. After continuous 10 hours of battery charger outage, trip and lockout the high-voltage ac circuit breaker, via the 86H relay and trip and lockout the dc circuit breakers via the 186H relays.

2.2 BATTERY CHARGER/ELIMINATOR

- A. Charger/eliminators: Solid-state, constant voltage, automatic, fully regulated, with output voltage temperature compensation, silicon controlled rectifier, convection cooled, complying with NEMA PE 5. Provide battery charger/eliminators to meet the following requirements:
 - 1. Rated for continuous operation, float-charging the battery, and for recharging the battery from a cell voltage of 1.1 V to 85 percent of battery capacity in a maximum of 8 hours, while simultaneously supplying the load demands.
 - 2. Input voltage Rating:
 - a. Mainline: 240 Vac, 60 Hz, single phase or 208V ac, 60Hz, 3 phase.
 - b. VMF: 208/120 Vac, 60 Hz, single phase.
 - 3. Output voltage and current: Matched to the requirements of the battery and the load.
 - 4. Output voltage regulation: Plus or minus 0.25 percent of output voltage over its complete load range with a plus or minus 10 percent variation of input ac voltage. Output ripple shall not exceed 30 mV rms.
 - 5. Output current limiting: Adjustable from 90 percent to 115 percent of output nominal current rating, and factory set at 110 percent.
 - 6. Filtered output to maintain ripple within the specified limits when the battery is disconnected.
 - 7. Adjustable 0 to 72 hour equalizing time charger, manually set for supplying an equalizing voltage per cell as recommended by battery manufacturer.
 - 8. Ac Input and Dc Output circuit breakers: Molded-case type complying with the requirements in UL 489.
 - 9. Enclosures: NEMA 250, Type 12 with hinged covers, lockable handles and two point (minimum) latches.
- B. Provide the following additional features/options:
 - 1. Dc voltmeter with 0 V to 200 V range.
 - 2. Dc ammeter.
 - 3. Ac input pilot light marked "AC POWER ON."
 - 4. Two-position selector switch marked "FLOAT" and "EQUALIZE."
 - 5. Output ground fault pilot lights for positive and negative poles.
 - 6. Input line surge and transient-protective devices.
 - 7. Battery charger failed alarm.
 - 8. Battery undervoltage alarm.
 - 9. Battery overvoltage alarm.
 - 10. Ground fault alarm.

- C. Send alarms to SAS, as specified in SECTION 34 21 31P – TES Substation Automation System (SAS).

2.3 BATTERIES

- A. Batteries shall be designed specifically for float application and shall be sized for the specified duty cycle:
 - 1. Type: Heavy-duty, nickel-cadmium.
 - 2. Venting:
 - a. Batteries shall not vent gas under normal operation.
 - b. Provide one-way self-resealing, safety pressure-relief valves.
 - 3. Battery containers:
 - a. Plastic, heat-resistant, flame retardant, impact resistant.
 - b. Covers shall be cemented in place to provide a permanent leak-proof seal.
 - c. Effectively seal at cell terminal posts with non-corrosive material
 - d. Clearly and permanently mark polarity of cell terminal posts.
 - 4. Vendor may offer alternate battery technology for review and acceptance by the engineer. Documentation supporting the change shall be provided.
- B. Ratings:
 - 1. Ampere-hour capacity: Select in accordance with IEEE 1115 taking into account the calculated loads from all devices, as indicated on the Contract Drawings, for a 10-hour discharge rate to a final cell voltage of 1.75 V for the specified duty cycle.
 - 2. Battery duty cycle:
 - a. Duration: Period of 10 hours with the battery charger/eliminator out of service, assuming batteries are in a fully charged state at the beginning of the 10 hours.
 - b. Load:
 - 1) Normal continuous demand of the substation auxiliary loads, including relays, indicating lamps, dc-connected lights, and alarm panel.
 - 2) Trip and reclose cycle of one dc feeder breaker every hour.
 - 3) Trip and reclose of the ac breaker after two hours and again after eight hours.
- C. Lockout: Provide a timer such that after a continuous 10 hours of battery charger outage, timer shall trip and lockout the main ac circuit breaker via the 86 relay and trip and lockout the dc circuit breakers via the 186 relays
- D. Connections:
 - 1. Provide inter-cell connector buses.
 - 2. Provide nickel plated solid copper terminal plates, connectors, plates, and lugs.
- E. Battery Racks:
 - 1. Provide a four tier structural steel battery support racks sized to allow 1/2 inch between batteries.
 - 2. Include insulating plastic strips to cover all supports, hold downs, and restraining rails that are in contact with cells.
 - 3. Finish with a caustic-resistant paint coat.
- F. Provide an insulating, electrolyte-resistant, plastic mat under each battery rack, extending a minimum of 12 inches outside the rack.
- G. Battery Rack Top:
 - 1. Clear polycarbonate, minimum 1/4 inch thick, with sharp edges removed.
 - 2. Dimensions: Minimum overall 1 inch longer and wider than battery rack length and width.
- H. Provide battery bank with a stainless steel nameplate. Nameplate shall be attached to the battery rack using stainless steel rivets and marked with the following information
 - 1. Manufacturer's name.
 - 2. Month and year of manufacture.
 - 3. Battery and cell type.

4. Ampere rating: 1 minute, 1 hour, and 5 hour.

2.4 FUSED DISCONNECT SWITCH

- A. Provide NEMA 250 Type 12, 2-pole, fused disconnect switch for isolation of the battery with the following requirements:
 1. Rating: 250 Vdc, current rating to match batteries.
 2. NEMA KS 1: Quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position.
 3. Handle lockable in OFF position.
- B. Fuse Clips: Suitable for Class R or J fuses with fuse rejection devices installed.
- C. Fuses: NEMA FU 1 rated to provide short circuit protection for the battery and battery cables.
- D. Coordinate fuse and switch ratings with the output circuit breaker in the battery charger.
- E. Install disconnect switches where indicated on Contract Drawings or required by Codes with external handle centered 60 inches above finished floor or grade level.
- F. Install fuse-rejection devices in fuse clips if required.
- G. Install fuses in fusible disconnect switches.

2.5 DC DISTRIBUTION PANELBOARDS

- A. Comply with requirements of SECTION 34 21 12P – TES Low-Voltage Panelboards.
- B. Circuit breakers: 125 Vdc, 2-pole.

2.6 DC CONTROL CIRCUIT PROTECTION AND ALARMS

- A. Within switchgear, dc control circuits shall be protected by mini circuit breakers. Fuses shall not be used.
- B. Mini circuit breakers: 125 Vdc, 1-pole.
- C. Provide an undervoltage alarm (Device 127) for each dc control circuit:
 1. If a circuit from the dc distribution panelboard feeds downstream mini circuit breakers, each of those circuits controlled by a mini circuit breaker is considered a control circuit for the purposes of this requirement.
 2. Provide alarm to SAS; see SECTION 34 21 31P – TES Substation Automation System (SAS).

2.7 LOW-VOLTAGE DC POWER SUPPLY

- A. Voltage: 24 V or 48 V, but not both.
- B. Power supply shall be powered from TES substation 125 Vdc power source. Power supply shall be redundant:
 1. Provide a main low-voltage power supply with automatic transfer to a backup low-voltage power supply or operate two low-voltage power supplies in parallel.
 2. Provide two circuits, each one fed from its own breaker in the 125 Vdc distribution panelboard, to power the two low-voltage power supplies

2.8 FACTORY ASSEMBLY

- A. Install charger, battery rack, and other specified equipment within each substation enclosure secure, plumb and level and in true alignment with related adjoining work.
- B. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and rigidly connect the Work.
- C. Temporarily install batteries to conduct factory testing, then remove before shipping.

- D. Anti-oxidants and other solvents that can cause cracking of cell jars shall not be used on batteries.
- E. Verify that float and recharging rates are set to the values recommended by battery manufacturer.

2.9 SOURCE QUALITY CONTROL

- A. Factory Design Tests:
 - 1. Battery Charger: Tests shall comply with design tests described in NEMA PE 5.
- B. Factory Production Tests:
 - 1. Test the following:
 - a. Cell voltages.
 - b. Pressure-relief vent operation and reseal.
 - c. Cell jar leakage.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.
- B. Following installation of each prefabricated substation at site, install battery cells on battery racks in accordance with manufacturer's recommendations. Verify that there is minimum 1/2 inch between each battery and adjacent batteries.
- C. Install specified battery rack top after installing battery cells. Secure to top of rack posts.
- D. After battery installation provide an equalizing charge as recommended by battery manufacturer.
- E. Mount battery rack and batteries per seismic requirements.

3.2 FIELD QUALITY CONTROL

- A. Test function of batteries and charging system and test terminal connection resistance after delivery of prefabricated substations and installation of built-in-place substation in conformance with SECTION 34 21 90P – TES Testing.

PART 4 - MEASUREMENT

4.1 MEASUREMENT

- A. The quantities of accepted work will be measured in the following units. All measurements will be plan measure except for authorized changes.
 - 1. Description: Lump Sum.

4.2 PAYMENT

- A. Payment will be made at the respective unit or lump-sum price listed in the proposal and shall be full compensation for all labor, materials, and equipment necessary to complete the respective unit in place. There will be no separate measurement or payment for any item of work not specifically identified and listed in the proposal, and all such work shall be considered a subsidiary item with all costs pertaining thereto included in the prices for other items listed in the proposal. At the Engineer's option, partial payment may be made for any lump sum item listed in the proposal, providing that the Vendor is diligently and satisfactorily pursuing full completion of such partially complete item in accordance with the approved job progress schedule.

END OF SECTION

SECTION 34 22 33P
TES RACEWAY AND BOXES
SUBSTATION PROCUREMENT ONLY

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Electrical conduit and ducts
 - 2. Cable tray
 - 3. Outlet, junction, and pull boxes
 - 4. Electrical distribution cabinets

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 01 43 00 – Systems Quality Assurance
- C. SECTION 01 60 01 – Buy America Requirements
- D. SECTION 34 21 05P – Common Work Results for TES
- E. SECTION 34 21 06P – TES Common Work Results for Metals
- F. SECTION 34 22 26P – TES Grounding and Bonding
- G. SECTION 34 22 29P – TES Raceway and Equipment Hangers and Supports

1.3 DEFINITIONS

- A. Raceway: As defined in NFPA 70, and products specified in this Section.

1.4 REFERENCED STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. American National Standards Institute (ANSI)
 - 1. ANSI C80.1, Standard for Electrical Rigid Steel Conduit (ERSC)
- C. National Electrical Contractor's Association (NECA)
 - 1. NECA 1, Standard Practice of Good Workmanship in Electrical Contracting
- D. National Electrical Manufacturers Association (NEMA)
 - 1. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
 - 2. NEMA FG 1, Fiberglass Cable Tray Systems
 - 3. NEMA ICS 2, Industrial Control and Systems Controller, Contactors, and Overload Relays 600 V
 - 4. NEMA RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
 - 5. NEMA TC 2, Electrical Polyvinyl Chloride (PVC) Conduit
 - 6. NEMA TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing
 - 7. NEMA TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
- E. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code
 - 2. NFPA 130, Fixed Guideway Transit and Passenger Rail Systems
- F. Underwriters Laboratories (UL)

1. UL 2024, Signaling, Optical Fiber and Communications Raceways and Cable Routing Assemblies

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Certification that products submitted meet Buy America requirements of 49 U.S.C. Section 5323(j) and 49 CFR Part 661, as per SECTION 01 60 01 – Buy America Requirements.
- C. List of Materials:
 1. Submit a list of materials proposed for use.
 2. Give name of manufacturer, brand name, product data, and catalog number of each item.
 3. Submit list complete at one time, with items arranged and identified in numerical sequence by Specification Section and Article number.
- D. Compliance with Applicable Standards:
 1. Where equipment or materials are specified to conform to standards of organizations such as ANSI, ASTM, and NEMA, submit evidence of conformance. The label or listing of specified agency will be acceptable evidence.
 2. Instead of the label or listing, Vendor may submit a written certificate from an approved, nationally recognized testing organization, stating that items have been tested and units conform to specified standard.
- E. Shop Drawings:
 1. Submit shop drawings showing exact location and arrangement of conduits, cabinets, and pullboxes installed under this Contract.
 2. Submit drawings with ample time to prevent delays in Work.

1.6 QUALITY ASSURANCE

- A. Quality Assurance/Quality Control shall be carried out in accordance with the requirements of SECTION 01 43 00 Systems Quality Assurance.
- B. Qualifications: Raceway installers shall be electricians licensed by the State.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, storage, and handling shall be carried out in accordance with the requirements of 26 05 00-13, Systemwide Electrical General Requirements for Systems, except as modified herein.
- B. Obtain written permission from the Engineer before shipping substation.

1.8 WARRANTY

- A. Comply with warranty requirements in accordance with the General Conditions, Article 6.20.

PART 2 - PRODUCTS

2.1 CONDUIT AND FITTINGS

- A. Galvanized Rigid Steel (GRS) Conduit and Accessories: ANSI C80.1; hot-dip galvanized inside and out after threading; ensure each length bears UL label.
- B. GRS Fittings and Accessories:
 1. Bushings: Nylon-insulated, metallic.
 2. Grounding bushings: Nylon-insulated, metallic, with lay-in lugs.
 3. Sealing Bushings:
 - a. Galvanized malleable or ductile iron bushings with Bakelite sealing and pressure discs and individual neoprene cable rings.
 - b. Bushings shall seal ends of GRS conduit against the entrance of water, air or dust around emerging cables.

- c. Approved Manufacturer/Product: O-Z/Gedney, type KR, or approved equal.
- 4. Conduit straps, clamps, and clamp backs: Galvanized malleable iron.
- 5. Vertical-Conduit Cable Supports:
 - a. Malleable or ductile iron body with hot-dip galvanized finish.
 - b. Non-metallic tapered wedging plug that supports cable without damaging insulation.
 - c. Weatherproof, ventilating type.
 - d. Acceptable Manufacturer/Product: O-Z/Gedney, type CMT, R-style, or approved equal.
- C. PVC-Coated GRS Conduit (PVC/GRS or PGRS): NEMA RN 1, with corrosion resistant internal coating.
- D. Reinforced Thermosetting Resin Conduit (RTRC): NEMA TC 14; standard or heavy-wall, UL listed.
 - 1. Conduit joints and fittings: Tapered or untapered; all of one type.
- E. PVC Electrical Conduit and Fittings:
 - 1. Conduit: NEMA TC 2, EPC-40-PVC or EPC-80-PVC; heavy wall, high impact strength, rigid PVC.
 - 2. Fittings: NEMA TC 3, EPC-40-PVC.
- F. Liquidtight Flexible Metallic Conduit and Fittings.
 - 1. Core: Flexible galvanized steel with a continuous copper bonding conductor spiral wound between the convolutions.
 - 2. Jacket: Extruded liquid-tight plastic or neoprene; moisture- and oil-proof, capable of conforming to the minimum radius bends of flexible conduit without cracking; self-extinguishing with low halogen containing material.
 - 3. Fittings: Zinc-coated.

2.2 OXIDE INHIBITING JOINT COMPOUNDS

- A. Petroleum-based compound with evenly suspended zinc particles.
- B. Approved Manufacturer/Product: Burndy, Penetrox A, or approved equal.

2.3 CABLE TRAY

- A. Type: Fiberglass, ladder or solid-bottom type with solid covers and other accessories, NEMA FG 1.
- B. Minimum Dimensions:
 - 1. Width: Minimum 6 inches.
 - 2. Loading depth: Minimum 3 inches.
 - 3. Inside nominal depth: Minimum 5 inches.
 - 4. Radius of curved fittings: Minimum 24 inches unless otherwise approved by Engineer.
- C. Performance Requirements:
 - 1. 30 inch width or less: Capable of supporting a total cable load of 55 pounds per linear foot on a maximum span of 8 feet, including a 200-pound static load as specified below.
 - 2. Over 30-inch width: Capable of supporting a total cable load of 88 pounds per linear foot on a maximum span of 8 feet including a 200-pound static load as specified below.
 - 3. Requirements shall be independent of type of splice plates or type of span, when tested in accordance with load test procedure specified in NEMA standards.
 - 4. Safety factor: 2, based on destructive load.
 - 5. 200 pound static load: Straight sections and fittings shall not permanently deform under a 200 pound static concentrated load applied vertically along a 4-inch length for both of the following conditions:
 - a. Load applied to center of one tray section having specified cable load and support spacing.
 - b. Load shall be applied at midpoint between supports over a splice connection.

- c. Load applied to one rung of empty tray section having specified support spacing. Load shall be located at midpoint between side rails and supports.

2.4 CONDUIT HANGERS AND SUPPORTS

- A. Refer to Section 34 22 29, TES Raceway and Equipment Hangers and Supports.

2.5 OUTLET, JUNCTION, AND PULL BOXES

- A. Sheet metal outlet boxes: Steel, galvanized.
- B. Sheet metal junction and pull boxes: Galvanized or stainless steel, hinged or screw-cover with stainless steel screws.
- C. Cast metal boxes: Hot-dip galvanized inside and out.
 - 1. Blank covers: Same thickness as boxes and secured with No. 10-24 stainless steel machine screws.
 - 2. Device covers: See Section 34 21 17P, TES Substation Design and Installation.
 - 3. Neoprene gaskets: 1/8-inch thick.
- D. Nonmetallic boxes: Heavy duty, phenolic, surface-mounted, with threaded nonmetallic conduit hubs, type FD, single- or double-gang as required. Provide non-metallic device covers.
 - 1. Acceptable Manufacturer/Product: Thomas & Betts, Carlon FSC-34, or approved equal.

2.6 ELECTRICAL CABINETS

- A. NEMA 1, 12, 4X, or as indicated.
- B. Galvanized or stainless steel, size as noted on Contract Drawings.
 - 1. Fronts: Steel.
 - 2. Mounting: Surface or recessed type as required for the application.
 - 3. Hinges: Continuous, stainless steel.
 - 4. Locks: Provide flush locks from a single manufacturer with standard key blank; field-keyable.
 - 5. Finish: Powder coat, as specified in Section 34 21 06, TES Common Work Results for Metals.
 - 6. Cabinet back panel: white, galvanized steel interior mounting panel suitable for mounting terminal blocks and relays.
- C. Fiberglass composite:
 - 1. Covers: Fiberglass.
 - 2. Hinges: Continuous, stainless steel.
 - 3. Surface: Smooth, no color variations, swirls, color pockets, or voids.

2.7 FACTORY ASSEMBLY

- A. See Part 3, below, for type requirements.
- B. Conduit:
 - 1. General:
 - a. Install electrical raceway, boxes and accessories in locations as indicated, in accordance with NFPA 70, NECA 1, local codes and ordinances, and as indicated to provide a complete and operable system.
 - b. Where a conduit type indicated on Contract Drawings is in conflict with this Section, refer discrepancy to Engineer.
 - 2. Conduit threading:
 - a. Clean threads with a solvent recommended by coating manufacturer to remove oil.
 - b. Coat threads with organic cold galvanizing coating, in accordance with manufacturer's instructions.
 - c. If spray application is used, provide at least three coats.
 - 3. Metal-to-metal threaded joints:

- a. Coat threads with oxide inhibiting compound.
 - b. Take care that compound is not present on interior of conduit after installation.
- 4. Conduit caps:
 - a. Provide threaded cap or similar closure designed for the purpose on conduits that are not terminated immediately.
 - b. Prohibited: Tape is not acceptable for temporary cap.
- 5. Conduit sealing:
 - a. Conduit exposed to different temperatures: Seal conduit to prevent condensation and passage of air from one area to the other.
 - b. Where waterproofing is required, seal conduits with watertight duct sealing system.
- 6. Liquid tight flexible metal conduit:
 - a. Install so that liquids tend to run off surface and do not drain toward fittings.
 - b. Provide sufficient slack to reduce the effects of vibration.
- C. Conduit Grounding and Bonding:
 - 1. Install metallic conduits to be electrically and mechanically continuous and connected to ground by bonding to the grounding system.
 - 2. See Section 34 22 26P, TES Grounding and Bonding, for additional requirements.
- D. Conduit terminations:
 - 1. Dry areas:
 - a. Provide two locknuts, one inside and one outside of box or enclosure, for rigid conduit terminating at steel box, panelboard, cabinet, or similar enclosure.
 - b. Provide insulating bushing or grounding bushing on conduit end.
 - 2. Exposed, damp and wet locations: Provide threaded, water-tight hubs with sealing o-rings for cabinet connections or threaded connections to tapered threaded hubs for cast boxes and fittings.
 - 3. Terminate the conduit in appropriate boxes at motors, switches, outlets, and junction points.
- E. Cable Tray:
 - 1. General:
 - a. Install cable trays using approved fittings and adequately support the complete system. See Section 34 22 29P, TES Raceway and Equipment Hangers and Supports.
 - b. Install cable trays parallel to each other and the building and plumb and level.
 - c. Support cable trays with wall brackets or ceiling-mounted supports from the prefabricated building structure, with anti-sway brackets or braces where necessary.
 - d. Trays shall be located no closer than 2-1/2 inches from the nearest wall, unless otherwise approved.
 - 2. Supports:
 - a. Finish: Hot-dip galvanized after fabrication.
 - b. Ceiling supports: See Section 34 22 29P, TES Raceway and Equipment Hangers and Supports.
 - c. End supports: Support terminating sections of cable tray not more than 12 inches from end of tray.
 - d. Wall supports: Capable of sustaining an end-load of 1,600 pounds.
 - e. Spacing:
 - 1) Supports: Space at maximum distance of 5 feet to provide rigidity and adequate strength to support weight of trays and cables.
 - 2) Splices: Each tray splice shall have a support between 6 inches and 24 inches from the splice.
 - 3. Seismic bracing: Provide bracing for cable tray system complying with sealed seismic calculations required in Section 34 21 05P, Common Work Results for TES.
 - 4. Fasteners:
 - a. Solidly bolt trays to supporting channels using countersunk machine screws, 1/4 inch by 20 threads per inch, minimum.
 - b. After installation of fasteners, tray shall be free from burrs or sharp edges.

5. Separators: Provide separators to isolate cables of different voltages.
- F. Boxes:
1. General:
 - a. Provide electrical boxes and cabinets of the material, finish, type, and size indicated and as required for the location, kind of service, number of wires, and function.
 - b. Ensure boxes and support fittings are of suitable and compatible materials that will not corrode when subjected to moisture or standing water.
 - c. Provide brackets, supports, hangers, fittings, bonding jumpers, and other installation accessories as required. Refer to Section 34 22 29P, TES Raceway and Equipment Hangers and Supports.
 - d. Securely attach outlet, junction, and pull boxes to the structure. Do not use conduits entering the box as supports for the box.
 2. Covers:
 - a. Provide boxes complete with accessible covers designed for quick removal and suitable for the purpose for which they will be used.
 - b. Provide flat or raised blank covers for boxes without devices or fixtures.
 - c. Provide neoprene gaskets for boxes subjected to weather.
 3. Installation:
 - a. Mount outlet, junction, and pull boxes so as to prevent moisture from entering or accumulating within the boxes.
 - b. Junction and Pull Boxes: Install so that covers are readily accessible after completion of the installation.
 4. Grounding: Ground/bond each box and cabinet as specified in Section 34 22 26P, TES Grounding and Bonding.
 5. Dc equipment: For areas within 6 feet of dc rectifier and dc circuit breaker enclosures provide nonmetallic pull-boxes, junction boxes, device boxes, and covers.

PART 3 - EXECUTION

3.1 RACEWAY TYPE REQUIREMENTS

- A. Permitted Conduit Types:
1. Conduits in TES substations:
 - a. GRS or RTRC.
 - b. Within 6 feet of dc rectifier or distribution breaker enclosures: RTRC.
 2. Liquid-tight flexible metal conduit:
 - a. Permitted only where required for flexibility such as connections to vibrating equipment and across joints subject to differential movement.
 - b. Not acceptable as a substitute for other conduit types in areas with complicated bending requirements.
 3. Conduit or raceway types not specifically called out in these Specifications or Contract Drawings shall not be used.
- B. Permitted Cable Tray Type: Fiberglass with insulating support hardware.
- C. Prohibited Raceway Types:
1. Wiring gutters or wireways, unless approved by the Agency for building auxiliary circuits only.
 2. Electrical Metallic Tubing (EMT).
 3. Intermediate Metal Conduit (IMC).
 4. Flexible metal conduit.
 5. Conduit running thread.

3.2 RACEWAY MINIMUM SIZES:

- A. GRS: 3/4-inch.

- B. RTRC: 3/4-inch.
- C. Liquid-tight Flexible Metallic Conduit: 1/2-inch.

3.3 RACEWAY BENDS

- A. Minimum Bend Radius (above grade): In accordance with NFPA 70 Chapter 9 Table 2, "Other Bends" column.
- B. Refer to Section 26 05 43, Systemwide Electrical Underground Ductbanks and Raceways for Systems, for bending requirements for underground ducts.

3.4 BOX AND CABINET TYPE REQUIREMENTS

- A. Dry locations:
 - 1. Outlet boxes: Sheet metal outlet boxes.
 - 2. Junction or pull boxes with volume less than 100 inches: Sheet metal junction or pull box.
 - 3. Cabinets: Galvanized steel, NEMA 250 Type 1.
- B. Damp locations:
 - 1. Outlet, junction, and pull boxes: Cast metal boxes.
 - 2. Cabinets: NEMA 250 Type 4X stainless steel unless otherwise approved.
- C. Within 6 feet of dc switchgear:
 - 1. Cabinets: Fiberglass composite.

3.5 INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. The quantities of accepted work will be measured in the following units. All measurements will be plan measure except for authorized changes.
 - 1. Description: Lump Sum

4.2 PAYMENT

- A. Payment will be made at the respective unit or lump-sum price listed in the proposal and shall be full compensation for all labor, materials, and equipment necessary to complete the respective unit in place. There will be no separate measurement or payment for any item of work not specifically identified and listed in the proposal, and all such work shall be considered a subsidiary item with all costs pertaining thereto included in the prices for other items listed in the proposal. At the Engineer's option, partial payment may be made for any lump sum item listed in the proposal, providing that the Vendor is diligently and satisfactorily pursuing full completion of such partially complete item in accordance with the approved job progress schedule.

END OF SECTION

TRACTION POWER SYMBOLS

	DISCONNECT SWITCH IS NORMALLY CLOSED (NC), UNLESS DESIGNATED WITH (NO) NORMALLY OPEN		ANNUNCIATOR / HMI / SAS PLC		EXTERIOR LIGHT
	FUSED DISCONNECT SWITCH		AMMETER		GROUND
	LOW VOLTAGE CIRCUIT BREAKER		VOLTMETER		CHASSIS GROUND
	POTENTIAL TRANSFORMER		KILOWATT HOUR METER		EXIT SIGN WITH EMERGENCY LIGHT
	CURRENT TRANSFORMER		KILOVAR HOUR METER		EMERGENCY LIGHT
	RECTIFIER TRANSFORMER, 12 PULSE		AMMETER SWITCH		CABLE POTHEAD/CABLE CONNECTOR
	RECTIFIER TRANSFORMER, 6 PULSE OR POWER TRANSFORMER		KILOWATT METER		THREE-WAY LIGHT SWITCH
	INTERPHASE TRANSFORMER		SCADA		ELECTRICAL PHASE
	WYE, TRANSFORMER CONNECTION		EMERGENCY TRIP STATION		FIRE EXTINGUISHER
	DELTA, TRANSFORMER CONNECTION		CURRENT TRANSDUCER		PHOTOCELL
	SURGE ARRESTER		VOLTAGE TRANSDUCER		MULTI-MODE FIBER OPTIC
	TRACTION RECTIFIER		MECHANICAL KEY INTERLOCK		
	FUSE		UTILITY GROUND CONNECTION		
	DRAWOUT FUSE		INTERLOCK		
	SHUNT OR TPSS BUS CONNECTION		SMOKE DETECTOR		
	WITHDRAWABLE DC CIRCUIT BREAKER WITH SERIES TRIP UNIT		GFI RECEPTACLE		
	DIRECTION OF CONTROL OR RELAY INFLUENCE LINE		MH/HH/VAULT		
	DIODE		LIGHT FIXTURE		
	CONTACTOR		INSULATED OVERLAP (IOL)		
	WITHDRAWABLE MEDIUM VOLTAGE AC BREAKER		OCS SECTION INSULATOR (SI)		

DEVICE / FUNCTION REFERENCES

52	RELAY OPERATING COIL. INSIDE NUMBER DESIGNATES DEVICE FUNCTION. OUTSIDE NUMBER DESIGNATES QUANTITY OF DEVICES
5	EMERGENCY STOP PUSHBUTTON
26R1	RECTIFIER OVERTEMP ALARM (1ST. STAGE)
26R2	RECTIFIER OVERTEMP TRIP (2ND. STAGE)
27	UNDERVOLTAGE RELAY
30	INTERPOSING RELAY
32	REVERSE CURRENT RELAY
33A	AC CIRCUIT BREAKER REAR DOOR SWITCH
33F	FEEDER BREAKER REAR DOOR SWITCH
33N	NEGATIVE SWITCH DOOR OPEN
33P	POSITIVE SWITCH DOOR OPEN
33R	RECTIFIER DOOR SWITCH
33T	TRANSFORMER DOOR SWITCH
43	MANUAL TRANSFER OR SELECTOR DEVICE
47	PHASE SEQUENCE
49T1	TRANSFORMER OVERTEMP ALARM (1ST STAGE)
49T2	TRANSFORMER OVERTEMP TRIP (2ND STAGE)
50/51	PHASE FAULT TIME OVERCURRENT RELAY (INST. AND TIME DELAY)
50N/51N	GROUND FAULT TIME OVERCURRENT RELAY (INST. AND TIME DELAY)
52	AC CIRCUIT BREAKER
59	AC OVERVOLTAGE
59B	BANK PHASE OVERVOLTAGE
64GS	GROUNDING STRUCTURE
64HS	HOT STRUCTURE
64V	NEGATIVE-TO-EARTH VOLTAGE RELAY
76	DC DIRECT ACTING OVERCURRENT TRIP DEVICE
86	AC LOCKOUT RELAY
89P	DC POSITIVE DISCONNECT SWITCH
89N	DC NEGATIVE DISCONNECT SWITCH
98R1	R1 RECTIFIER DIODE FAILURE ALARM
98R2	R2 RECTIFIER DIODE FAILURE TRIP
148	DC INCOMPLETE SEQ. RELAY
150	DC INSTANTANEOUS OVERCURRENT RELAY
151	DC TIME OVERCURRENT RELAY
172	DC CIRCUIT BREAKER
182	DC LOAD MEASURING RELAY
183	DC RECLOSING RELAY
185	TRANSFER TRIP RELAY
186	DC LOCKOUT RELAY
R2G	RAIL-TO-GROUND SYSTEM
ROR	DC RATE OF RISE RELAY

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3		DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE		
			CHECKED BY	PGL		 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	TRACTION POWER TRACTION POWER SYMBOLS		FILENAME:	G036.DWG	
			DRAWN BY	JDW						CONTRACT NO.:	CONTRACT NO. ###	
			CHECKED BY	PGL						VOLUME:	1	
			APPROVED BY	NKS						DRAWING NO.:	SHEET NO.:	
										G036		
PLOT DATE: 9/12/2022			5:15:24 PM		DATE 06/24/2022		NOT FOR CONSTRUCTION					

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TRACTION POWER ABBREVIATIONS

A

A AMPERE
AM AMMETER
ANSI AMERICAN NATIONAL STANDARDS INSTITUTE
APPROX APPROXIMATELY
A ANNUNCIATOR / SAS ALARM
AC ALTERNATING CURRENT / AC BREAKER
AS AMMETER SWITCH
AT CURRENT TRANSDUCER
AUX AUXILARY

B

BAL. BALANCE
BKR BREAKER
BLVD BOULEVARD

C

C CONDUIT
CB CIRCUIT BREAKER
CKT CIRCUIT
COMP COMPARATOR
CONN CONNECTION
CT CURRENT TRANSFORMER
CUB CUBICLE

D

DC DIRECT CURRENT
DR DUCTBANK/RACEWAY
DS DISCONNECT SWITCH

E

ELT EXTERIOR LIGHTS
ETS EMERGENCY TRIP STATION

F

F DC FEEDER BREAKER
FACP FIRE ALARM CONTROL PANEL
FX FAST ETHERNET

G

GFI GROUND FAULT INTERRUPTER
GL GREEN LIGHT
GND GROUND

H

HH HAND HOLE
HMI HUMAN MACHINE INTERFACE
HR HOUR
HTS HEAVY TRACTION SERVICE
HS HOT STRUCTURE
HVAC HEATING VENTING AND AIR CONDITIONING
HW HARDWIRE

I

ILT INTERIOR LIGHTS
INST. INSTANTANEOUS
I/O INPUT/OUTPUT
IOS INSULATED OVERLAP

K

K MECHANICAL KEY INTERLOCK
KCMIL THOUSANDS CIRCULAR MILS
KV KILOVOLT
KVA KILOVOLT AMPERE
KVAC KILOVOLT ALTERNATING CURRENT
KW KILOWATT

L

LMR LOAD MEASURING RESISTOR

M

MCB MAIN CIRCUIT BREAKER
MFPR MULTI-FUNCTION PROTECTION RELAY
MH MANHOLE
MOC MECHANISM OPERATED CONTACT

N

N NEGATIVE
NC NORMALLY CLOSED
NEG NEGATIVE
NO NORMALLY OPEN
NR NEGATIVE FEEDER

O

OCS OVERHEAD CONTACT SYSTEM

P

P, POS POSITIVE
PAC PROGRAMMABLE AUTOMATION CONTROLLER
PC PERSONAL COMPUTER
PF POSITIVE FEEDER
PSC PHOTOCELL SHORTING CAP
PSI POUNDS PER SQUARE INCH
PT POTENTIAL TRANSFORMER
PVC POLYVINYL CHLORIDE

R

R RECTIFIER
R2G RAIL-TO-GROUND SYSTEM
RL RED LIGHT
RT RECTIFIER TRANSFORMER
REV. REVERSE
ROR DC RATE OF RISE RELAY
RTU REMOTE TERMINAL UNIT

S

SAS SUBSTATION AUTOMATION SYSTEM
SC SIGNAL/COMMUNICATIONS
SCC STATION CONTROL CABINET
SCADA SUPERVISORY CONTROL AND DATA ACQUISITION
SD SMOKE DETECTOR
SFP SMALL FORM-FACTOR PLUGABLE
SEQ. SEQUENCE
SI SECTION INSULATOR
SPD SURGE PROTECTIVE DEVICE
STA STATIONING
SUMM SUMMARY ALARM (COMMON ALARM)

T

TB TERMINAL BLOCK
TBD TO BE DETERMINED
TD TIME DELAY
TE TRACTION ELECTRIFICATION
TOC TRUCK OPERATED CONTACT
TPD TRACTION POWER DUCTBANK
TPSS TRACTION POWER SUBSTATION
TRFY TRAFFICWAY
TT TRANSFER TRIP
TYP. TYPICAL

V

V VOLT
VM VOLTMETER
VAC VOLT ALTERNATING CURRENT
VDC VOLT DIRECT CURRENT
VT VOLTAGE TRANSDUCER

VT

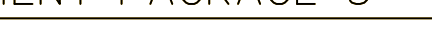
VAULT

W

W WATT
WL WHITE LIGHT
WT WEIGHT

NOTES:

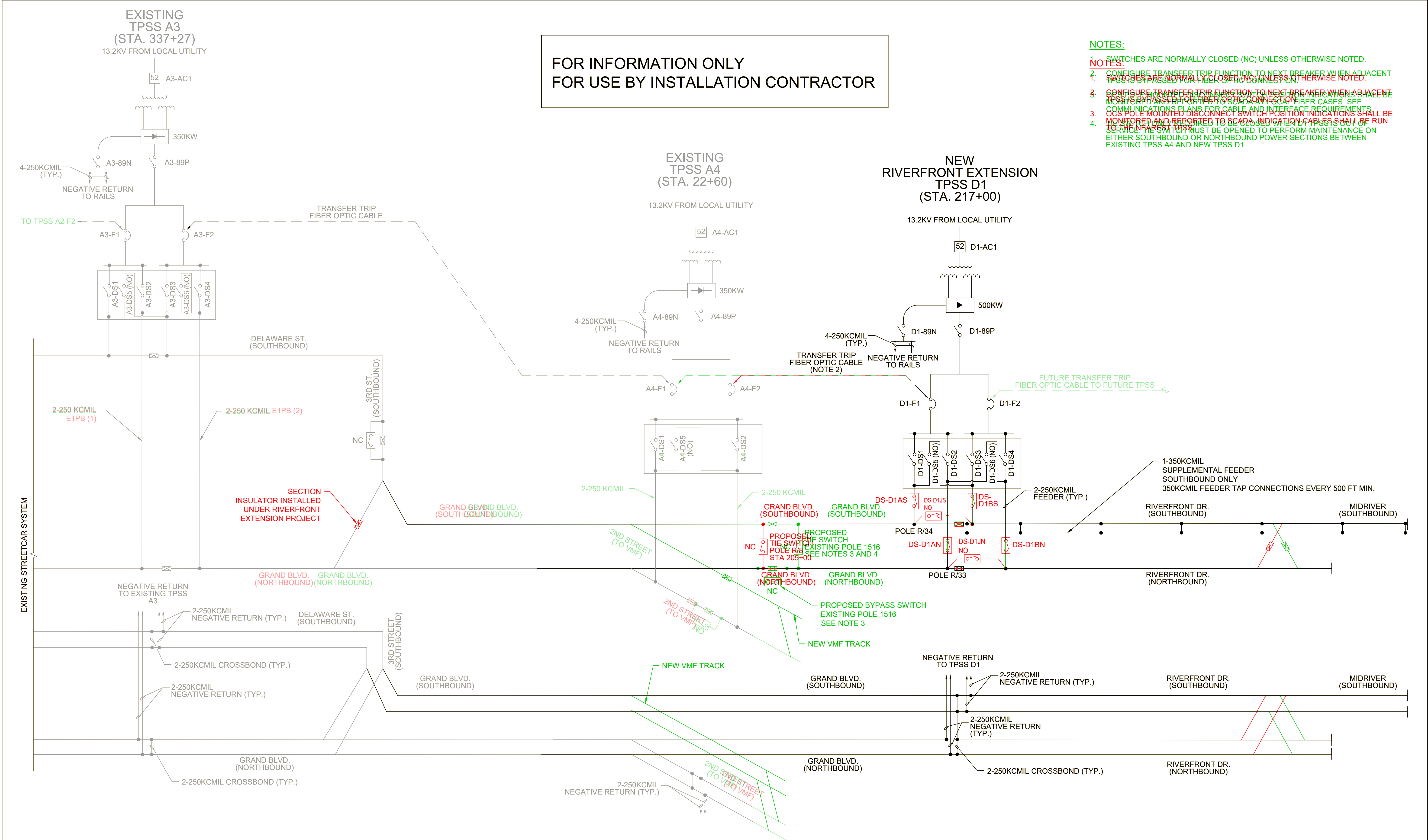
1. SEE CITY OF KANSAS CITY STANDARD PLANS FOR ADDITIONAL ABBREVIATIONS.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW			EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER ABBREVIATIONS	SCALE FOR 22"x34": NOT TO SCALE
			CHECKED BY	PGL			 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270			FILENAME: G037.DWG
			DRAWN BY	JDW							CONTRACT NO.: CONTRACT NO. ###
			CHECKED BY	PGL							VOLUME: 1
			APPROVED BY	NKS							DRAWING NO.:
											SHEET NO.:
PLOT DATE: 9/7/2022		3:17:17 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION		G037			

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FOR INFORMATION ONLY
FOR USE BY INSTALLATION CONTRACTOR

- NOTES:
1. SWITCHES ARE NORMALLY CLOSED (NC) UNLESS OTHERWISE NOTED.
 2. CONFIGURE TRANSFER TRIP FUNCTION TO NEXT BREAKER WHEN ADJACENT TPSS IS BYPASSED FOR FIBER OPTIC CONNECTION.
 3. CONFIGURE TRANSFER TRIP FUNCTION TO NEXT BREAKER WHEN ADJACENT TPSS IS BYPASSED FOR FIBER OPTIC CONNECTION.
 4. OCS POLE MOUNTED DISCONNECT SWITCHES FOR INDICATION SHALL BE MONITORED AND REPORTED TO SCADA CONNECTION FIBER CASES. SEE COMMUNICATIONS PLANS FOR CABLE AND INTERFACE REQUIREMENTS.
- OCS POLE MOUNTED DISCONNECT SWITCH POSITION INDICATIONS SHALL BE MONITORED AND REPORTED TO SCADA INDICATION CABLES SHALL BE RUN TO THE NEAREST TPSS. OCS POLE MOUNTED DISCONNECT SWITCHES SHALL BE OPENED TO PERFORM MAINTENANCE ON EITHER SOUTHBOUND OR NORTHBOUND POWER SECTIONS BETWEEN EXISTING TPSS A4 AND NEW TPSS D1.



REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER SYSTEM MASTER SINGLE LINE DIAGRAM RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE
			CHECKED BY	PGL								FILENAME: J101.DWG
			DRAWN BY	JDW								CONTRACT NO.: CONTRACT NO. ###
			CHECKED BY	PGL								VOLUME: 1
			APPROVED BY	NKS								DRAWING NO.: SHEET NO.:
PLOT DATE: 9/12/2022			5:13:29 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION			J101		

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AC LOCKOUT (86) IS ACTIVATED BY THE FOLLOWING DEVICES:

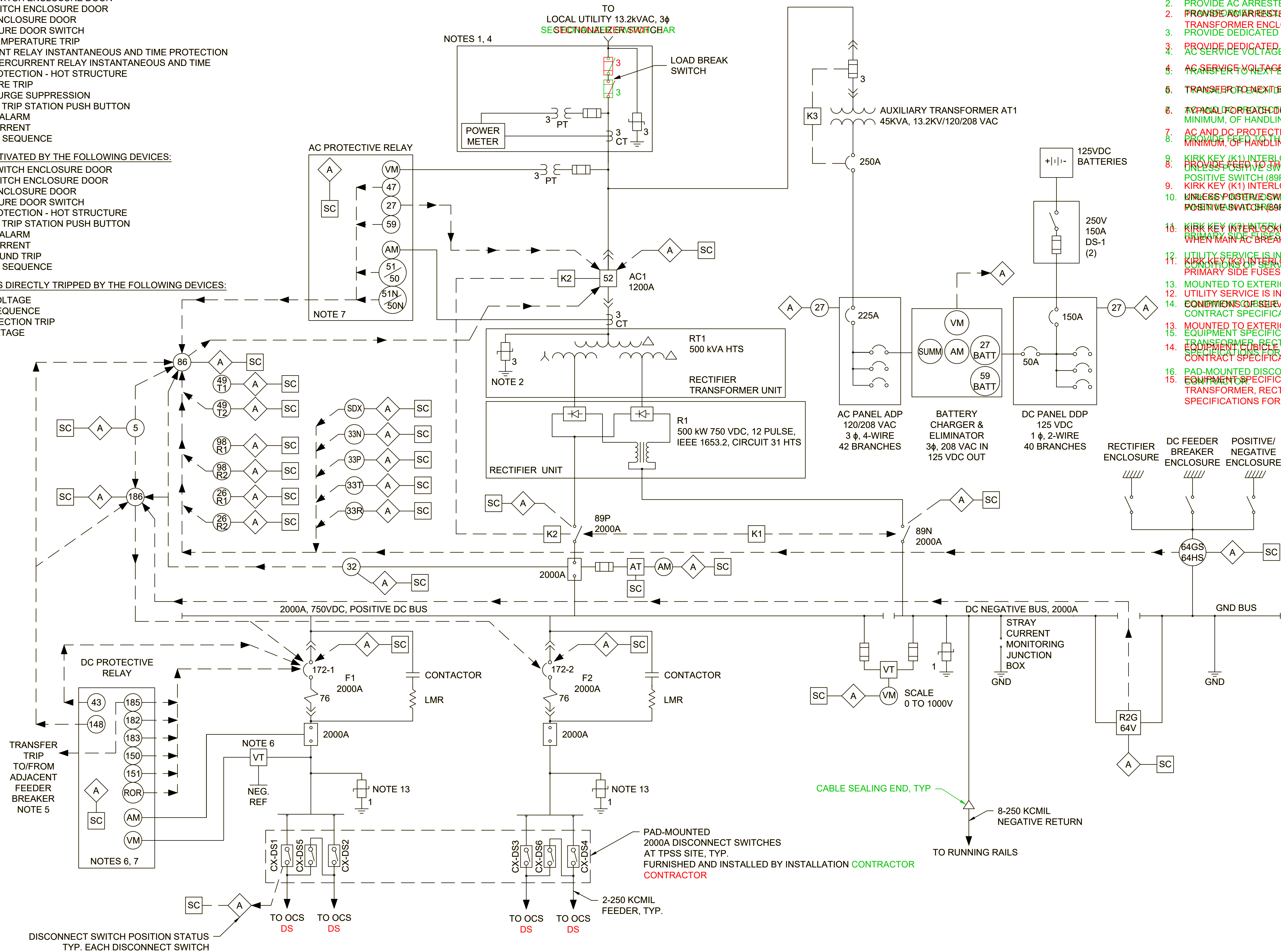
26-R2	RECTIFIER DIODE OVER TEMP TRIP
33A-X	MAIN AC BREAKER CUBICLE REAR DOOR
33F-X	DC FEEDER BREAKER CUBICLE REAR DOOR
33N-X	NEGATIVE SWITCH ENCLOSURE DOOR
33P-X	POSITIVE SWITCH ENCLOSURE DOOR
33R-X	RECTIFIER ENCLOSURE DOOR
33T-X	TPT ENCLOSURE DOOR SWITCH
49-WT2	TPT OVER TEMPERATURE TRIP
50/51	OVERCURRENT RELAY INSTANTANEOUS AND TIME PROTECTION
50N/51N	NEUTRAL OVERCURRENT RELAY INSTANTANEOUS AND TIME
64HS	GROUND PROTECTION - HOT STRUCTURE
98R2	DIODE FAILURE TRIP
99T	RECTIFIER SURGE SUPPRESSION
5	EMERGENCY TRIP STATION PUSH BUTTON
SDX	FIRE/SMOKE ALARM
32	REVERSE CURRENT
148	INCOMPLETE SEQUENCE

DC LOCKOUT (186) IS ACTIVATED BY THE FOLLOWING DEVICES:

33N-X	NEGATIVE SWITCH ENCLOSURE DOOR
33P-X	POSITIVE SWITCH ENCLOSURE DOOR
33R-X	RECTIFIER ENCLOSURE DOOR
33T-X	TPT ENCLOSURE DOOR SWITCH
64HS	GROUND PROTECTION - HOT STRUCTURE
5	EMERGENCY TRIP STATION PUSH BUTTON
SDX	FIRE/SMOKE ALARM
32	REVERSE CURRENT
R2G	RAIL TO GROUND TRIP
148	INCOMPLETE SEQUENCE

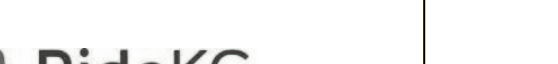
AC MAIN BREAKER (52) IS DIRECTLY TRIPPED BY THE FOLLOWING DEVICES:

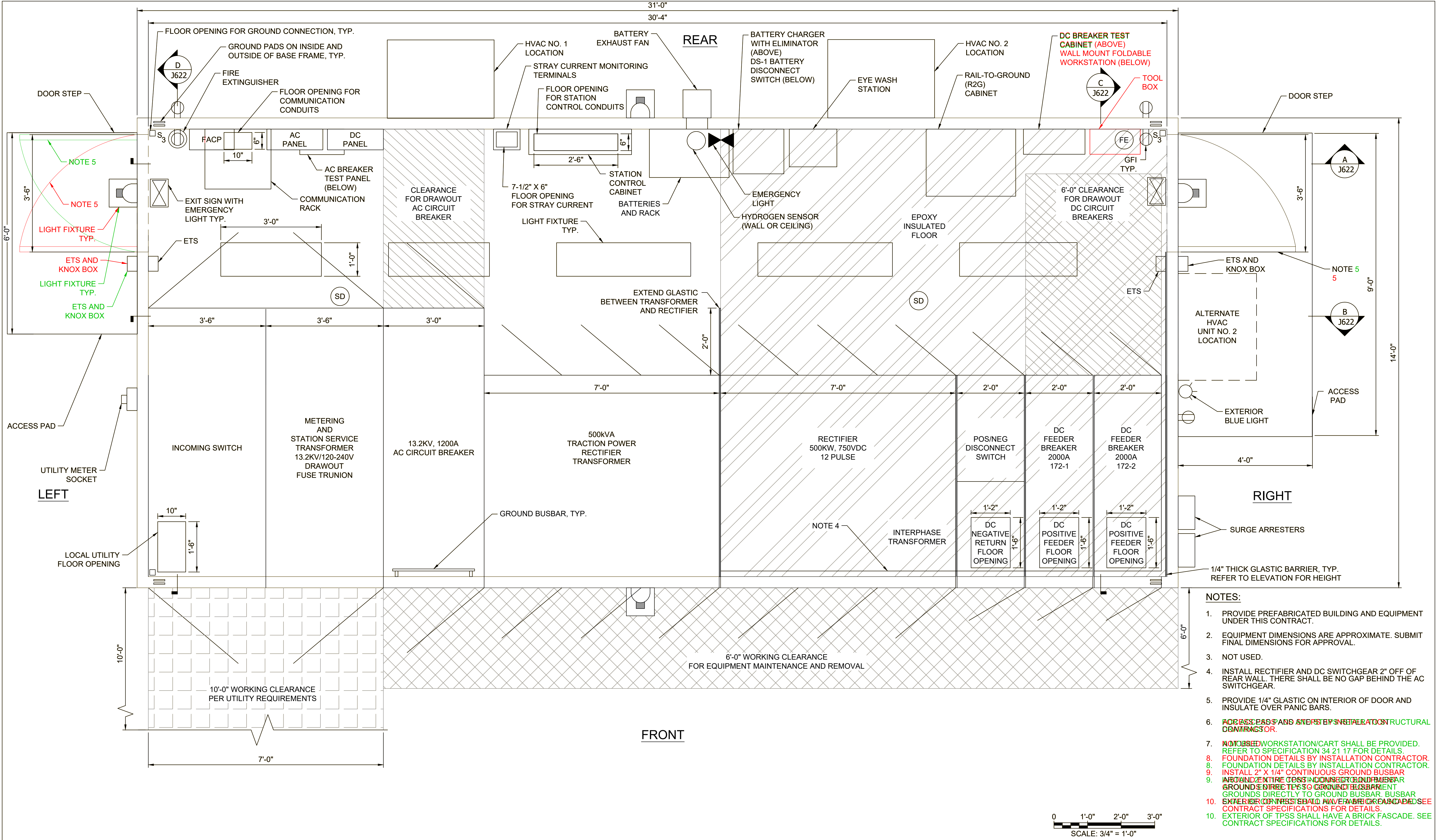
27	AC UNDERVOLTAGE
47	AC PHASE SEQUENCE
50/51	RELAY PROTECTION TRIP
59	AC OVERVOLTAGE



~~NOTES:~~

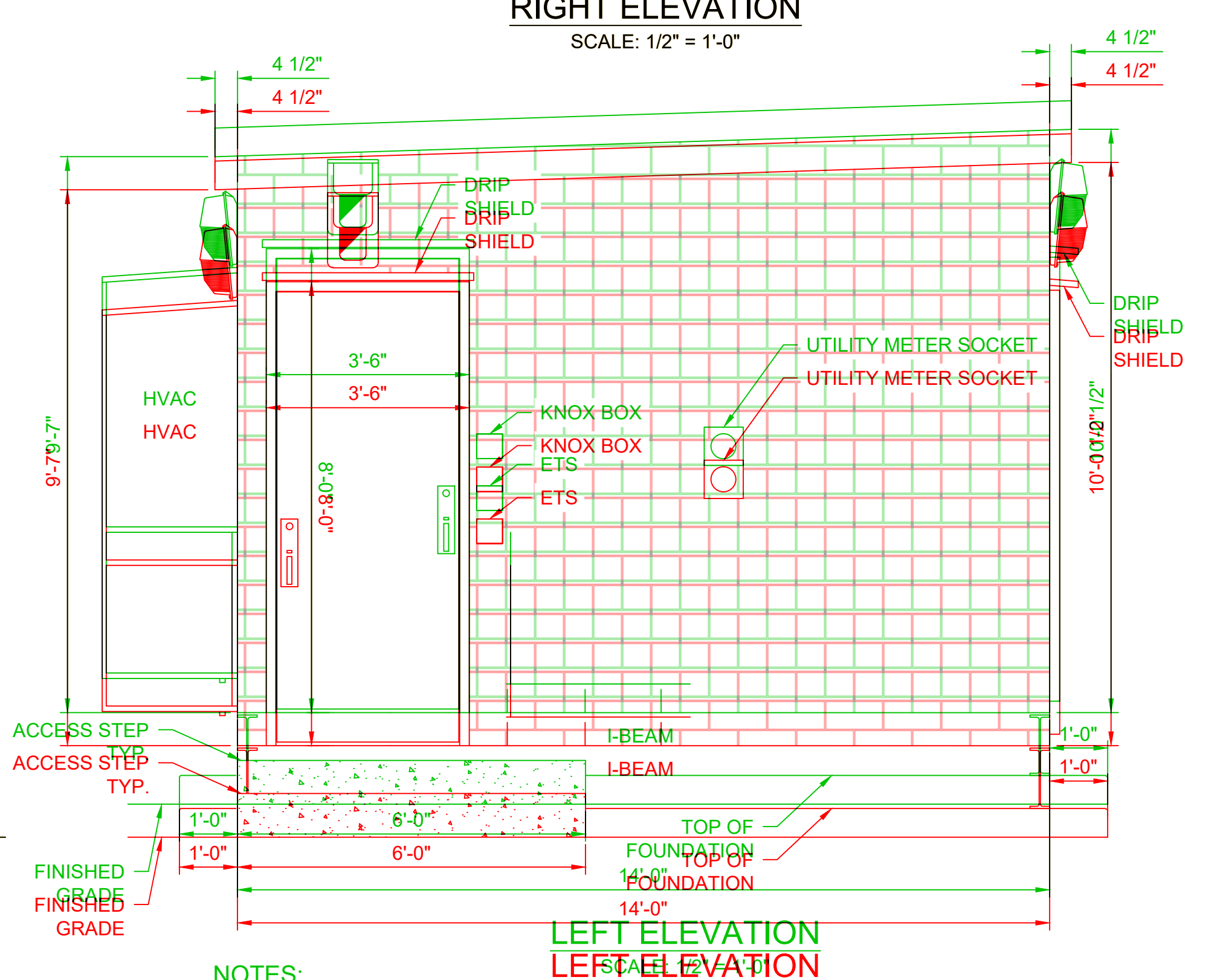
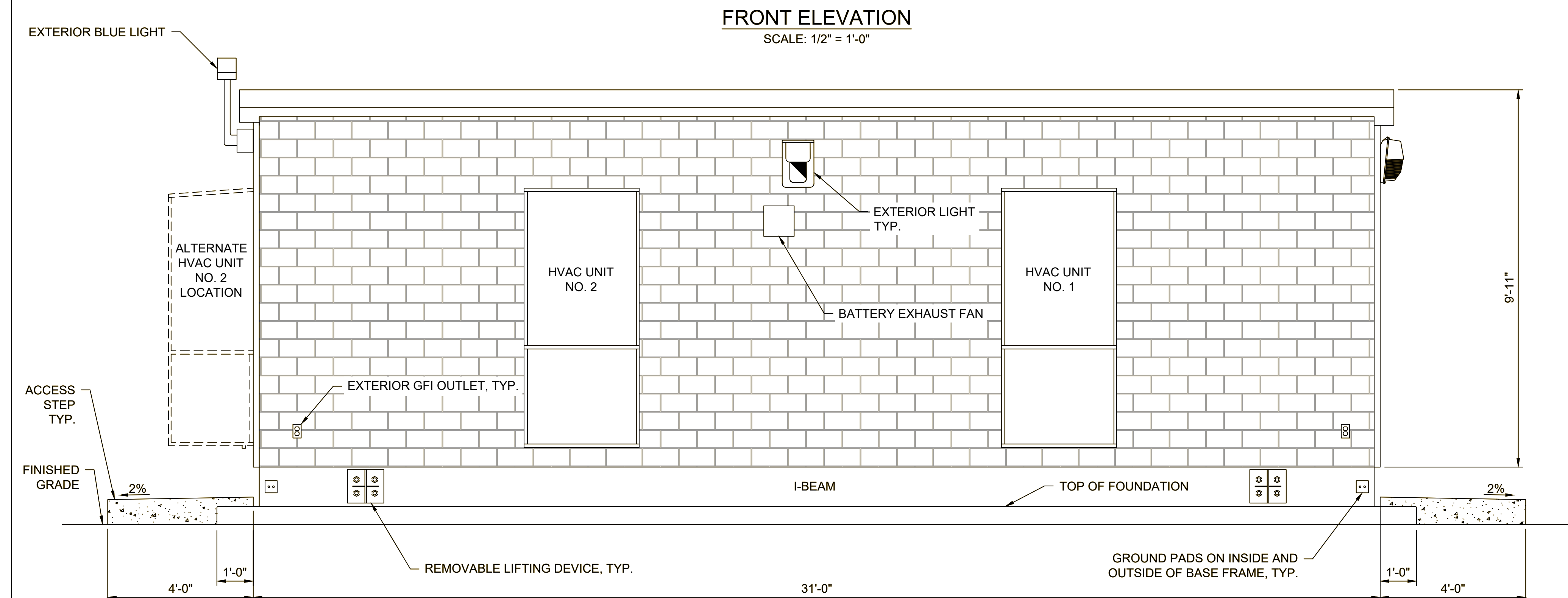
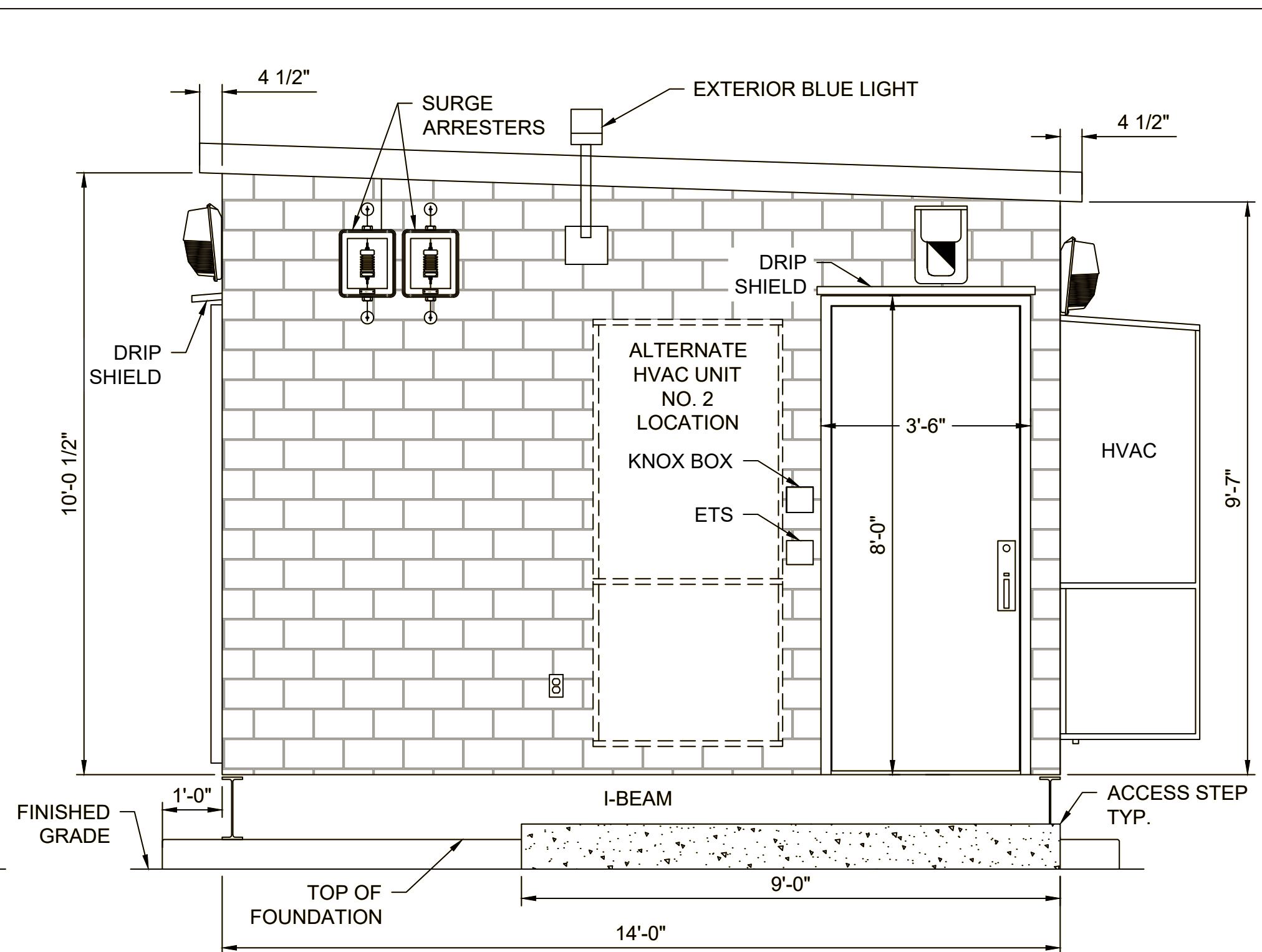
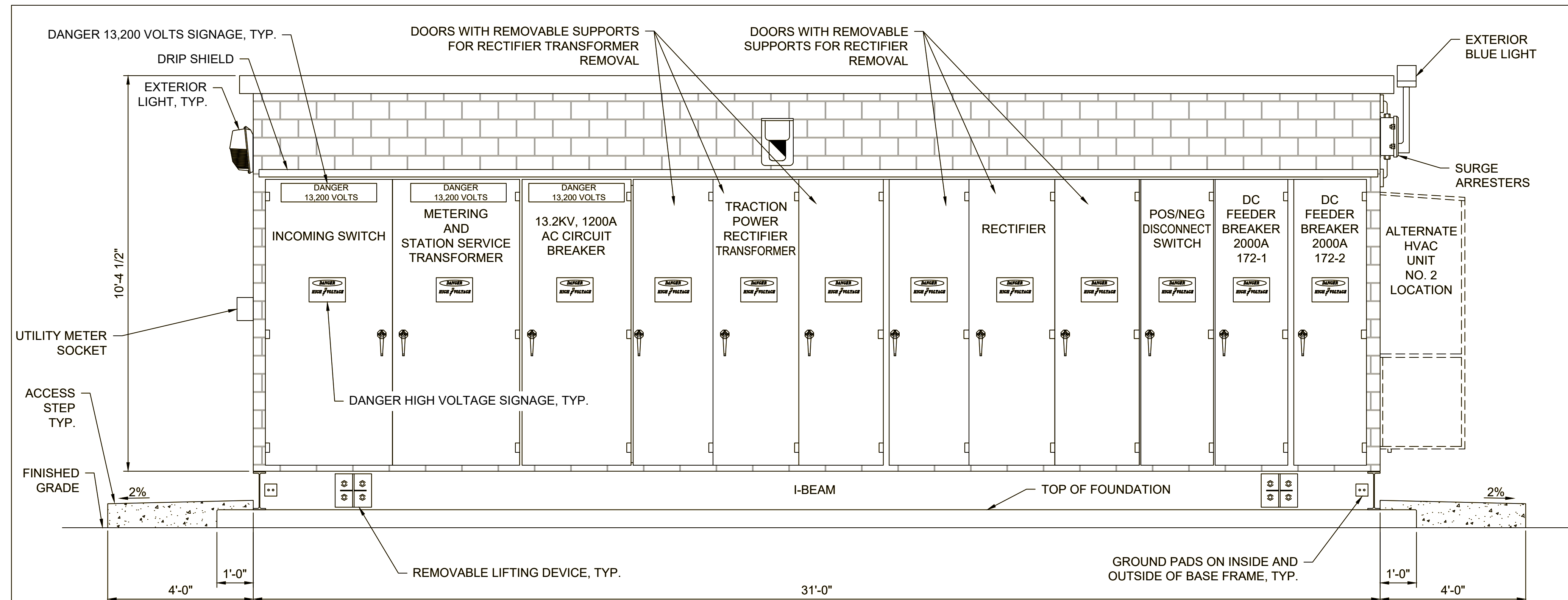
1. UTILITY METERING INSTRUMENT TRANSFORMERS AND METER PROVIDED BY LOCAL UTILITY.
2. UTILITY METERING INSTRUMENT TRANSFORMERS AND METER PROVIDED BY LOCAL UTILITY.
3. PROVIDE AC ARRESTER IN A SEPARATE ENCLOSURE WITH BARRIER WITHIN
4. PROVIDE AC ARRESTER IN A SEPARATE ENCLOSURE WITH BARRIER WITHIN
5. TRANSFORMER ENCLOSURE.
6. PROVIDE DEDICATED 120V AC CIRCUIT FOR TPSS BUILDING EXTERIOR RECEPTACLES.
7. PROVIDE DEDICATED 120V AC CIRCUIT FOR TPSS BUILDING EXTERIOR RECEPTACLES.
8. AC SERVICE VOLTAGE FOR ALL SUBSTATIONS IS 13.2KV, 3-PHASE.
9. AC SERVICE VOLTAGE FOR ALL SUBSTATIONS IS 13.2KV, 3-PHASE.
10. TRANSFER TO NEXT BREAKER WHEN ADJACENT TPSS IS IN BYPASS.
11. TRANSFER TO NEXT BREAKER WHEN ADJACENT TPSS IS IN BYPASS.
12. AC AND DC PROTECTIVE RELAYS SHALL BE MULTIFUNCTION AND CAPABLE, AT A MINIMUM, OF HANDLING ALL FUNCTIONS SHOWN.
13. AC AND DC PROTECTIVE RELAYS SHALL BE MULTIFUNCTION AND CAPABLE, AT A MINIMUM, OF HANDLING ALL FUNCTIONS SHOWN.
14. KIRK KEY (K1) INTERLOCK WILL PREVENT OPENING OF 89N NEGATIVE DISCONNECT UNLESS POSITIVE SWITCH (89P) IS DISCONNECTED AND SHALL PREVENT CLOSE OF THE POSITIVE SWITCH (89P) UNLESS THE 89N NEGATIVE DISCONNECT IS CLOSED.
15. KIRK KEY (K1) INTERLOCK WILL PREVENT OPENING OF 89N NEGATIVE DISCONNECT UNLESS POSITIVE SWITCH (89P) IS DISCONNECTED AND SHALL PREVENT CLOSE OF THE POSITIVE SWITCH (89P) UNLESS POSITIVE SWITCH (89P) IS DISCONNECTED AND NEGATIVE DISCONNECT IS CLOSED.
16. KIRK KEY (K2) INTERLOCK WILL PREVENT REMOVAL OF AUXILIARY TRANSFORMER #1 PRIMARY SIDE FUSES UNLESS SECONDARY (250A) CB IS OPEN.
17. UTILITY SERVICE IS IN ACCORDANCE WITH LOCAL UTILITY REQUIREMENTS AND CONDITIONS OF SERVICE WILL PREVENT REMOVAL OF AUXILIARY TRANSFORMER AT 1 PRIMARY SIDE FUSES UNLESS SECONDARY (250A) CB IS OPEN.
18. MOUNTED TO EXTERIOR OF TPSS.
19. UTILITY SERVICE IS IN ACCORDANCE WITH LOCAL UTILITY REQUIREMENTS AND CONDITIONS OF SERVICE.
20. LIGHTING AND HEATING TO BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
21. MOUNTED TO EXTERIOR OF TPSS.
22. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
23. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
24. PAD-MOUNTED DISCONNECT SWITCHES FURNISHED AND INSTALLED BY THE CONTRACTOR.
25. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION TRACTION POWER TYPICAL MAINLINE TPSS SINGLE LINE SINGLE LINE DIAGRAM	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL		 HNTB Engineering, Inc. The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	HNTB The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270		FILENAME:	
			DRAWN BY	JDW					FILENAME:	
			CHECKED BY	PGL					CONTRACT NO.:	
			APPROVED BY	NKS					CONTRACT NO. ###	
									VOLUME:	
PLOT DATE: 9/12/2023		5:36:25 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION		1	DRAWING NO.:	SHEET NO.:
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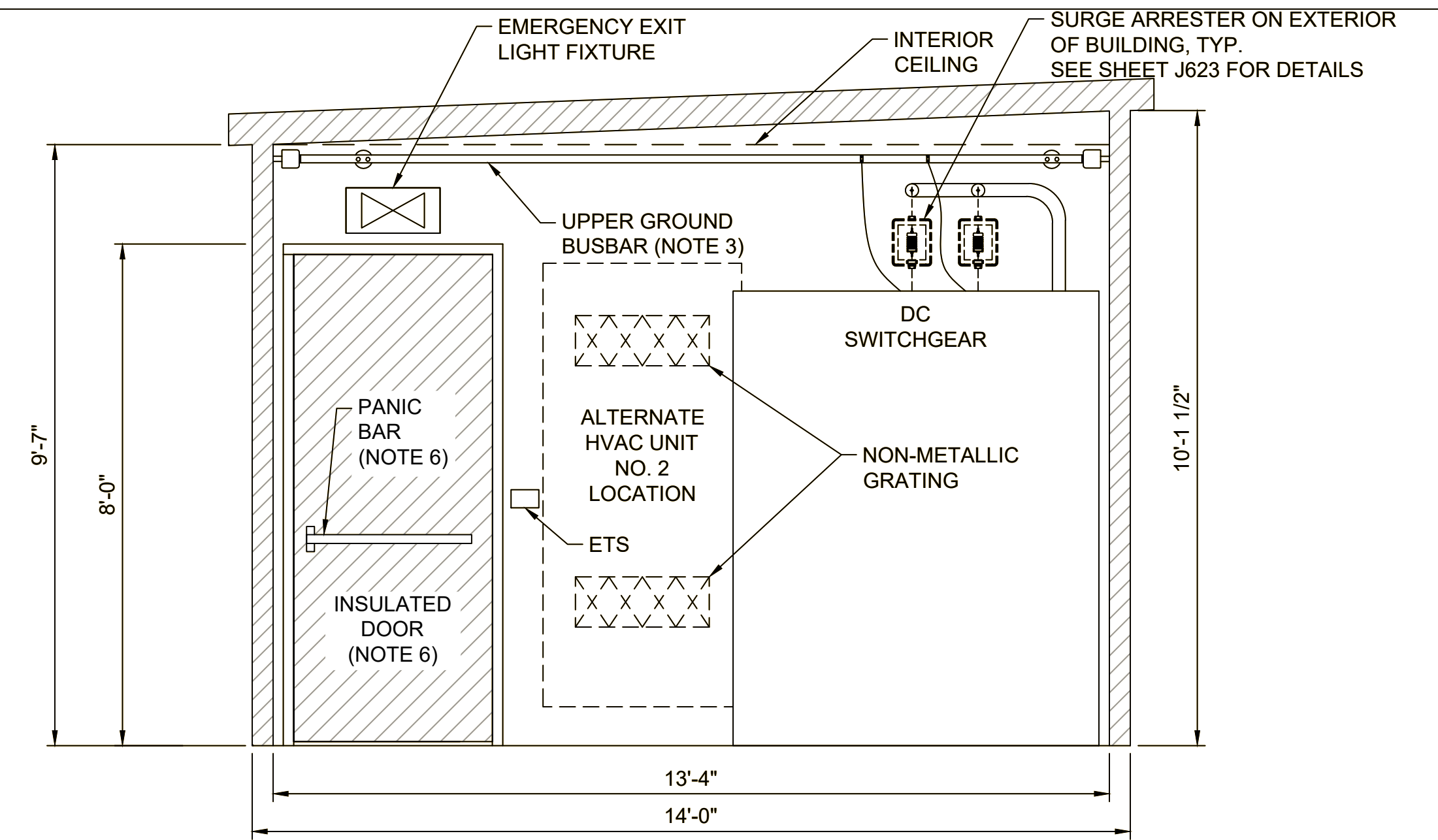
REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	 HNTB The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER TYPICAL PREFABRICATED TPSS PLAN EQUIPMENT LAYOUT PLAN	SCALE FOR 22"x34": 3/4"=1'-0"	
			CHECKED BY	PGL								FILENAME:
			DRAWN BY	JDW								CONTRACT NO.: J620-J623.DWG
			CHECKED BY	PGL								CONTRACT NO. ###
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PLOT DATE: 9/12/2022			5:33:35 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION		DRAWING NO.: J620			SHEET NO.:

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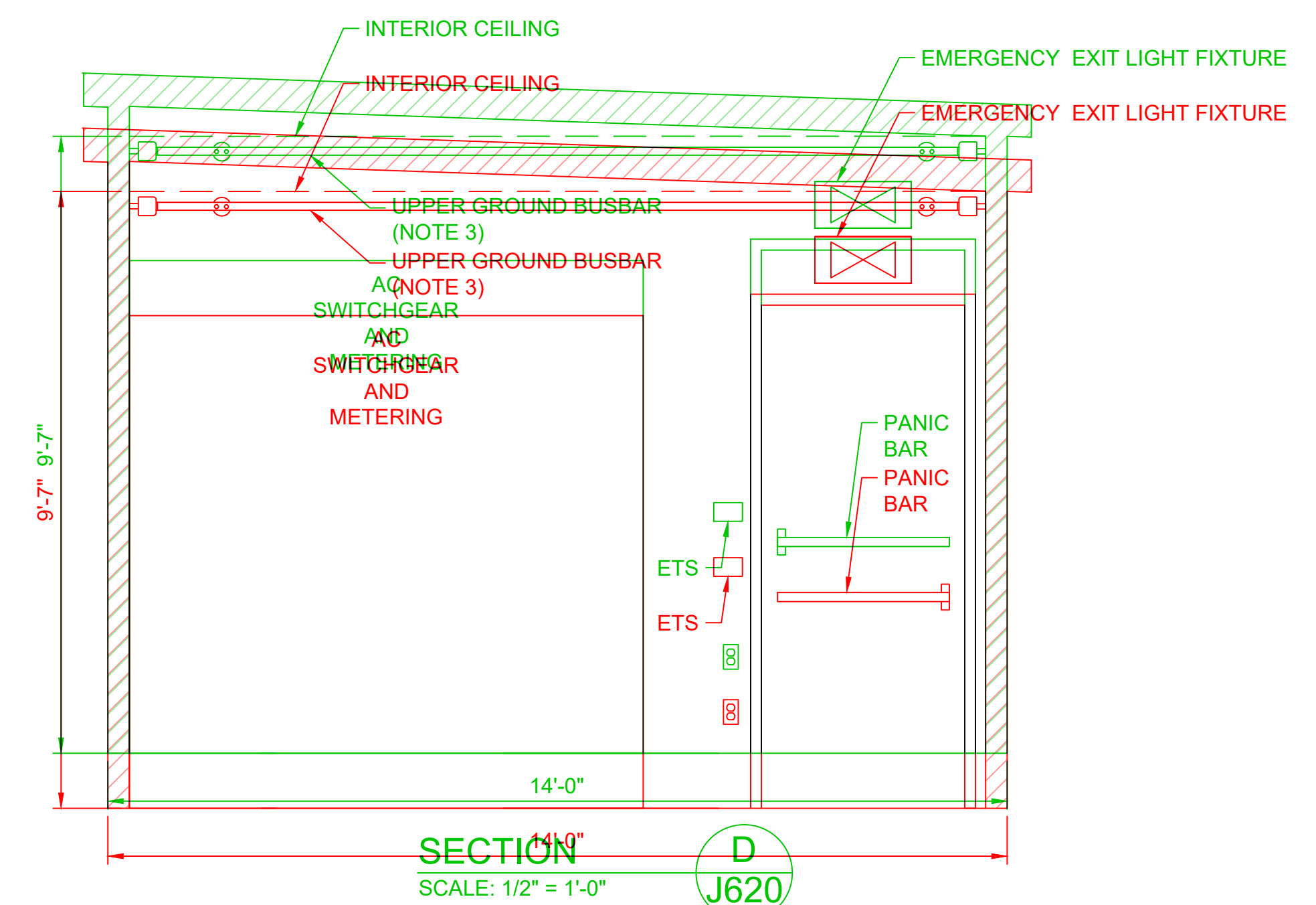


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REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2022	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION TRACTION POWER TYPICAL PREFABRICATED TPSS - EXTERIOR ELEVATIONS ELEVATION VIEW	SCALE FOR 22"x34": 1/2"=1'-0"
			CHECKED BY	PGL		 HNTB HNTB Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	THE HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270		FILENAME:
			DRAWN BY	JDW					J620-J623.DWG
			CHECKED BY	PGL					CONTRACT NO.:
			APPROVED BY	NKS					CONTRACT NO. ###
									VOLUME:
PLOT DATE: 9/12/2022		5:23:25 PM	DATE	06/24/2022		NOT FOR CONSTRUCTION			DRAWING NO.: J621
									SHEET NO.:



SECTION
SCALE: 1/2" = 1'-0"

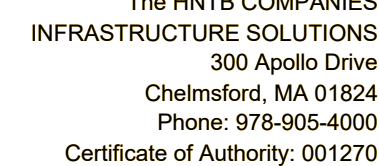
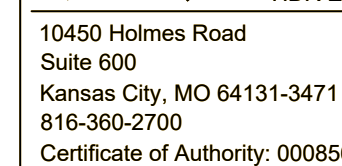


1. ~~INSTALL DIMENSIONS FOR APPROXIMATE SUBSIDIARY DIMENSIONS FOR APPROXIMATE~~ BUSBAR. BUSBAR SHALL BE CONNECTED TO ALL FRAME GROUND PADS.
2. ~~LOCATION OF TRANSFORMER AND RECTIFIER VENTILATION.~~
3. ~~INCOMING SWITCH, METERING EQUIPMENT, AND SOCKET DETAILS SUBJECT TO APPROVAL OF UTILITY.~~
4. ~~INSTALL 2" x 1/4" CONTINUOUS GROUND BUSBAR AROUND ENTIRE TPSS. CONNECT EQUIPMENT GROUNDS DIRECTLY TO GROUND BUSBAR TO SPECIFICATIONS FOR COMMUNICATIONS RACK REQUIREMENTS.~~
5. ~~PROVIDE SWITCH TO BE INTERLOCKED WITH AND SUBSTANTIAL SPACED BARS.~~
6. ~~INSTALL THE SPECIFICATIONS FOR COMMUNICATIONS RACK REQUIREMENTS SHALL BE NO GAP BEHIND THE AC SWITCHGEAR.~~
7. ~~PROVIDE WORKS TO CONCRETE SHALL BE PROVIDED SUBJECT TO SPECIFICATIONS 34 21 17 FOR DETAILS.~~
8. ~~INSTALL RECTIFIER AND DC SWITCHGEAR 2" OFF OF REAR WALL. THERE SHALL BE NO GAP BEHIND THE AC SWITCHGEAR.~~



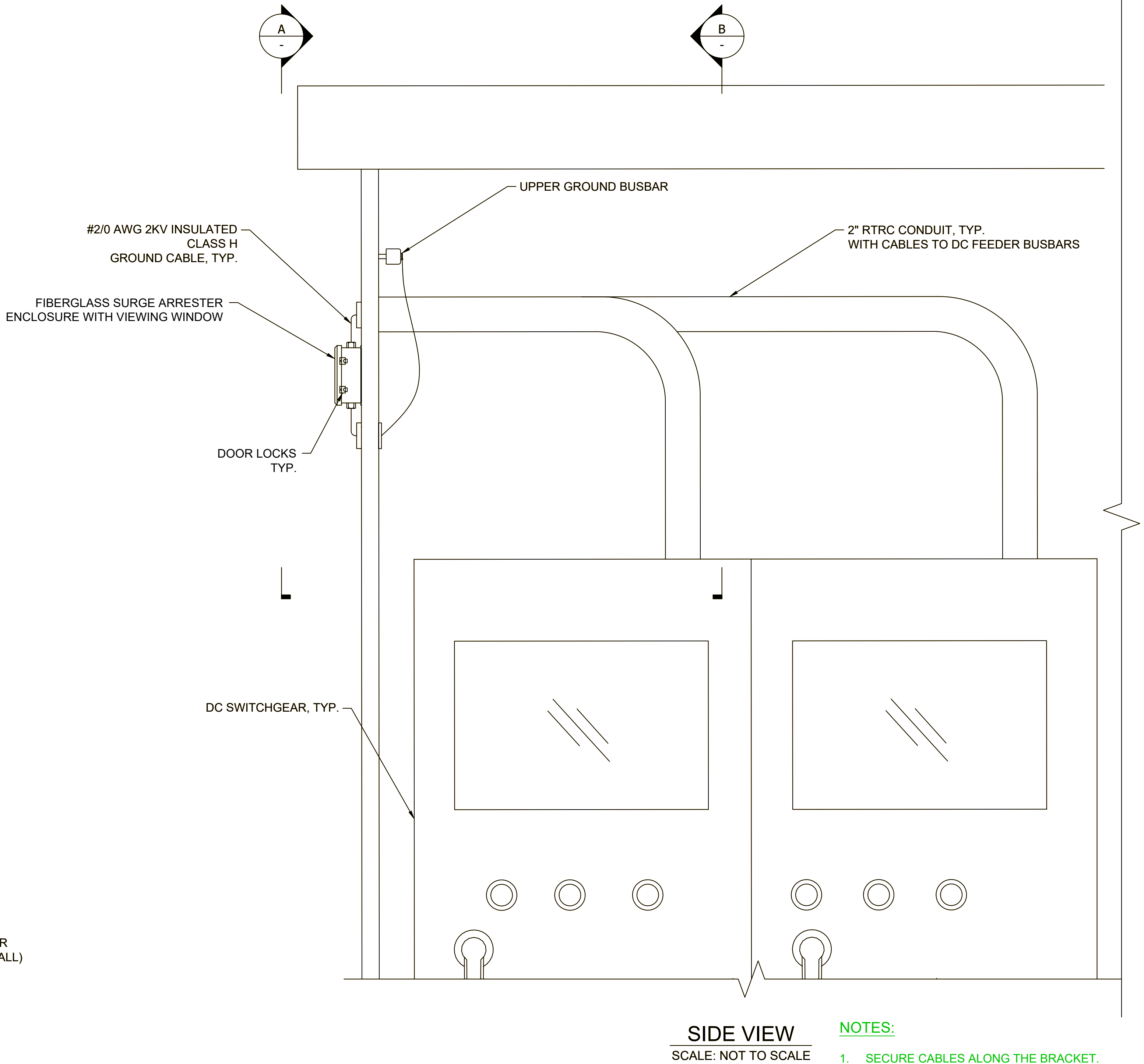
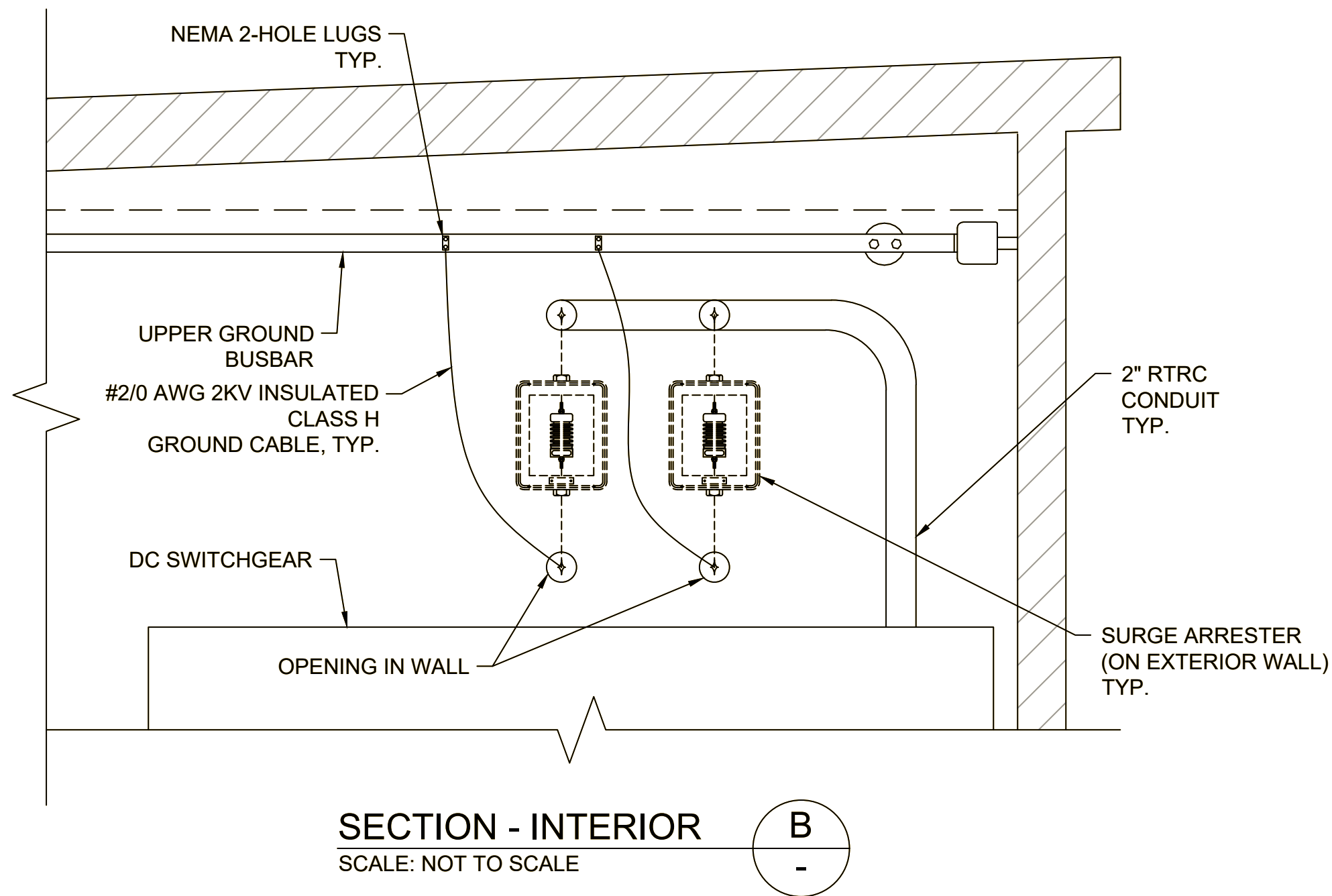
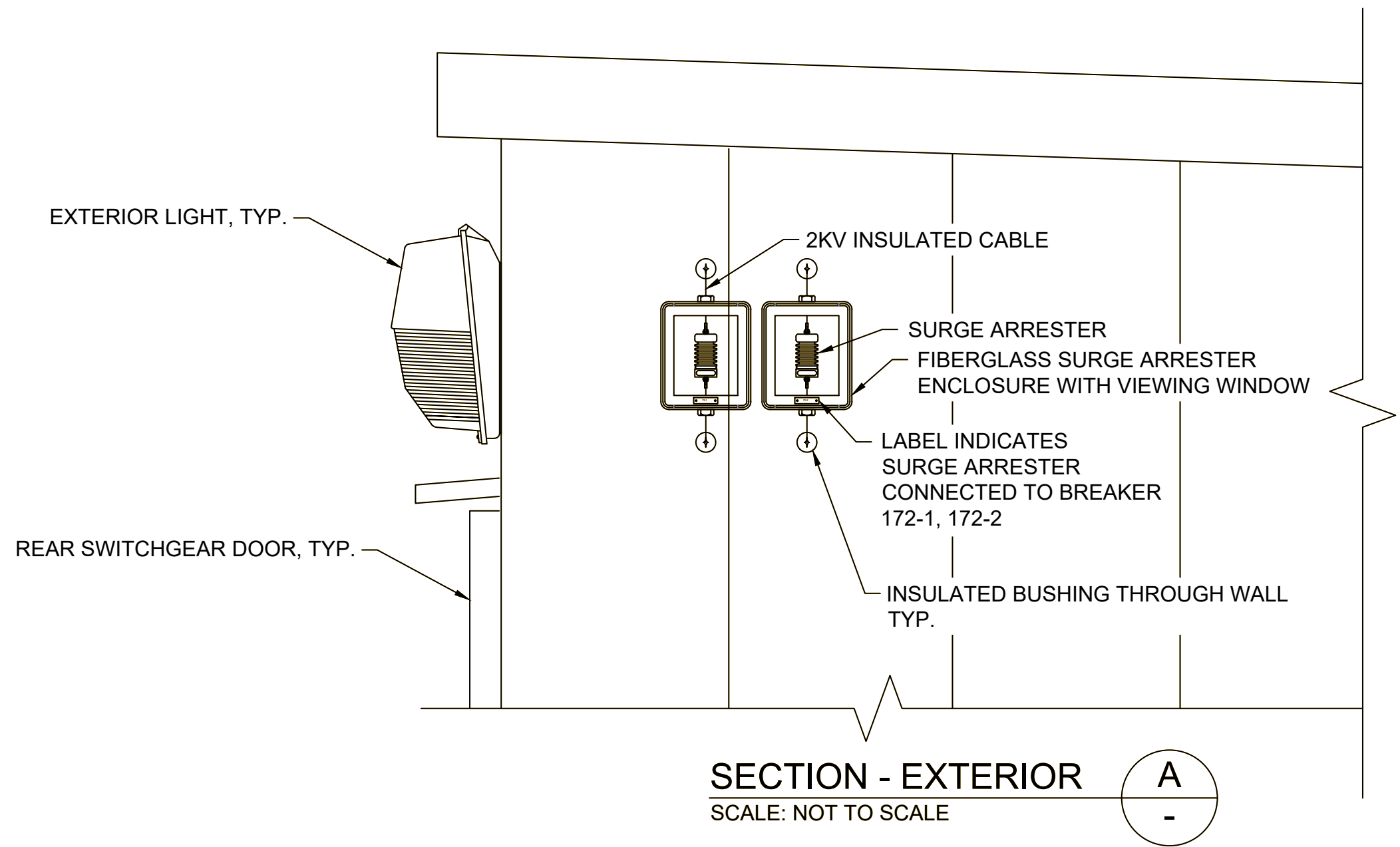
RideKC
STREETCAR

DATE: **09-29-2023**



TRACTION POWER
TYPICAL PREFABRICATED TPSS INTERIOR ELEVATIONS
INTERIOR ELEVATIONS

SCALE FOR 22"x34": 1/2"=1'-0"	
FILENAME: J620-J623.DWG	
CONTRACT NO.:	
CONTRACT NO. ###	
VOLUME: 1	
DRAWING NO.: J622	SHEET N



- NOTES:
1. SECURE CABLES ALONG THE BRACKET.
 2. PROVIDE ENOUGH SLACK IN CABLE FOR SURGE ARRESTER TO FALL AWAY FROM BRACKET.
 3. PROVIDE FIBERGLASS ENCLOSURE WITH VIEWING WINDOW AND DOOR LOCKS.
 4. SURGE ARRESTERS SHALL BE MOUNTED AT A MINIMUM OF 9'-6" ABOVE FINISHED GRADE.
- NOTES:
1. SECURE CABLES ALONG THE BRACKET.
 2. PROVIDE ENOUGH SLACK IN CABLE FOR SURGE ARRESTER TO FALL AWAY FROM BRACKET.
 3. PROVIDE FIBERGLASS ENCLOSURE WITH VIEWING WINDOW AND DOOR LOCKS.
 4. SURGE ARRESTERS SHALL BE MOUNTED AT A MINIMUM OF 9'-6" ABOVE FINISHED GRADE.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW				EARLY PROCUREMENT PACKAGE 3	DATE: ~~09-28-2023~~	 HNTB The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 HNTB The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER TYPICAL SURGER ARRESTER INTERIOR ELEVATIONS	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL										FILENAME:	
			DRAWN BY	JDW										CONTRACT NO.: CONTRACT NO. ###	
			CHECKED BY	PGL										VOLUME:	
			APPROVED BY	NKS										1	
PLOT DATE: 9/12/2022			5:33:35 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION					DRAWING NO.: J623	SHEET NO.:		

Red text and lines are the older version. Green text and lines are the updates. See updated BATES 304477 - 304504 for clean updated plan sheets.

FROM AUXILIARY POWER
TRANSFORMER AT1

NOTE 2

208/120 VAC PANEL 3 ϕ , 4W, 42 CIRCUIT

AC PANEL ADP

MCB
225A, 3P

TYPE 2 SPD

NEUTRAL

GROUND

27

LOAD DESCRIPTION	LOAD KVA			CKT. NO.	CB SIZE AMPS		CB SIZE AMPS	CKT. NO.	LOAD KVA			LOAD DESCRIPTION
	A ϕ	B ϕ	C ϕ						C ϕ	B ϕ	A ϕ	
INTERIOR LIGHTS	-	-	-	1	20A		20A	2	-	-	-	EXTERIOR LIGHTS
INTERIOR RECEPTACLES	-	-	-	3	20A		20A	4	-	-	-	EXTERIOR RECEPTACLES
HVAC #1	-	-	-	5	60A		60A	6	-	-	-	HVAC #2
				7				8				
				9				10				
BATTERY CHARGER	-	-	-	11	60A		20A	12	-	-	-	AC SWITCHGEAR HEATER STRIPS
				13			20A	14	-	-	-	EXHAUST FAN
				15			20A	16	-	-	-	SMOKE DETECTOR
FIRE ALARM PANEL	-	-	-	17	20A		20A	18	-	-	-	DC SWITCHGEAR HEATER STRIPS
EXIT LIGHTS/ EMERGENCY LIGHT	-	-	-	19	20A		20A	20	-	-	-	SWITCHGEAR LIGHTS
SPARE	-	-	-	21	60A		60A	22	-	-	-	SPARE
				23				24				
				25				26				
RECTIFIER TRANSFORMER	-	-	-	27	20A		20A	28	-	-	-	RECTIFIER HEATERS
SPARE	-	-	-	29	20A		20A	30	-	-	-	RECTIFIER LIGHTS
SPARE	-	-	-	31	20A		20A	32	-	-	-	SPARE
SPACE	-	-	-	33	-		-	34	-	-	-	SPACE
SPACE	-	-	-	35	-		-	36	-	-	-	SPACE
SPACE	-	-	-	37	-		-	38	-	-	-	SPACE
SPACE	-	-	-	39	-		-	40	-	-	-	SPACE
SPACE	-	-	-	41	-		-	42	-	-	-	SPACE

AC PANEL ADP - PANEL SCHEDULE
SCALE: NOT TO SCALE

NOTES:

1. NOT FOR CONSTRUCTION: FOR INFORMATIONAL PURPOSES ONLY. REFER TO VENDOR'S AC PANELBOARD DRAWING FOR AC PANEL LAYOUT

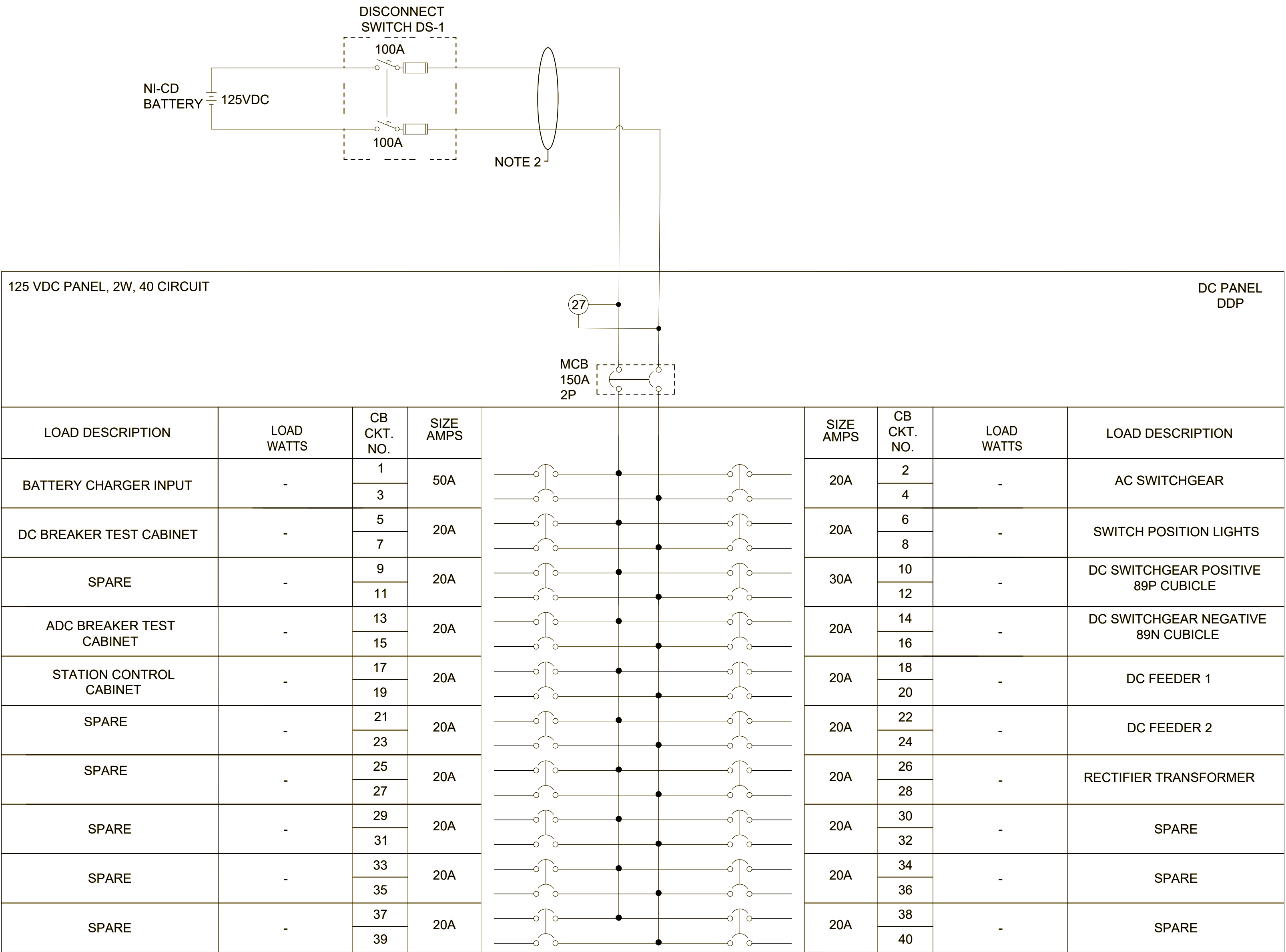
2. ALL INTERNAL BUILDING WIRING AND FINAL BREAKER SIZES TO BE DETERMINED BY VENDOR.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER 120/208V AC PANEL ADP PANEL SCHEDULE	SCALE FOR 22"x34": NOT TO SCALE FILENAME: J642.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.: J642	
			CHECKED BY	PGL									
			DRAWN BY	JDW									
			CHECKED BY	PGL									
			APPROVED BY	NKS									
PLOT DATE: 9/12/2022			5:18:33 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION						

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304457302602

Red text and lines are the older version. Green text and lines are the updates. See updated BATES 304477 - 304504 for clean updated plan sheets.



DC PANEL DDP - PANEL SCHEDULE
SCALE: NOT TO SCALE

NOTES:

1. NOT FOR CONSTRUCTION: FOR INFORMATIONAL PURPOSES ONLY. REFER TO VENDOR'S DC PANELBOARD DRAWING FOR DC PANEL LAYOUT
2. ALL INTERNAL BUILDING WIRING AND FINAL BREAKER SIZES TO BE DETERMINED BY VENDOR.
3. FOR THE DC DISTRIBUTION PANEL: AUXILIARY CONTACTS OF THE MAIN AND EACH BRANCH CIRCUIT BREAKER SHALL BE FACTORY WIRED TO A TERMINAL STRIP FOR CONNECTION TO THE ANNUNCIATOR AND SUPERVISORY CIRCUITS. TRIPPED OR OPEN CIRCUIT BREAKERS SHALL BE ANNUNCIATED.

REV

DATE

DESCRIPTION

DESIGNED BY

CHECKED BY

DRAWN BY

CHECKED BY

APPROVED BY

JDW

PGL

JDW

PGL

NKS

DATE

5:18:58 PM

06/24/2022



EARLY PROCUREMENT PACKAGE 3

DATE: 09-28-2023



HDR Engineering, Inc.

10450 Holmes Road
Suite 600
Kansas City, MO 64131-3471
816-360-2700
Certificate of Authority: 000856



The HNTB COMPANIES

INFRASTRUCTURE SOLUTIONS

300 Apollo Drive
Chelmsford, MA 01824
Phone: 978-905-4000
Certificate of Authority: 001270

NOT FOR CONSTRUCTION

KANSAS CITY STREETCAR - RIVERFRONT EXTENSION

TRACTION POWER
125V DC PANEL DDP
PANEL SCHEDULE

SCALE FOR 22"x34":
NOT TO SCALE

FILENAME:
J643.DWG

CONTRACT NO.:
CONTRACT NO. ###

VOLUME:
1

DRAWING NO.:
J643

SHEET NO.:

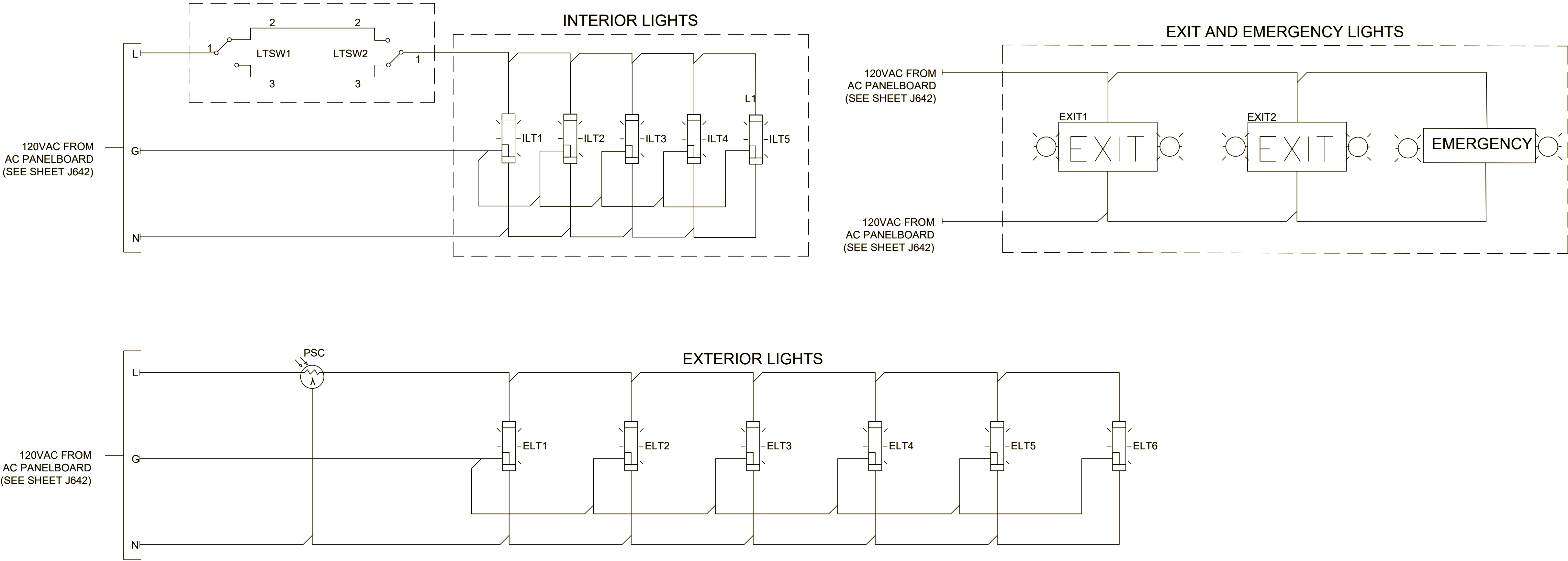
Page 96 of 142

304454 302603

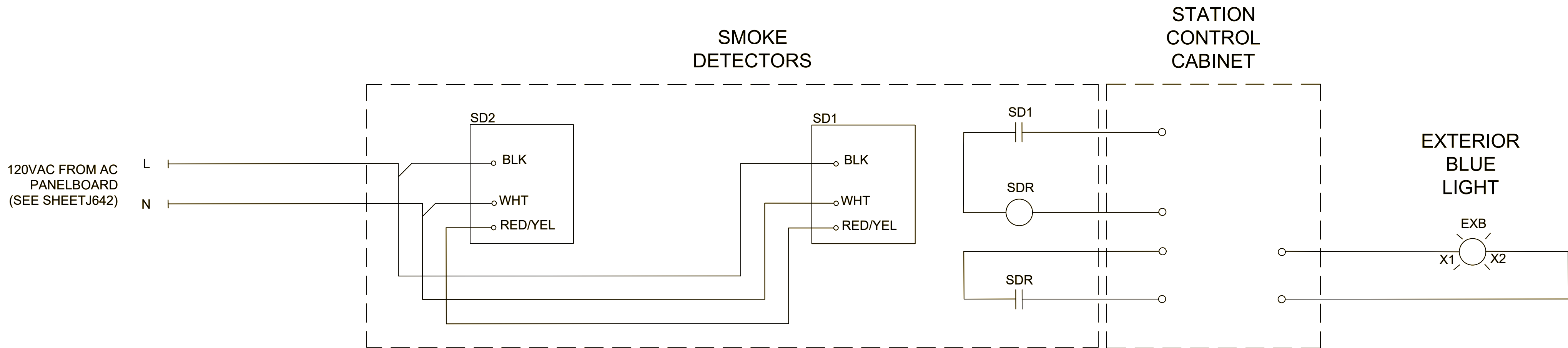
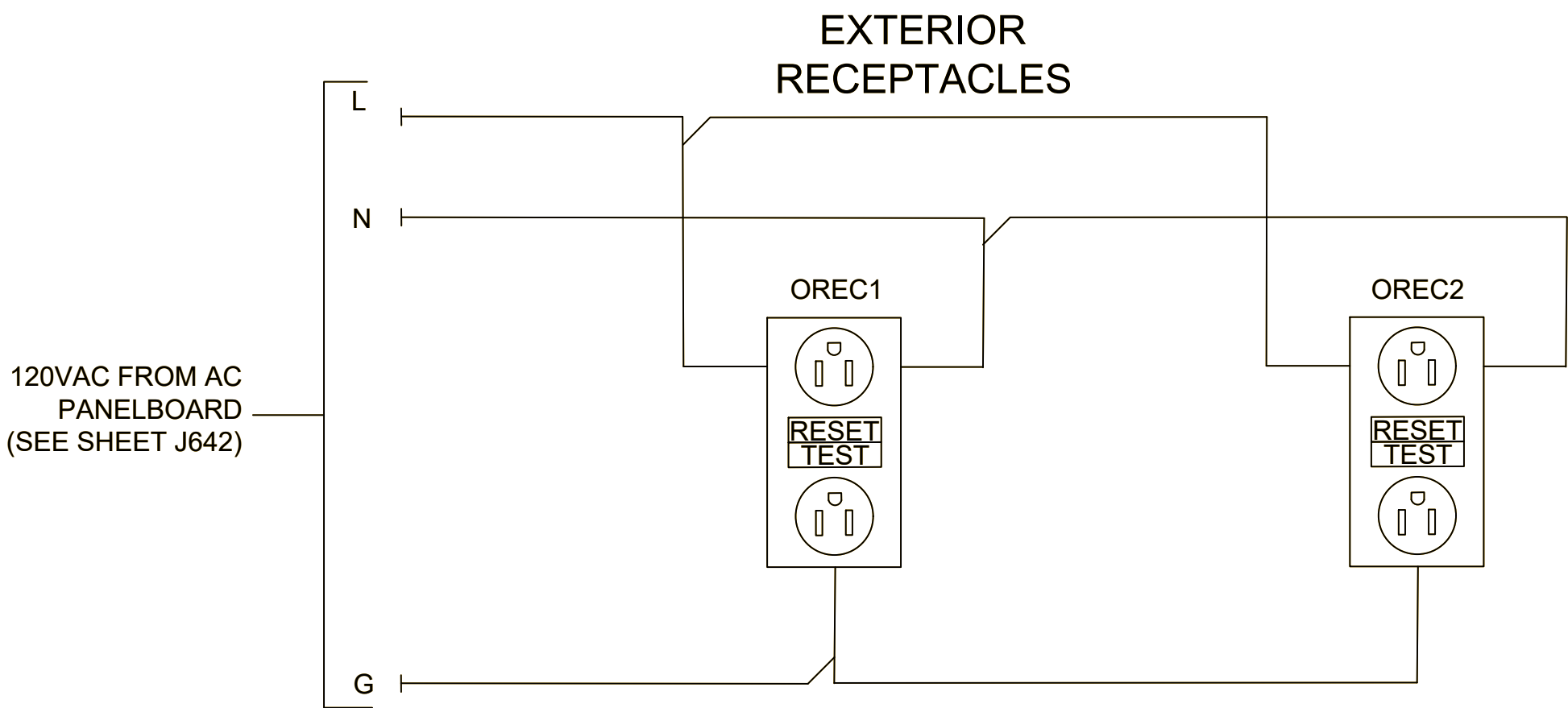
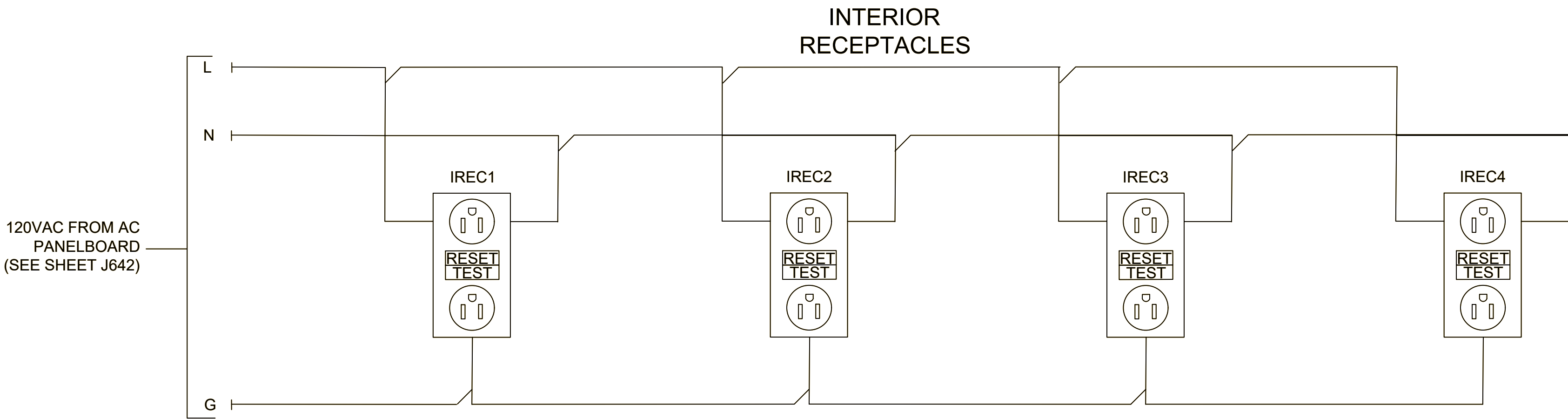
Red text and lines are the older version. Green text and lines are the updates. See updated BATES 304477 - 304504 for clean updated plan sheets.

NOTES:

- 1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.
- 2. EQUIPMENT CUBICLE LIGHTING AND HEATING TO BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
- 3. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.



REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3 DATE: 09-28-2023  HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856  The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION TRACTION POWER TYPICAL TPSS LIGHTING SCHEMATIC	SCALE FOR 22"x34": NOT TO SCALE
			CHECKED BY	PGL				FILENAME: J644.DWG
			DRAWN BY	JDW				CONTRACT NO.: CONTRACT NO. ###
			CHECKED BY	PGL				VOLUME: 1
			APPROVED BY	NKS				DRAWING NO.: SHEET NO.:
								J644
PLOT DATE: 9/12/2022			5:31:17 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION	

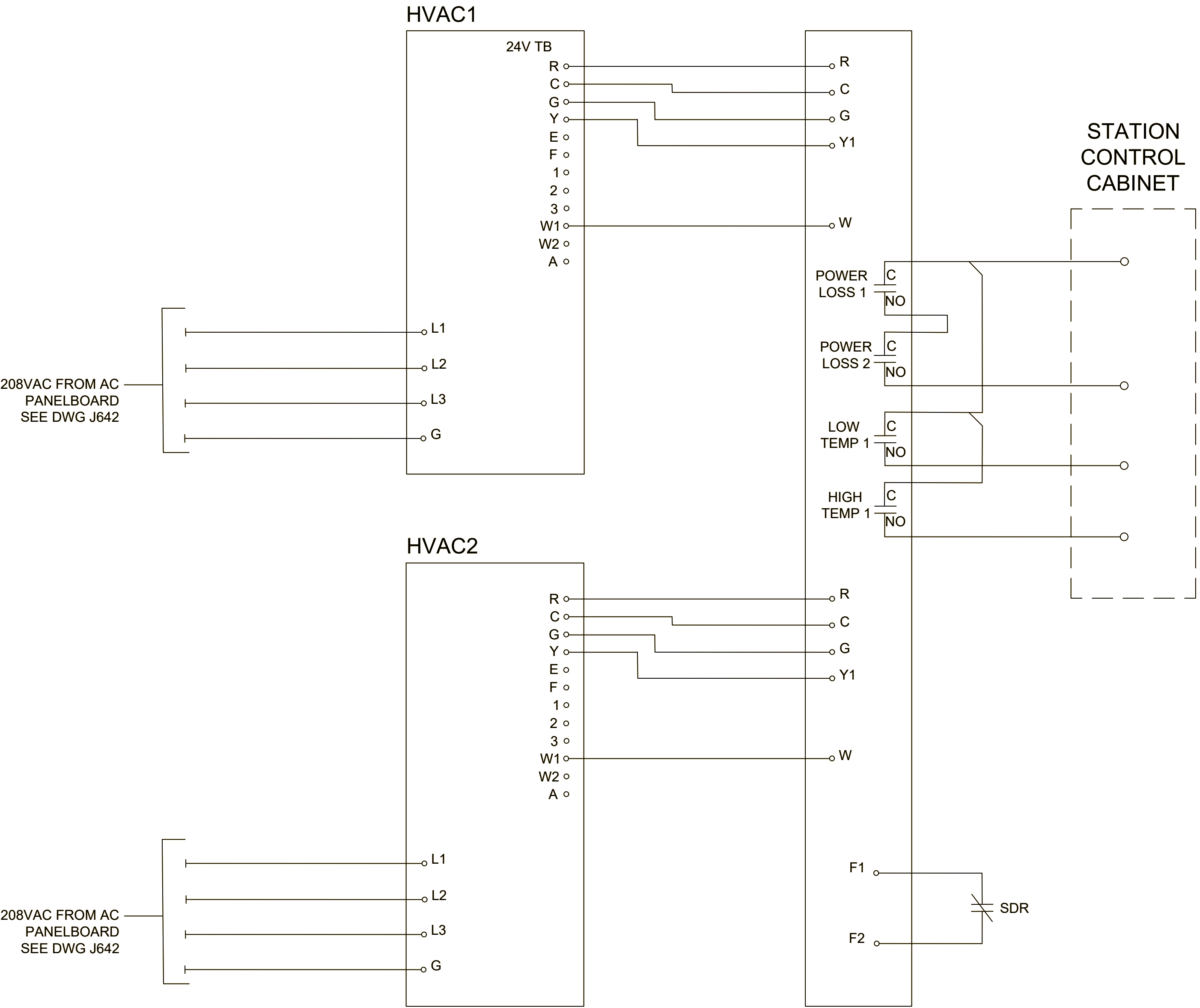


NOTES:

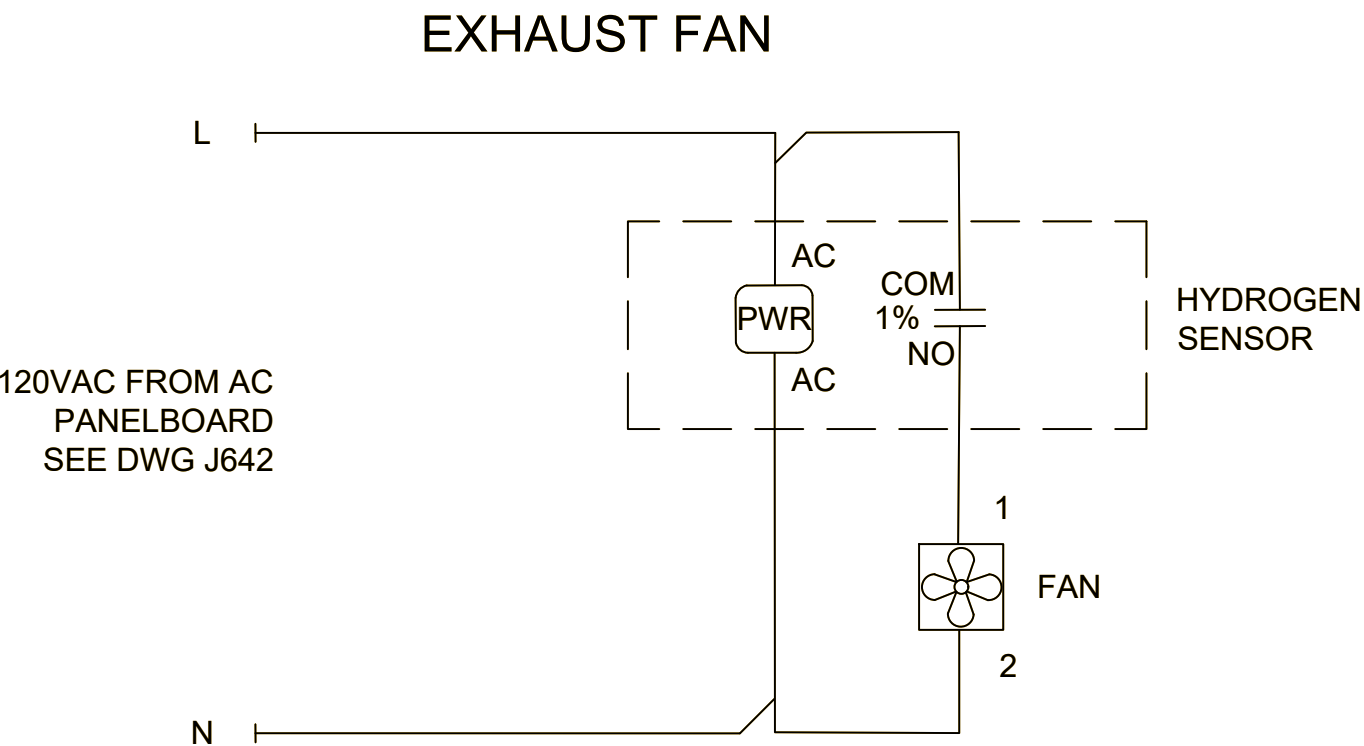
1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.
2. EQUIPMENT CUBICLE LIGHTING AND HEATING TO BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
3. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER TYPICAL TPSS RECEPTACLES AND SMOKE DETECTOR SCHEMATIC	SCALE FOR 22"x34": NOT TO SCALE FILENAME: J645.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.: J645
			CHECKED BY	PGL						
			DRAWN BY	WAC						
			CHECKED BY	PGL						
			APPROVED BY	NKS						
PLOT DATE: 9/12/2022			5:32:18 PM		DATE	06/24/2022		NOT FOR CONSTRUCTION		

Red text and lines are the older version. Green text and lines are the updates. See updated BATES 304477 - 304504 for clean updated plan sheets.



- NOTES:**
- 1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.
 - 2. EQUIPMENT CUBICLE LIGHTING AND HEATING TO BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 - 3. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.

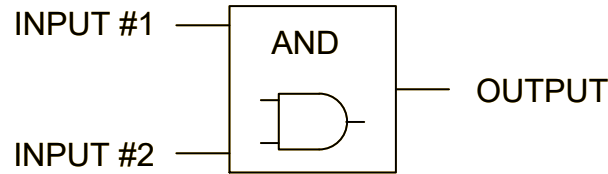


REV	DATE	DESCRIPTION	DESIGNED BY	JDW			 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE
			CHECKED BY	PGL					FILENAME: J646.DWG			
			DRAWN BY	WAC					CONTRACT NO.: CONTRACT NO. ###			
			CHECKED BY	PGL					VOLUME: 1			
			APPROVED BY	NKS					DRAWING NO.: SHEET NO.:			
PLOT DATE: 9/12/2022		5: 32: 36 PM	DATE	06/24/2022					J646			
								NOT FOR CONSTRUCTION				

Red text and lines are the older version. Green text and lines are the updates. See updated BATES 304477 - 304504 for clean updated plan sheets.

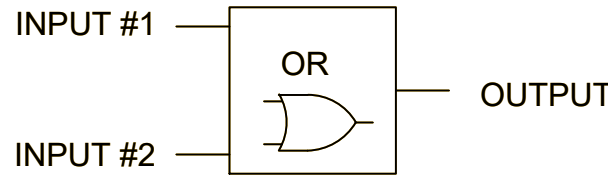
- NOTES:
1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

AND GATE



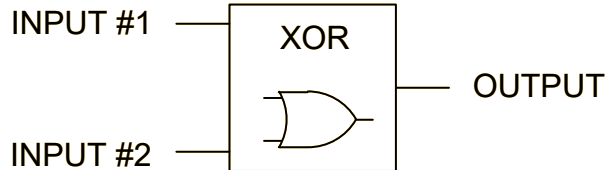
INPUT #1	INPUT #2	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

OR GATE



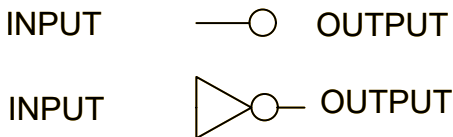
INPUT #1	INPUT #2	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	1

EXCLUSIVE OR GATE



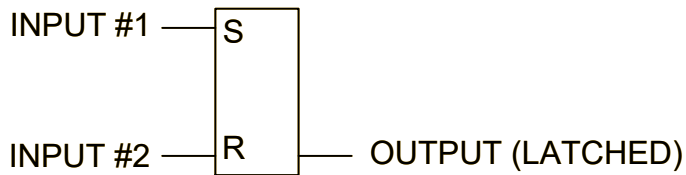
INPUT #1	INPUT #2	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	0

SIGNAL INVERSION



INPUT	OUTPUT
0	1
1	0

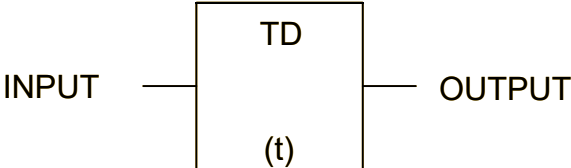
SET OVER RESET OPERATOR



INPUT #1	INPUT #2	OUTPUT (LATCHED)
0	0	PREVIOUS STATE
0	1	0
1	0	1
1	1	PREVIOUS STATE

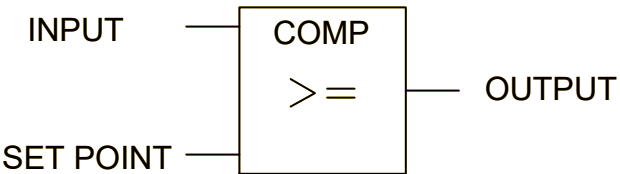
OUTPUT CHANGES STATE ONLY UPON RISING EDGE OF INPUT SIGNAL

TIME DELAY



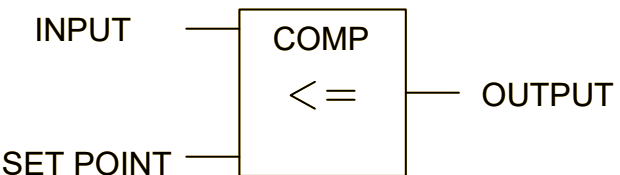
A RISING EDGE ON THE INPUT STARTS THE TIMER(t). THE TIMER COUNTS AS LONG AS THE INPUT IS HIGH. IF THE TIMER EXPIRES WHILE THE INPUT IS HIGH THE OUTPUT BECOMES ACTIVE. A FALLING INPUT EDGE RESETS THE TIMER.

GREATER THAN COMPARATOR



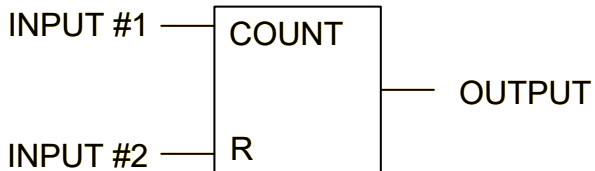
IF THE INPUT VALUE IS GREATER THAN OR EQUAL TO THE SET POINT, THE OUTPUT BECOMES ACTIVE.

LESS THAN COMPARATOR



IF THE INPUT VALUE IS LESS THAN OR EQUAL TO THE SET POINT, THE OUTPUT BECOMES ACTIVE.

COUNTER



EACH TIME INPUT #1 IS PULSED HIGH THE COUNTER INCREMENTS AND THE OUTPUT REFLECTS THE COUNT VALUE. WHEN INPUT #2 IS PULSED HIGH THE COUNT VALUE IS RESET.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER LOGIC DIAGRAMS SYMBOLS AND LEGEND	SCALE FOR 22"x34": NOT TO SCALE FILENAME: J648.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.: J648
			CHECKED BY	PGL						
			DRAWN BY	WAC						
			CHECKED BY	PGL						
			APPROVED BY	NKS						
PLOT DATE: 9/12/2022			5: 33: 08 PM		DATE	06/24/2022				

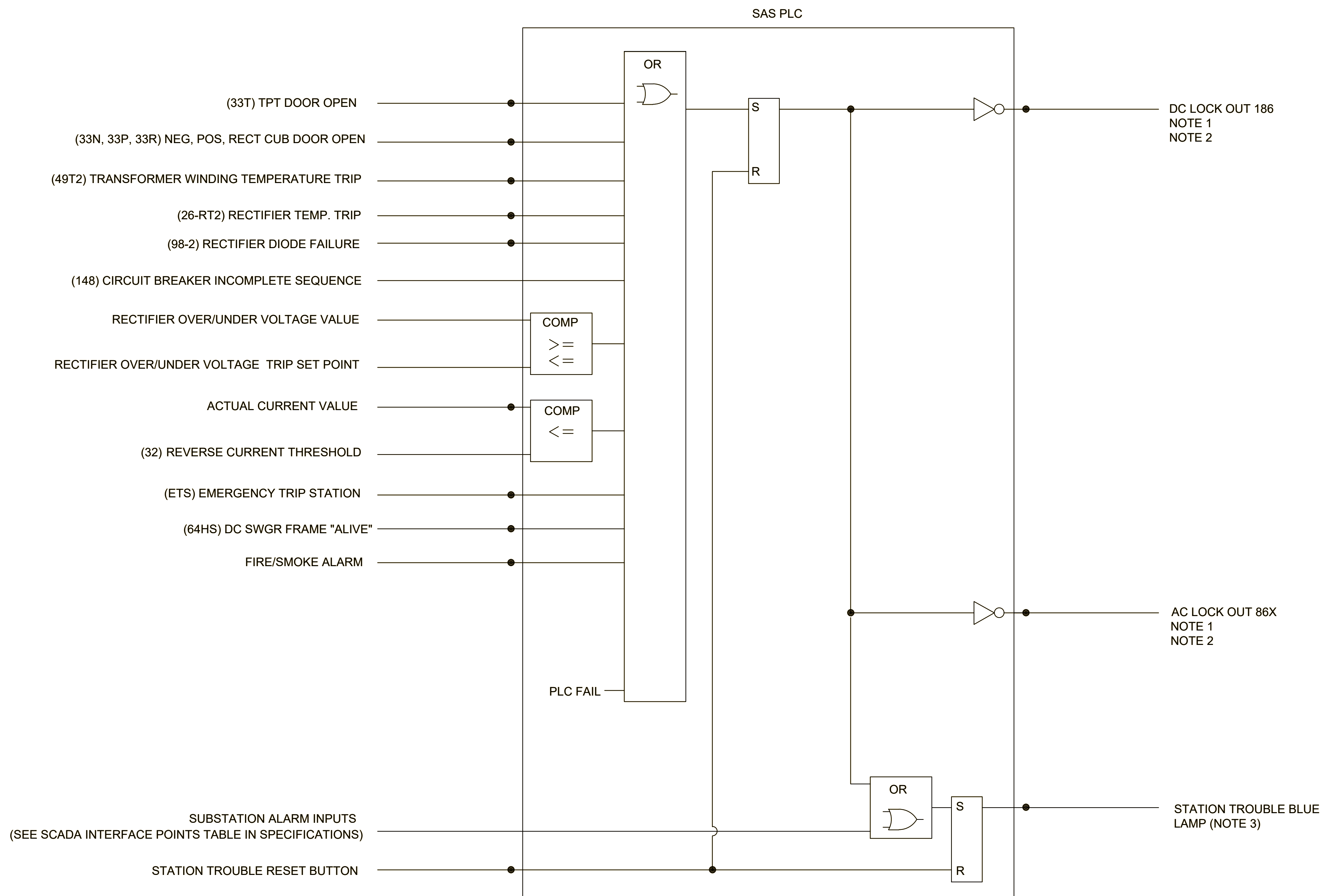


HDR Engineering, Inc.
10450 Holmes Road
Suite 600
Kansas City, MO 64131-3471
816-360-2700
Certificate of Authority: 000856



The HNTB COMPANIES
INFRASTRUCTURE SOLUTIONS
300 Apollo Drive
Chelmsford, MA 01824
Phone: 978-905-4000
Certificate of Authority: 001270

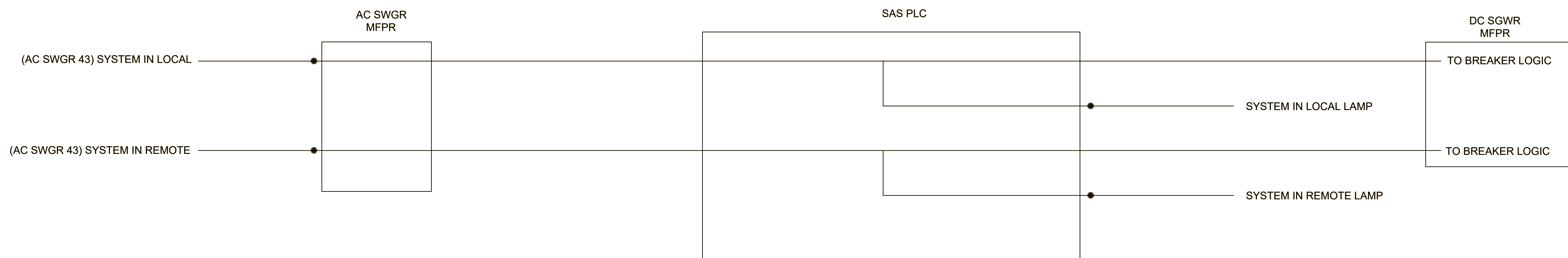
SUBSTATION LOCKOUT AND ALARM LOGIC

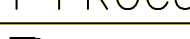


NOTES:

1. PLC OUTPUT ACTIVATES LOCKOUT RELAY 186 & 86X.
2. THIS SIGNAL IS ACTIVE LOW.
3. FLASHING BLUE LIGHT (NEW UNACKNOWLEDGED ALARM)
SOLID BLUE LIGHT (ACTIVE ACKNOWLEDGED ALARMS)
BLUE LIGHT OFF (NO ACTIVE ALARMS).
4. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL
REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

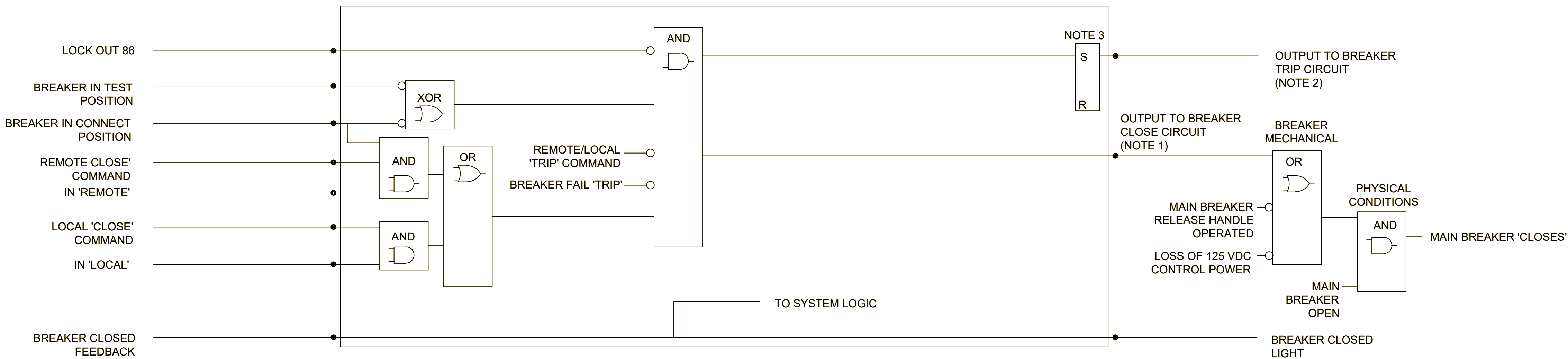
LOCAL / REMOTE LOGIC



REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-20-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION TRACTION POWER SUBSTATION LOCKOUT AND ALARM LOGIC DIAGRAM	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL		 HNTB Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	HNTB The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270		FILENAME:	
			DRAWN BY	WAC					CONTRACT NO.:	
			CHECKED BY	PGL					CONTRACT NO. ###	
			APPROVED BY	NKS					VOLUME:	
									1	
PLOT DATE: 9/12/2022		5:33:18 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION		DRAWING NO.:	SHEET NO.:	
								J649		

NOTES:

1. WHEN CONDITIONS ARE MET OUTPUT IS PULSED ONCE.
2. WHEN THE BREAKER IS CLOSED THIS OUTPUT IS SET HIGH.
3. THE BREAKER OPEN OUTPUT LATCH IS SET WHEN ALL CONDITIONS ARE SATISFIED FOR BREAKER CLOSE AND IT IS RESET WHEN CONDITIONS ARE SATISFIED FOR BREAKER OPEN.
4. BREAKER GROUP ALARM IS A SUMMARY ALARM. AVAILABILITY OF THIS ALARM VARIES BY MFPR MANUFACTURER.
5. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

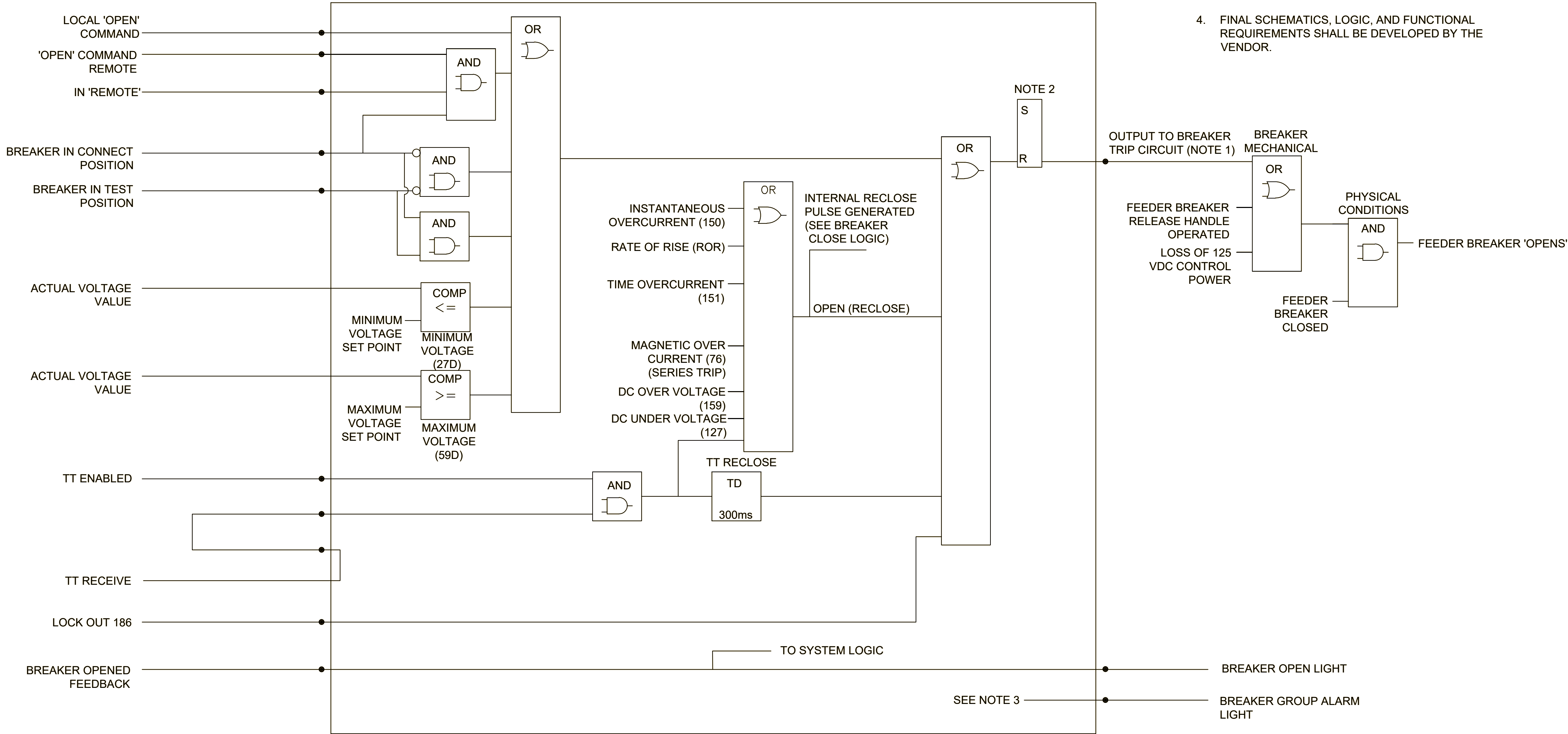


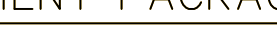
REV	DATE	DESCRIPTION	DESIGNED BY	JDW			EARLY PROCUREMENT PACKAGE 3	DATE: ~~09-08-2023~~	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL			 HDR Engineering, Inc.	 The HNTB COMPANIES		TRACTION POWER AC SWITCHGEAR INCOMING CUBICLE LOGIC DIAGRAM	FILENAME:
			DRAWN BY	JDW			10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270			J650.DWG
			CHECKED BY	PGL							CONTRACT NO.: ###
			APPROVED BY	NKS							VOLUME:
											1
PLOT DATE: 9/12/2022			5:33:31 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION			DRAWING NO.: J650	SHEET NO.:

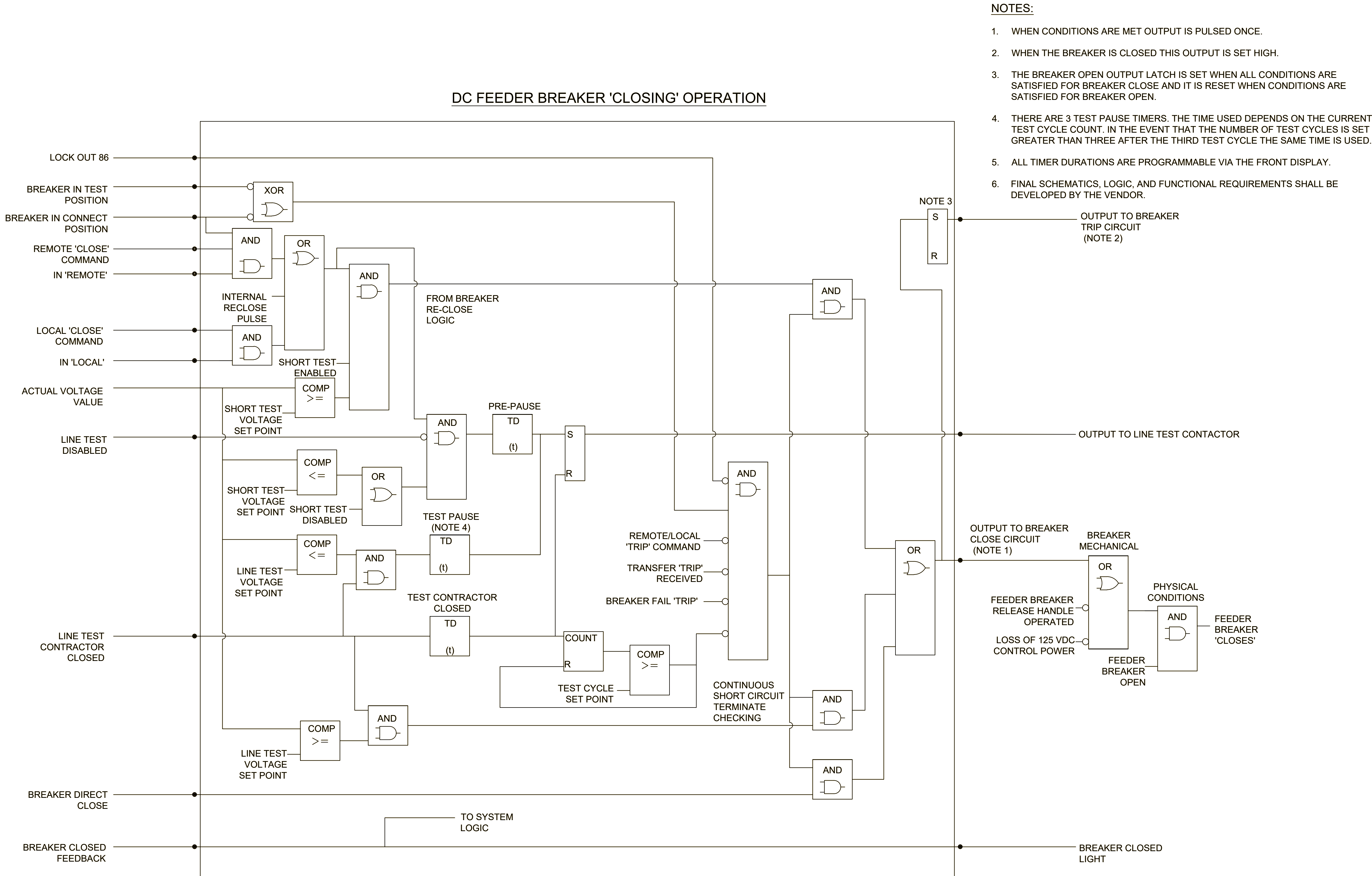
NOTES:

1. WHEN THE BREAKER IS CLOSED THIS OUTPUT IS SET HIGH.
2. THE BREAKER OPEN OUTPUT LATCH IS SET WHEN ALL CONDITIONS ARE SATISFIED FOR BREAKER CLOSE AND IT IS RESET WHEN CONDITIONS ARE SATISFIED FOR BREAKER OPEN.
3. BREAKER GROUP ALARM IS A SUMMARY ALARM. AVAILABILITY OF THIS ALARM VARIES BY MFPR MANUFACTURER.
4. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

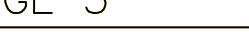
DC FEEDER BREAKER 'TRIPPING' OPERATION



REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE		
			CHECKED BY	PGL		 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270		TRACTION POWER TYPICAL DC FEEDER CUBICLE LOGIC DIAGRAM SHEET 1 OF 2	J652.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1	
			DRAWN BY	JDW							
			CHECKED BY	PGL							
			APPROVED BY	NKS							
PLOT DATE: 9/12/2022			5: 33: 38 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION				
									DRAWING NO.:	SHEET NO.:	
									J652		

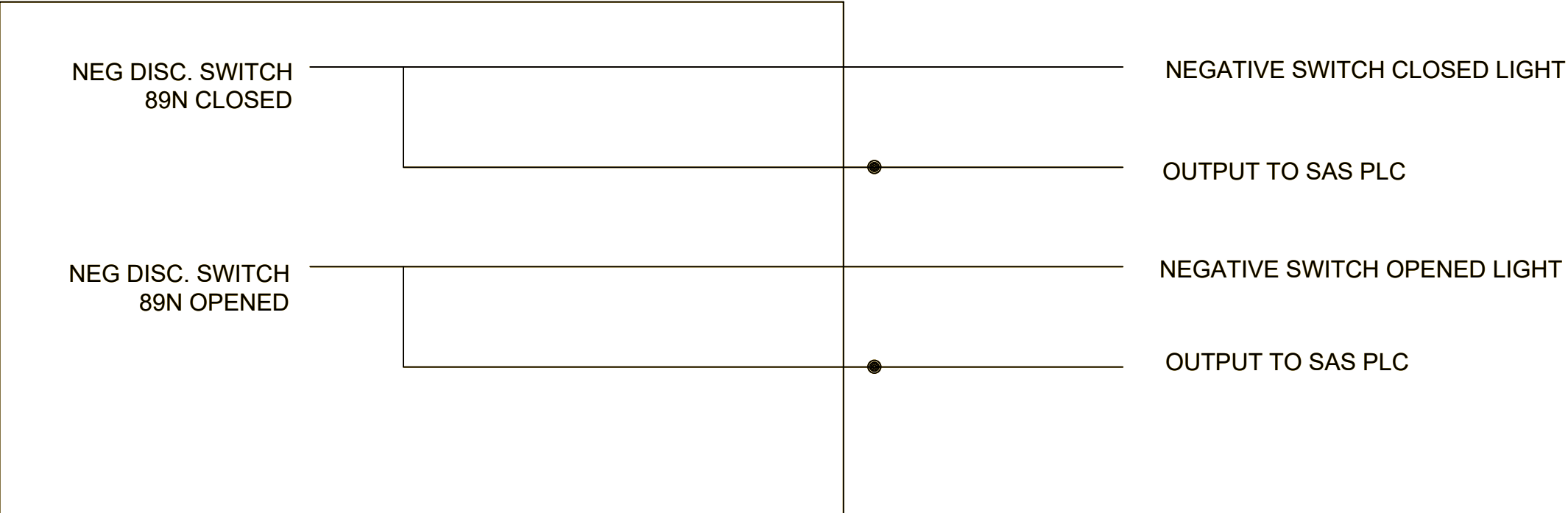


- NOTES:**
1. WHEN CONDITIONS ARE MET OUTPUT IS PULSED ONCE.
 2. WHEN THE BREAKER IS CLOSED THIS OUTPUT IS SET HIGH.
 3. THE BREAKER OPEN OUTPUT LATCH IS SET WHEN ALL CONDITIONS ARE SATISFIED FOR BREAKER CLOSE AND IT IS RESET WHEN CONDITIONS ARE SATISFIED FOR BREAKER OPEN.
 4. THERE ARE 3 TEST PAUSE TIMERS. THE TIME USED DEPENDS ON THE CURRENT TEST CYCLE COUNT. IN THE EVENT THAT THE NUMBER OF TEST CYCLES IS SET GREATER THAN THREE AFTER THE THIRD TEST CYCLE THE SAME TIME IS USED.
 5. ALL TIMER DURATIONS ARE PROGRAMMABLE VIA THE FRONT DISPLAY.
 6. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

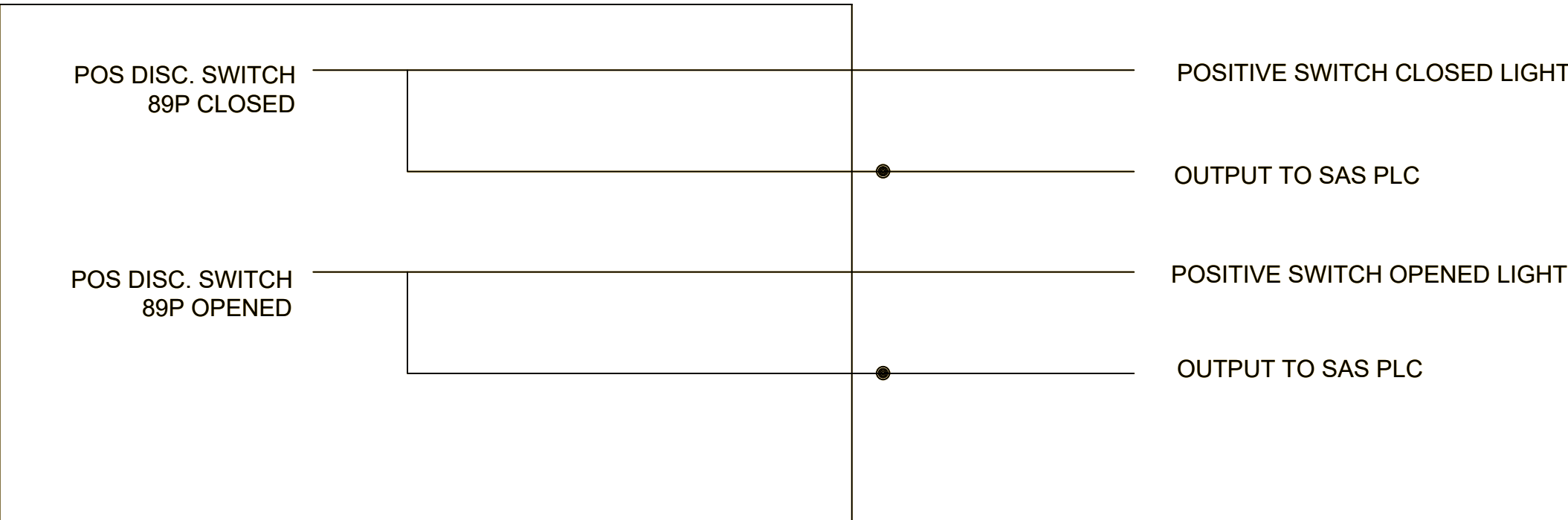
REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: ~~09-28-2023~~	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION TRACTION POWER TYPICAL DC FEEDER CUBICLE LOGIC DIAGRAM SHEET 2 OF 2	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL		 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270		FILENAME:	
			DRAWN BY	JDW					CONTRACT NO.: ###	
			CHECKED BY	PGL					VOLUME:	
			APPROVED BY	NKS					1	
PLOT DATE: 9/12/2022			5:33:50 PM		DATE	06/24/2022		DRAWING NO.:	SHEET NO.:	
						NOT FOR CONSTRUCTION		J653		

- NOTES:
1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

NEGATIVE DISCONNECT SWITCH LOGIC

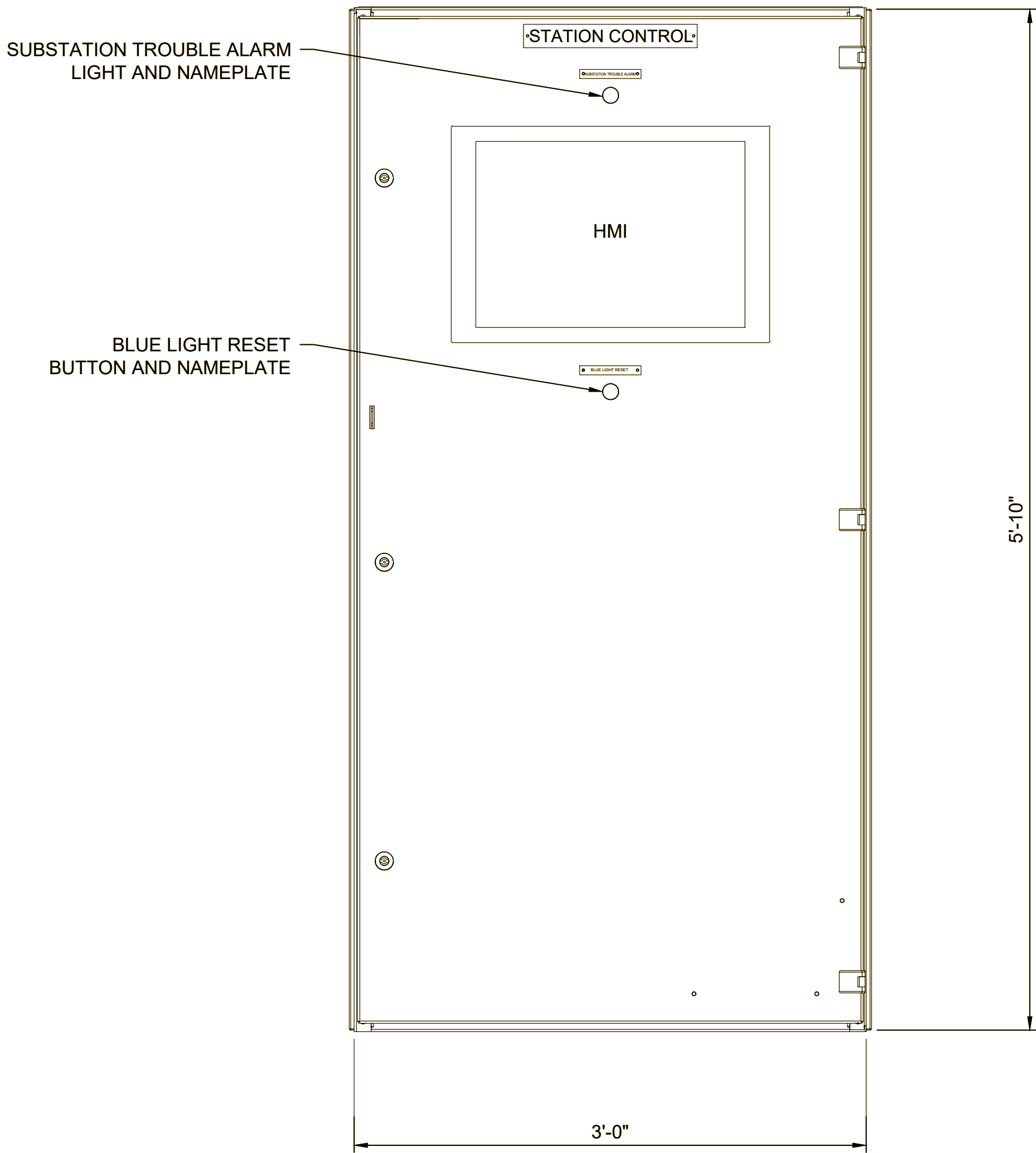


POSITIVE DISCONNECT SWITCH LOGIC

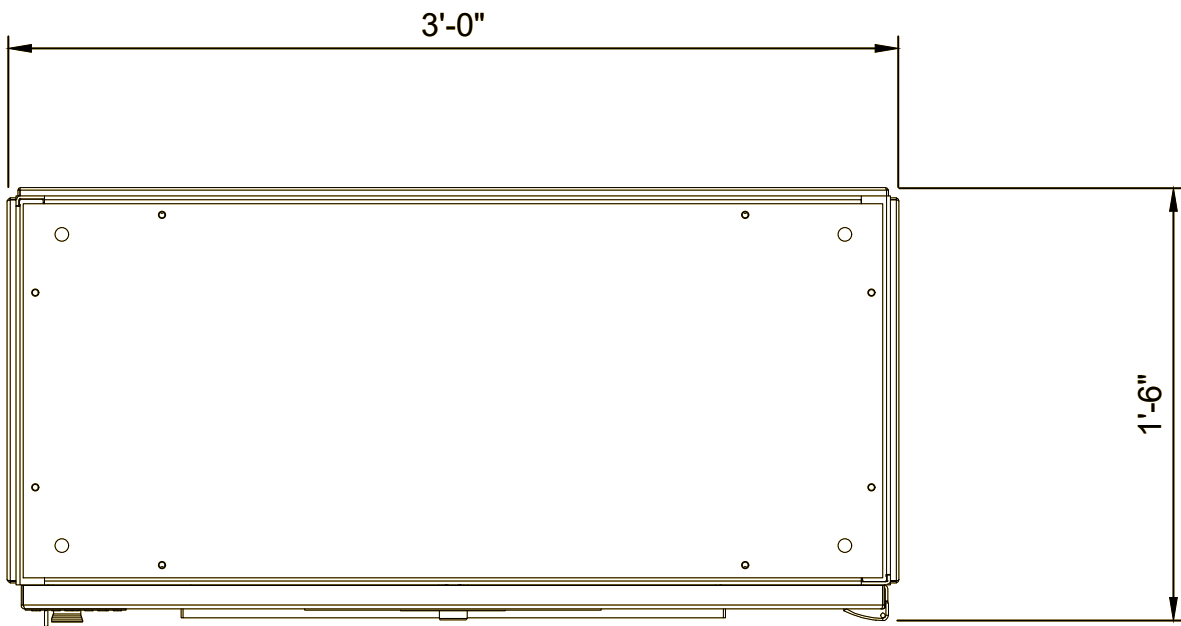


REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER NEGATIVE AND POSITIVE DISCONNECT SWITCH LOGIC DIAGRAM	SCALE FOR 22"x34": NOT TO SCALE		
			CHECKED BY	PGL								FILENAME: J654.DWG		
			DRAWN BY	WAC								CONTRACT NO.: CONTRACT NO. ###		
			CHECKED BY	PGL								VOLUME: 1		
			APPROVED BY	NKS								DRAWING NO.: J654		
												SHEET NO.:		
PLOT DATE: 9/12/2022			5: 33: 57 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION							

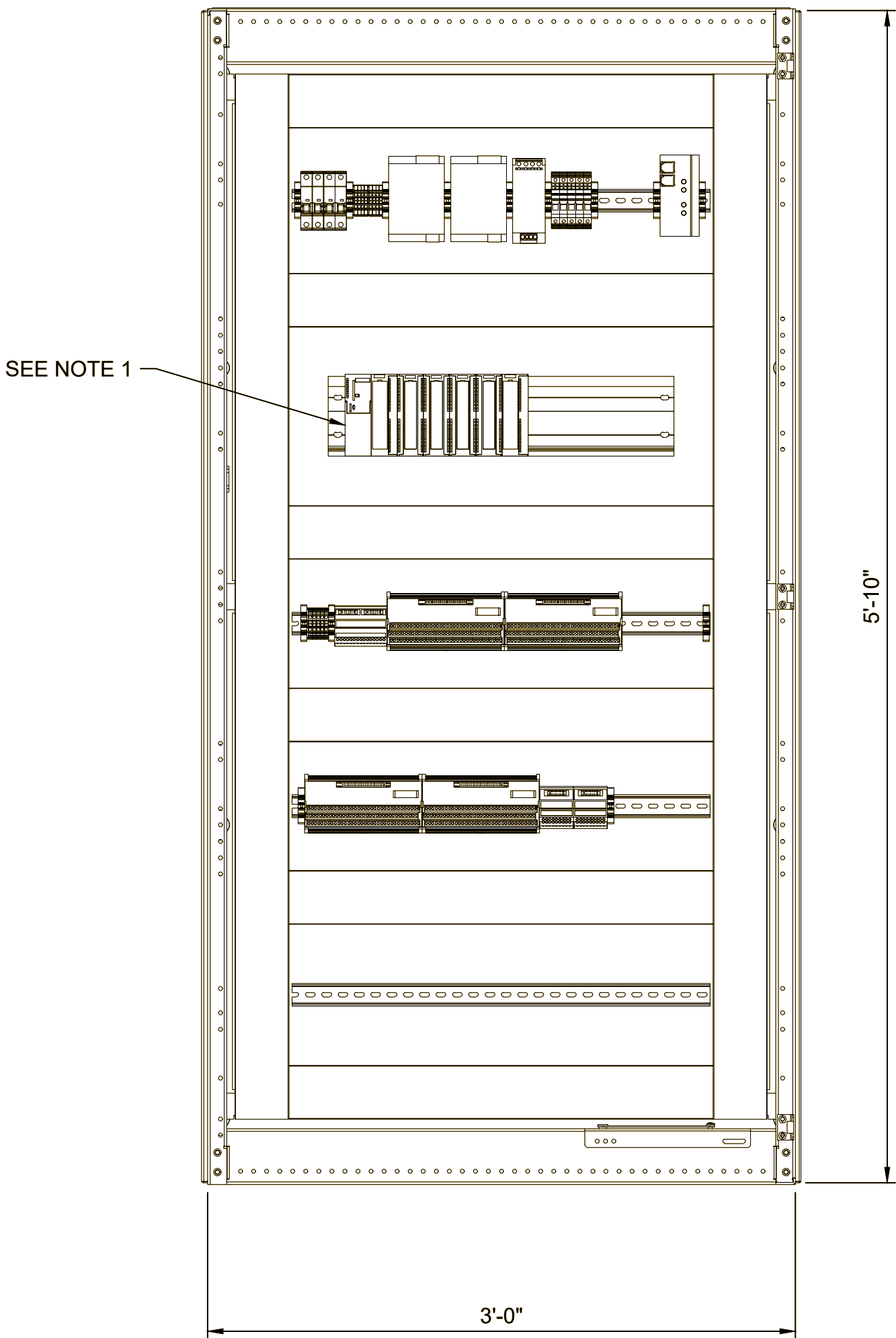
- NOTES:
- SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 - FINAL DIMENSIONS SHALL BE DETERMINED BY VENDOR.



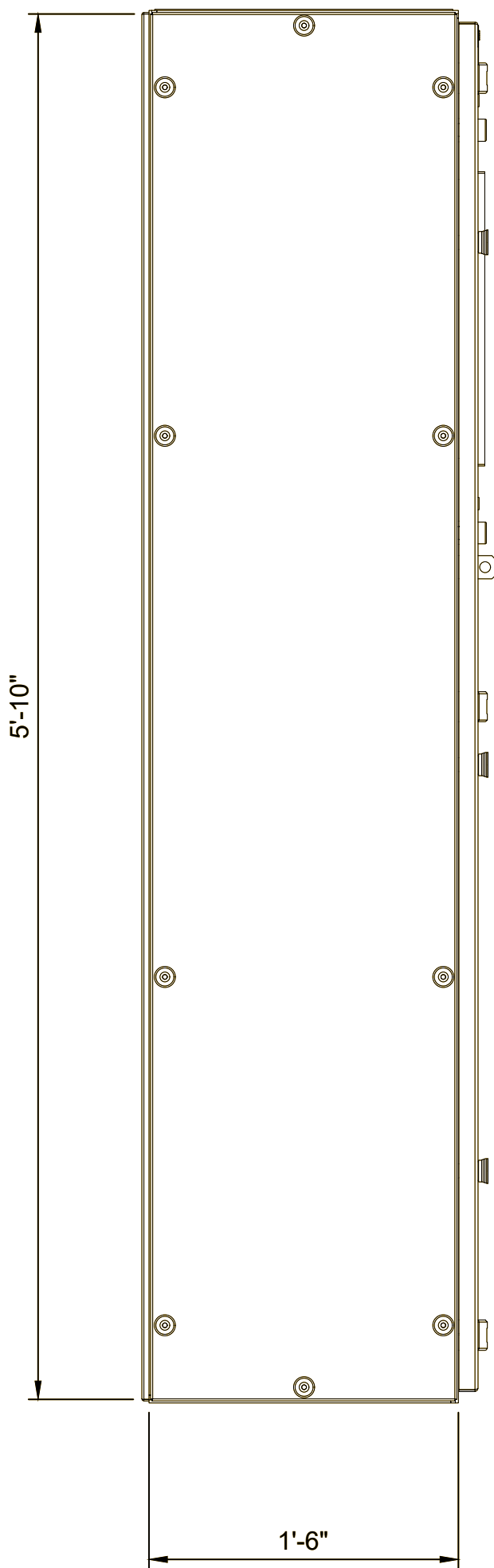
FRONT VIEW
SCALE: NOT TO SCALE



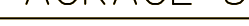
TOP VIEW
SCALE: NOT TO SCALE



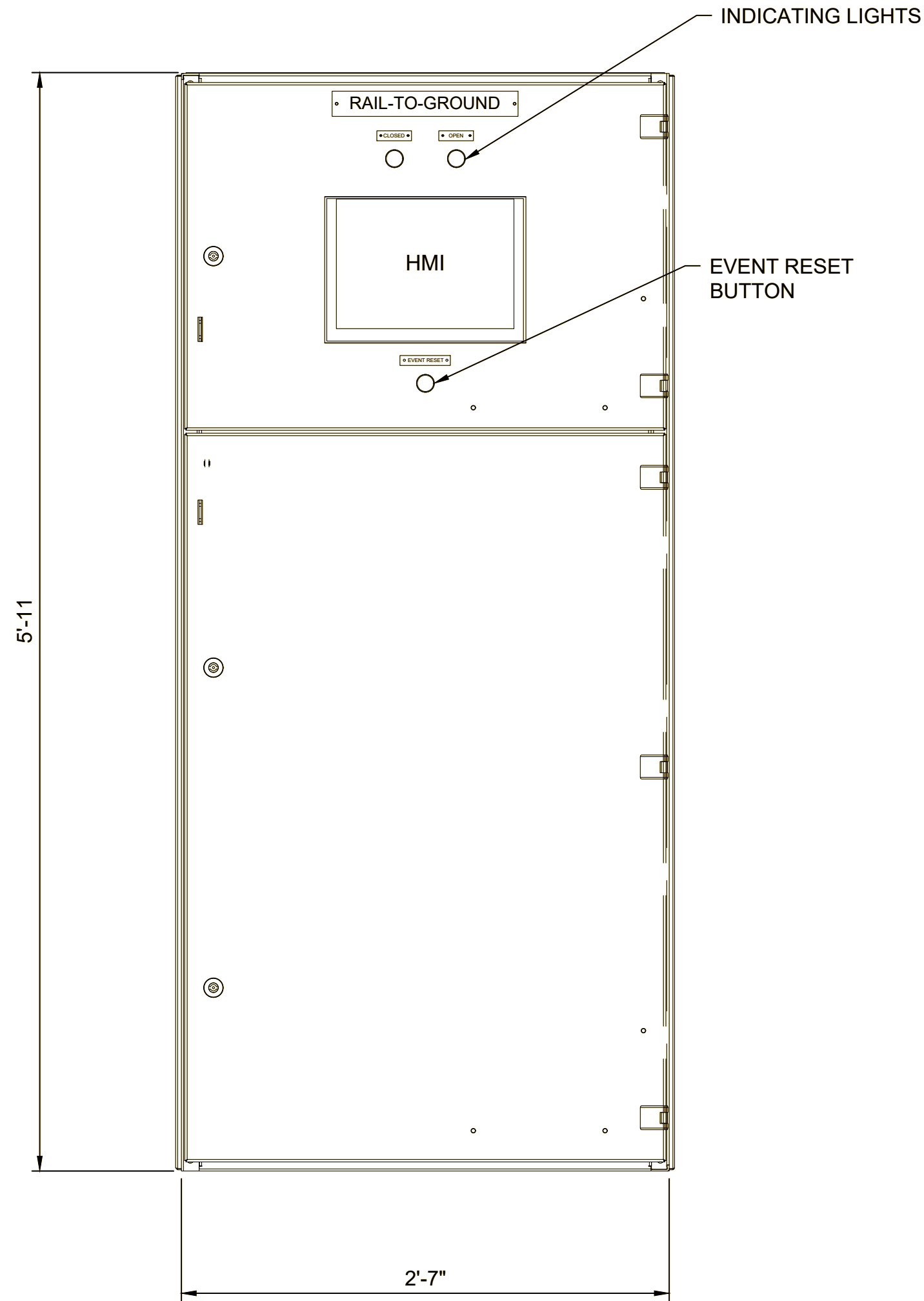
FRONT VIEW
(WITHOUT DOORS AND TRUCK)
SCALE: NOT TO SCALE



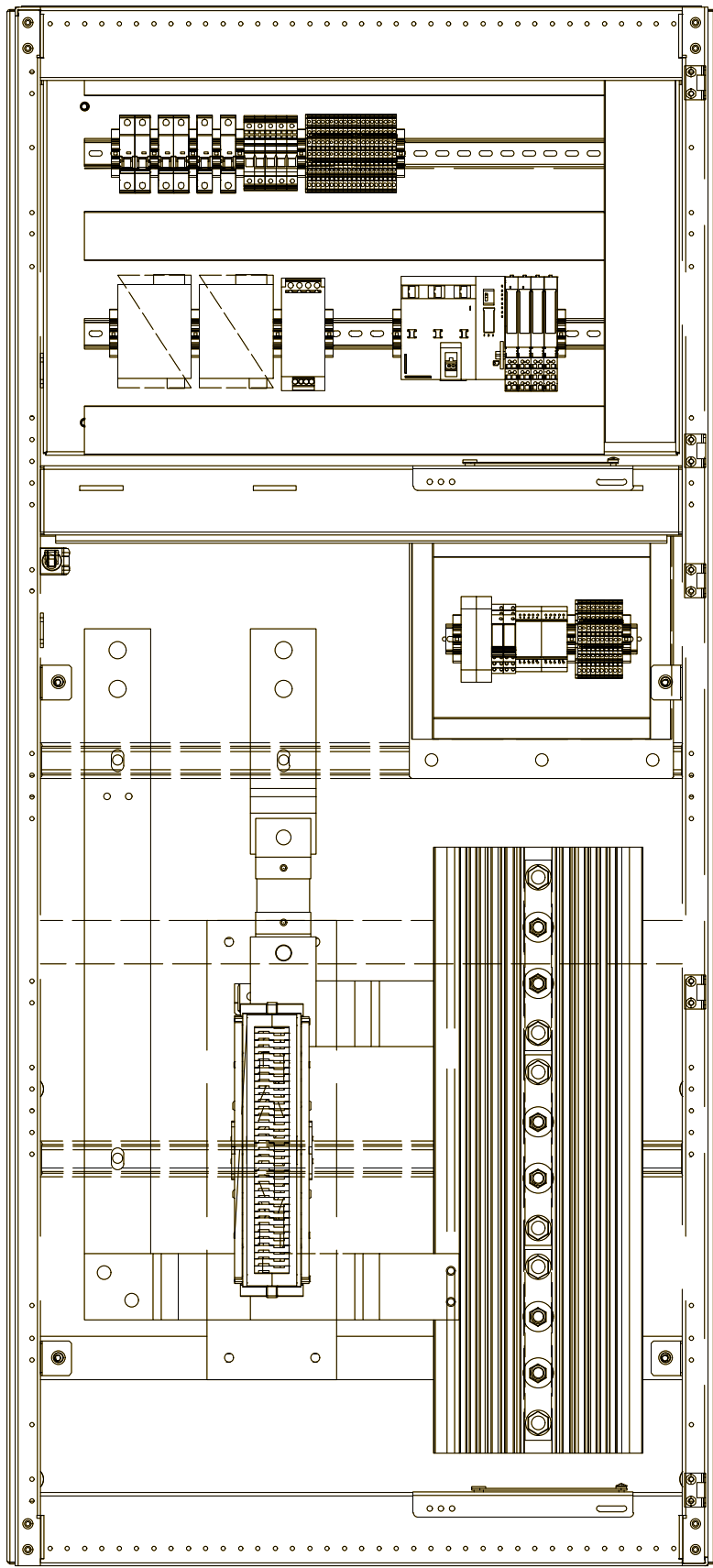
SIDE VIEW
SCALE: NOT TO SCALE

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER STATION CONTROL CABINET TYPICAL LAYOUT	SCALE FOR 22"x34": NOT TO SCALE		
			CHECKED BY	PGL							 HNTB The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 HNTB The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270
			DRAWN BY	JDW								
			CHECKED BY	PGL								
			APPROVED BY	NKS								
PLOT DATE: 9/12/2022			5: 34: 07 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION		DRAWING NO.:	SHEET NO.:		
									J660			

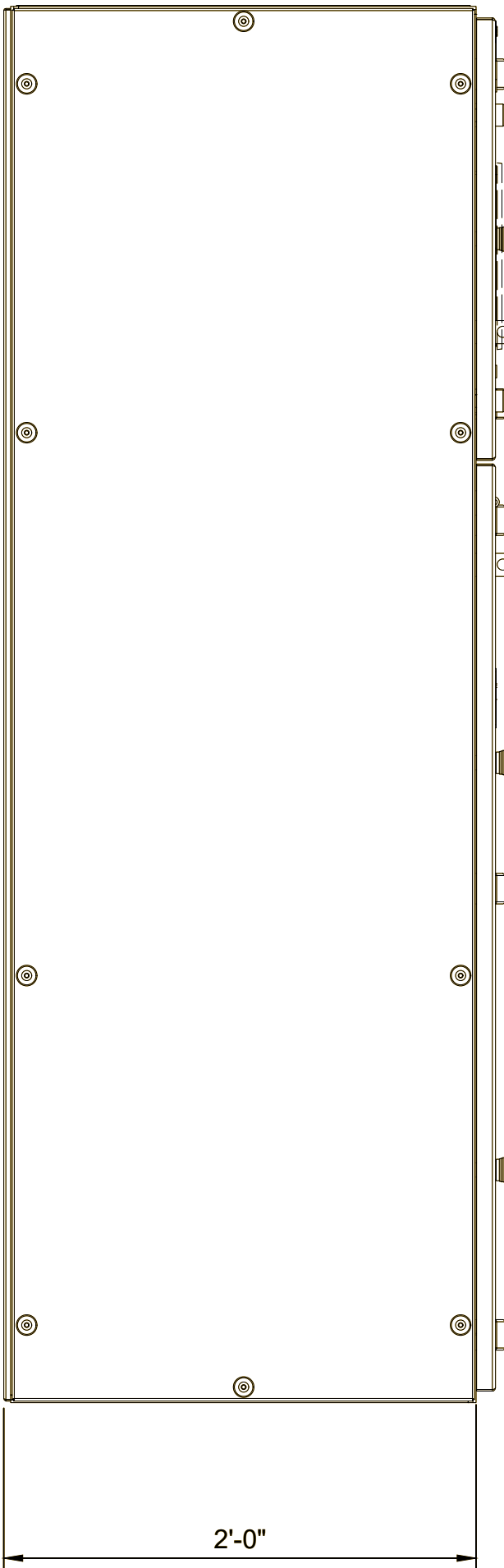
Red text and lines are the older version. Green text and lines are the updates. See updated BATES 304477 - 304504 for clean updated plan sheets.



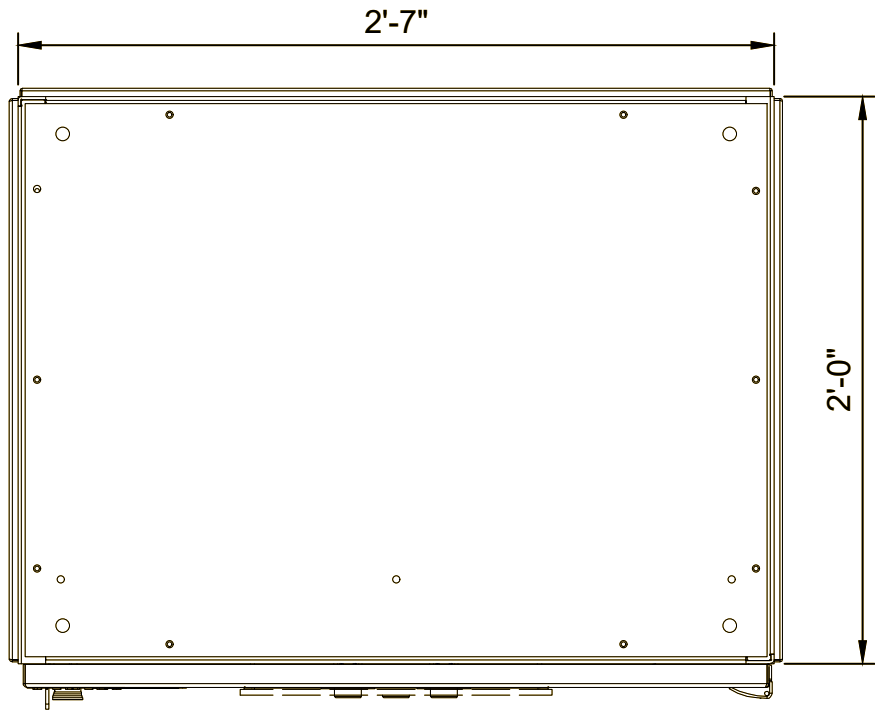
FRONT VIEW
SCALE: NOT TO SCALE



FRONT VIEW
(WITHOUT DOORS AND TRUCK)
SCALE: NOT TO SCALE



SIDE VIEW
SCALE: NOT TO SCALE



TOP VIEW
SCALE: NOT TO SCALE

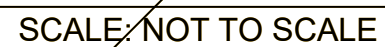
- NOTES:
- SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 - FINAL DIMENSIONS AND CABINET CONFIGURATION SHALL BE DETERMINED BY VENDOR.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER RAIL-TO-GROUND (R2G) CABINET TYPICAL LAYOUT	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL								FILENAME:	J661.DWG
			DRAWN BY	JDW								CONTRACT NO.:	CONTRACT NO. ###
			CHECKED BY	PGL								VOLUME:	1
			APPROVED BY	NKS								DRAWING NO.:	SHEET NO.:
												J661	
PLOT DATE: 9/12/2022			5:34:18 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION						

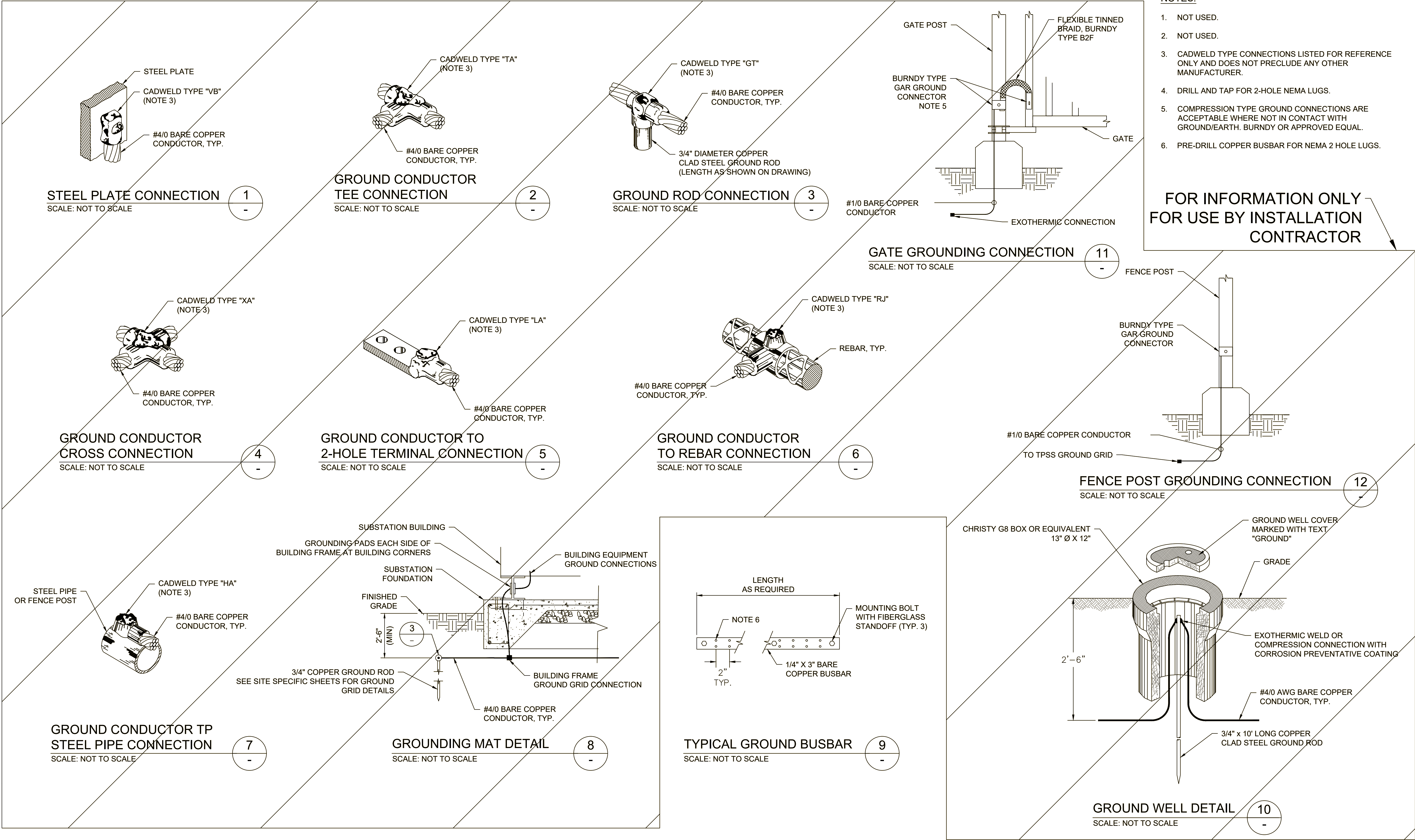
Red text and lines are the older version. Green text and lines are the updates. See updated BATES 304477 - 304504 for clean updated plan sheets.


$$\frac{1}{-}$$

1. ~~CONFIRMERS SHALL CONFIRMATION SERVER ADMINISTRATION TSS DO
BETWEEN ADMINISTRATION THE COMMUNICATIONS SYSTEM THE
ADMINISTRATION SYSTEM FOR THE OPERATION OF THE
SPECIFICATIONS FOR ADDITIONAL DETAILS.~~
2. PROVIDE ONE ENGINEERING LAPTOP PER THE SPECIFICATIONS.



304470 302815



- NOTES:**
1. NOT USED.
 2. NOT USED.
 3. CADWELD TYPE CONNECTIONS LISTED FOR REFERENCE ONLY AND DOES NOT PRECLUDE ANY OTHER MANUFACTURER.
 4. DRILL AND TAP FOR 2-HOLE NEMA LUGS.
 5. COMPRESSION TYPE GROUND CONNECTIONS ARE ACCEPTABLE WHERE NOT IN CONTACT WITH GROUND/EARTH. BURNDY OR APPROVED EQUAL.
 6. PRE-DRILL COPPER BUSBAR FOR NEMA 2 HOLE LUGS.
- FOR INFORMATION ONLY
FOR USE BY INSTALLATION
CONTRACTOR**

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL		 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270		TRACTION POWER TYPICAL GROUNDING DETAILS	FILENAME: J673.DWG
			DRAWN BY	JDW						CONTRACT NO.: CONTRACT NO. ###
			CHECKED BY	PGL						VOLUME: 1
			APPROVED BY	NKS						DRAWING NO.: SHEET NO.:
PLOT DATE: 9/12/2022			5:55:17 PM		DATE	06/24/2022		NOT FOR CONSTRUCTION		J673

Red text and lines are the older version. Green text and lines are the updates. See updated BATES 304477 - 304504 for clean updated plan sheets.

FOR INFORMATION ONLY
FOR USE BY INSTALLATION CONTRACTOR

NOTES:
1. SEE SHEET J630 FOR TPSS D1 SITE RACEWAY LAYOUT.

TPSS D1 - CONDUCTOR SCHEDULE											
FEEDER NUMBER	FROM	TO	VIA DUCTBANK/CONDUIT	DUCTBANK SECTION	CABLE DESCRIPTION					DRAWING NUMBER	COMMENTS
					QUANTITY	SIZE	TYPE	VOLTAGE RATING	TEMPERATURE RATING		
D1-PF1	D1-F1	D1-DS1	TPD-D1P1	2A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	POSITIVE FEEDER
	D1-DS1	TE-MH-D101	TPD-D1P5	2A / C404 10A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	
	TE-MH-D101	OCS FEEDER POLE R/34 (SB) DS-D1AS			2	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-PF2	D1-F1	D1-DS2	TPD-D1P2	2A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	POSITIVE FEEDER
	D1-DS2	TE-MH-D101	TPD-D1P6	2A / C404 10A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	
	TE-MH-D101	OCS FEEDER POLE R/33 (NB) DS-D1AN			2	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-PF3	D1-F2	D1-DS3	TPD-D1P3	2A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	POSITIVE FEEDER
	D1-DS3	TE-MH-D101	TPD-D1P7	2A / C404 10A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	
	TE-MH-D101	OCS FEEDER POLE R/34 (SB) DS-D1BS			2	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-PF4	D1-F2	D1-DS4	TPD-D1P4	2A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	POSITIVE FEEDER
	D1-DS4	TE-MH-D101	TPD-D1P8	2A / C404 10A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	
	TE-MH-D101	OCS FEEDER POLE R/33 (NB) DS-D1BN			2	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-NR1	DC NEGATIVE BUS	TE-MH-D102	TPD-D1N1	4A / C404	4	250 KCMIL	EPR	2000 V	90° C	J630	NEGATIVE RETURN
	TE-MH-D102	TRACK BLOCKOUT (SB)			4	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-NR2	DC NEGATIVE BUS	TE-MH-D102	TPD-D1N1	4A / C404	4	250 KCMIL	EPR	2000 V	90° C	J630	NEGATIVE RETURN
	TE-MH-D102	TRACK BLOCKOUT (NB)			4	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-HV1	FUSED LOAD BREAK FUSED /METERING CABINET	LOCAL UTILITY SECTIONALIZER SWITCHGEAR	TPD-D1U1	2A / C404	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	J630	COORDINATE CABLE AND DUCTBANK REQUIREMENTS WITH LOCAL UTILITY
D1-HV2	LOCAL UTILITY SECTIONALIZER SWITCHGEAR	LOCAL UTILITY MANHOLE / SPLICE	TPD-D1U2	2A / C404	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	J630	COORDINATE CABLE AND DUCTBANK REQUIREMENTS WITH LOCAL UTILITY
D1-SS1	HMI PAC I/O MODULE	D1-DS1, D1-DS2, D1-DS3, D1-DS4, D1-DS5, D1-DS6 OPEN/CLOSE AUX CONTACTS	TPD-D1S1	2B / C404	2	12/C - #12 AWG	XLPE	600 V	90° C	J630	SWITCH STATUS INDICATIONS
FIBER	COMMUNICATIONS RACK	DS-D1AS, DS-D1JS, DS-D1BS, DS-D1BN FIBER BACKBONE SEE COMMUNICATIONS PLANS SC-PB-D101	TPD-D1S2	2B / C404 4C / C404	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS 7/C - #12 AWG PLANS	SEE COMMUNICATIONS XLPE PLANS	SEE COMMUNICATIONS 600 V PLANS	SEE COMMUNICATIONS 90° C PLANS	SEE COMMUNICATIONS J630 PLANS	OCS DISCONNECT SWITCH STATUS INDICATIONS
	SC-PB-D101	TE-MH-D101	TPD-D1S3	2A / C404	6	7/C - #12 AWG	XLPE	600 V	90° C	J630	OCS DISCONNECT SWITCH STATUS INDICATIONS
FIBER	COMMUNICATIONS RACK	FIBER BACKBONE SEE COMMUNICATIONS PLANS	TPD-D1C1	2B / C404 4C / C404	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS

REV

DATE

DESCRIPTION

DESIGNED BY

JDW

CHECKED BY

PGL

DRAWN BY

JDW

CHECKED BY

PGL

APPROVED BY

NKS

PLOT DATE:

9/12/2023

5:29:08 PM

DATE

06/24/2022

RideKC

STREETCAR

EARLY PROCUREMENT PACKAGE 3

DATE: 09-28-2023

HDR

HDR Engineering, Inc.

10450 Holmes Road
Suite 600
Kansas City, MO 64131-3471
816-360-2700
Certificate of Authority: 000856

HNTB

The HNTB COMPANIES

INFRASTRUCTURE SOLUTIONS

300 Apollo Drive
Chelmsford, MA 01824
Phone: 978-905-4000
Certificate of Authority: 001270

NOT FOR CONSTRUCTION

KANSAS CITY STREETCAR - RIVERFRONT EXTENSION

TRACTION POWER
D1 CONDUCTOR SCHEDULE

SCALE FOR 22"x34":
NOT TO SCALE

FILENAME:
J680.DWG

CONTRACT NO.:
CONTRACT NO. ###

VOLUME:
1

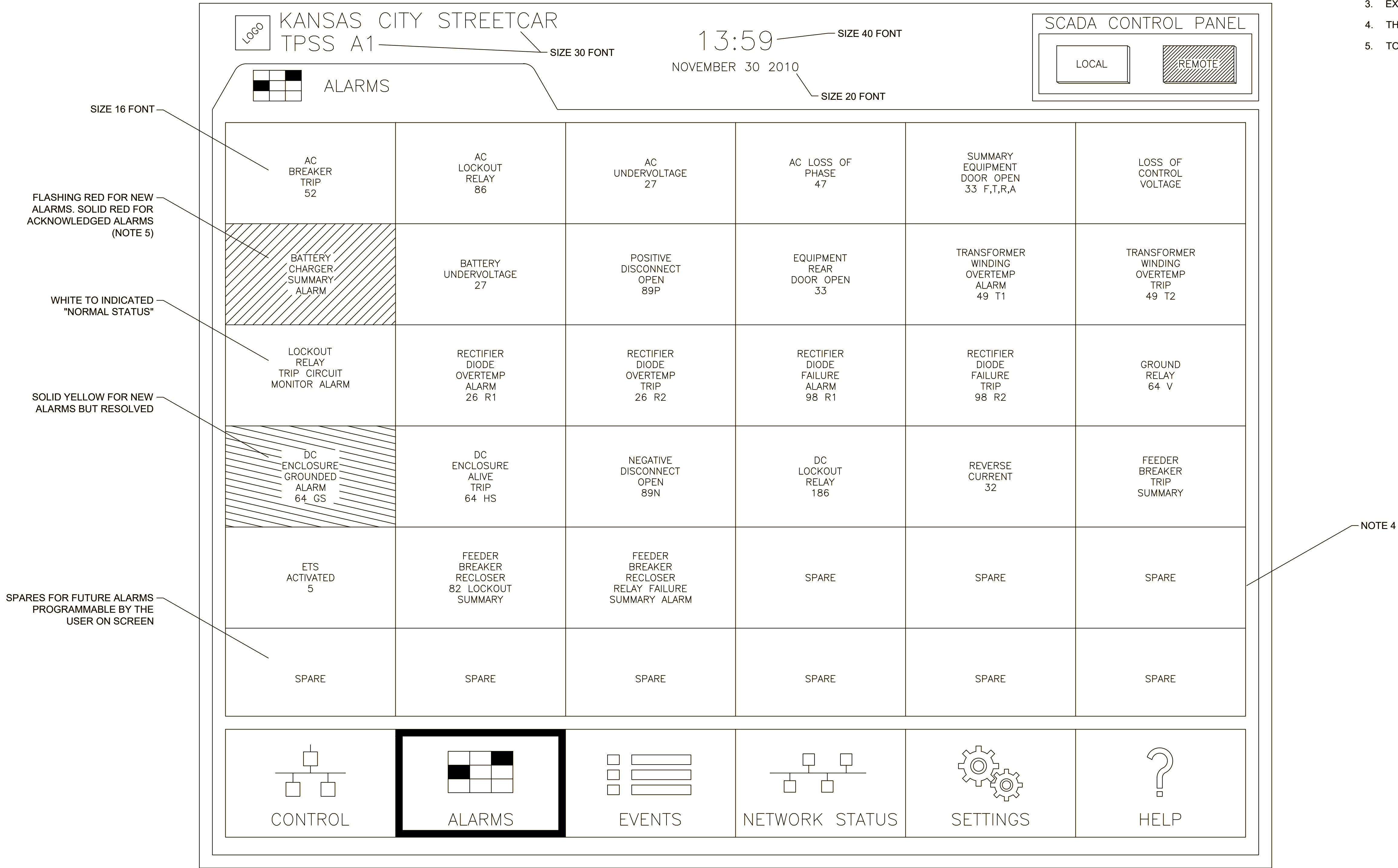
DRAWING NO.:
SHEET NO.:

J680

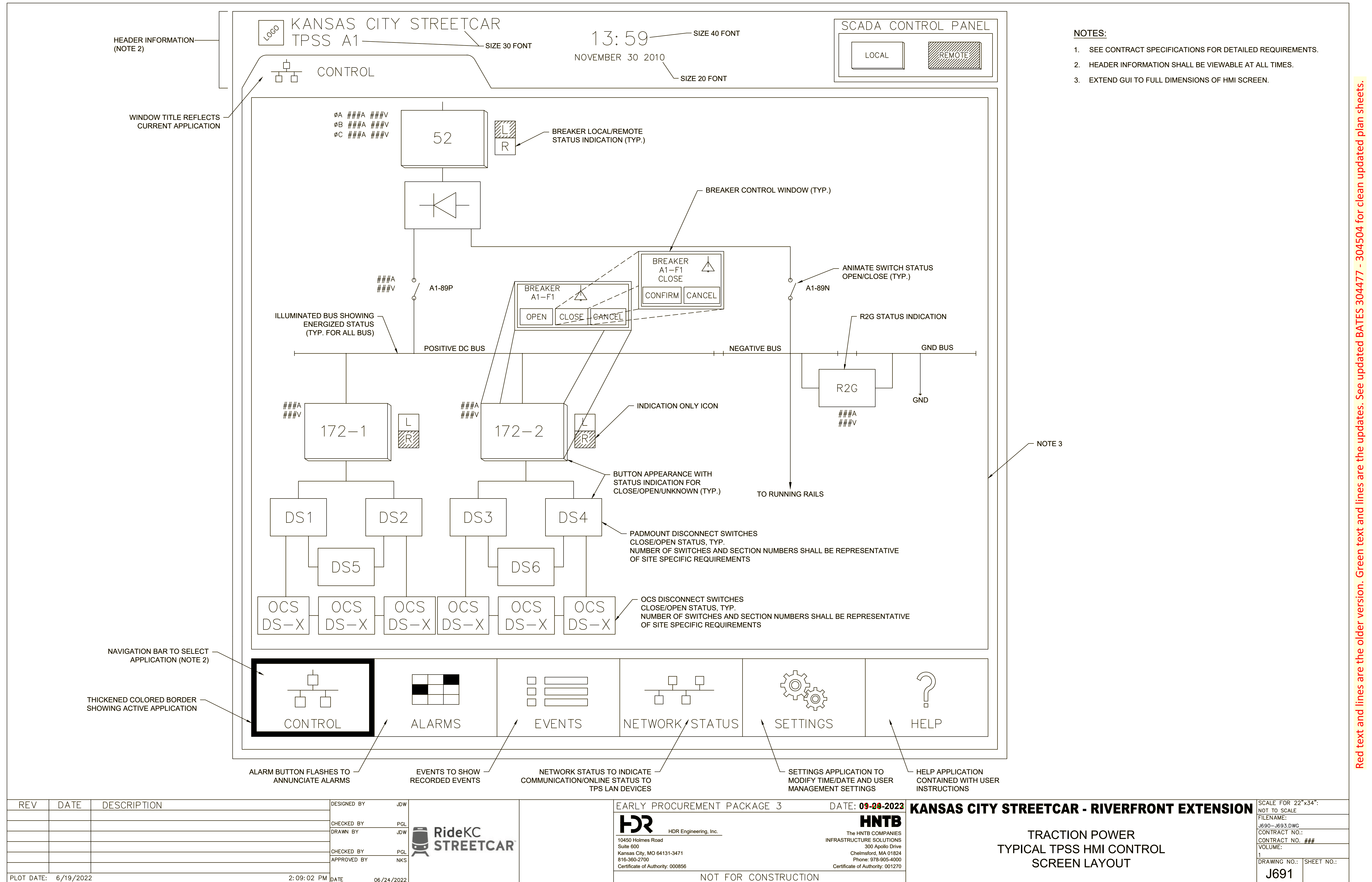
Page 110 of 142

304472302517

- NOTES:
- 1. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 - 2. HEADER INFORMATION SHALL BE VIEWABLE AT ALL TIMES.
 - 3. EXTEND GUI TO FULL DIMENSIONS OF HMI SCREEN.
 - 4. THERE SHALL BE A MINIMUM OF 36 WINDOWS.
 - 5. TOUCH WINDOW TO ACKNOWLEDGE ALARMS.



REV	DATE	DESCRIPTION	DESIGNED BY	JDW	 RideKC STREETCAR		EARLY PROCUREMENT PACKAGE 3		DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL			 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	TRACTION POWER TYPICAL TPSS HMI ALARM SCREEN LAYOUT		FILENAME: J690-J693.DWG	
			DRAWN BY	JDW					CONTRACT NO.:		CONTRACT NO. ###	
			CHECKED BY	PGL					VOLUME:		1	
			APPROVED BY	NKS					DRAWING NO.:		SHEET NO.:	
									J690			
PLOT DATE: 6/19/2022			2:09:02 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION					

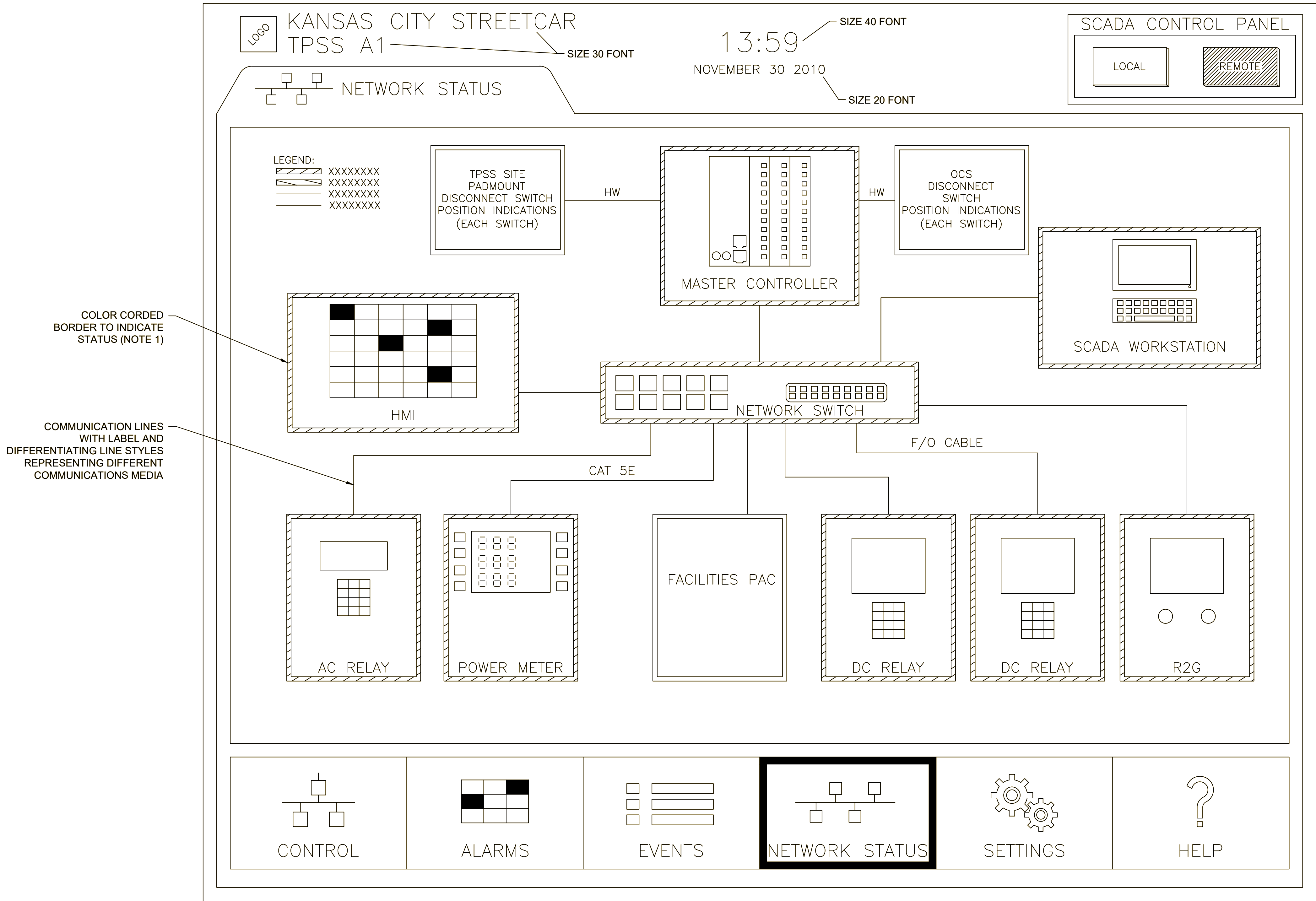


- Red text and lines are the older version. Green text and lines are the updates. See updated BATES 304477 - 304504 for clean updated plan sheets.

- SCROLL FORWARD
TO LAST PAGE

304475 302820

- NOTES:
- SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 - HEADER INFORMATION SHALL BE VIEWABLE AT ALL TIMES.
 - EXTEND GUI TO FULL DIMENSIONS OF HMI SCREEN.

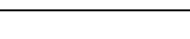


REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 09-28-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER TYPICAL TPSS HMI NETWORK STATUS SCREEN LAYOUT	SCALE FOR 22"x34":
			CHECKED BY	PGL						NOT TO SCALE
			DRAWN BY	JDW						FILENAME:
			CHECKED BY	PGL						J690-J693.DWG
			APPROVED BY	NKS						CONTRACT NO.:
										CONTRACT NO. ###
PLOT DATE: 6/19/2022			2:09:02 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION		VOLUME:	
								1	DRAWING NO.:	
								J693	SHEET NO.:	

TRACTION POWER SYMBOLS

	DISCONNECT SWITCH IS NORMALLY CLOSED (NC), UNLESS DESIGNATED WITH (NO) NORMALLY OPEN		ANNUNCIATOR / HMI / SAS PLC		EXTERIOR LIGHT
	FUSED DISCONNECT SWITCH		AMMETER		GROUND
	LOW VOLTAGE CIRCUIT BREAKER		VOLTMETER		CHASSIS GROUND
	POTENTIAL TRANSFORMER		KILOWATT HOUR METER		EXIT SIGN WITH EMERGENCY LIGHT
	CURRENT TRANSFORMER		KILOVAR HOUR METER		EMERGENCY LIGHT
	RECTIFIER TRANSFORMER, 12 PULSE		AMMETER SWITCH		CABLE POTHEAD/CABLE CONNECTOR
	RECTIFIER TRANSFORMER, 6 PULSE OR POWER TRANSFORMER		KILOWATT METER		THREE-WAY LIGHT SWITCH
	INTERPHASE TRANSFORMER		SCADA		ELECTRICAL PHASE
	WYE, TRANSFORMER CONNECTION		EMERGENCY TRIP STATION		FIRE EXTINGUISHER
	DELTA, TRANSFORMER CONNECTION		CURRENT TRANSDUCER		PHOTOCELL
	SURGE ARRESTER		VOLTAGE TRANSDUCER		MULTI-MODE FIBER OPTIC
	TRACTION RECTIFIER		MECHANICAL KEY INTERLOCK		
	FUSE		UTILITY GROUND CONNECTION		
	DRAWOUT FUSE		INTERLOCK		
	SHUNT OR TPSS BUS CONNECTION		SMOKE DETECTOR		
	WITHDRAWABLE DC CIRCUIT BREAKER WITH SERIES TRIP UNIT		GFI RECEPTACLE		
	DIRECTION OF CONTROL OR RELAY INFLUENCE LINE		MH/HH/VAULT		
	DIODE		LIGHT FIXTURE		
	CONTACTOR		INSULATED OVERLAP (IOL)		
	WITHDRAWABLE MEDIUM VOLTAGE AC BREAKER		OCS SECTION INSULATOR (SI)		

DEVICE / FUNCTION REFERENCES	
	RELAY OPERATING COIL. INSIDE NUMBER DESIGNATES DEVICE FUNCTION. OUTSIDE NUMBER DESIGNATES QUANTITY OF DEVICES
5	EMERGENCY STOP PUSHBUTTON
26R1	RECTIFIER OVERTEMP ALARM (1ST. STAGE)
26R2	RECTIFIER OVERTEMP TRIP (2ND. STAGE)
27	UNDERVOLTAGE RELAY
30	INTERPOSING RELAY
32	REVERSE CURRENT RELAY
33A	AC CIRCUIT BREAKER REAR DOOR SWITCH
33F	FEEDER BREAKER REAR DOOR SWITCH
33N	NEGATIVE SWITCH DOOR OPEN
33P	POSITIVE SWITCH DOOR OPEN
33R	RECTIFIER DOOR SWITCH
33T	TRANSFORMER DOOR SWITCH
43	MANUAL TRANSFER OR SELECTOR DEVICE
47	PHASE SEQUENCE
49T1	TRANSFORMER OVERTEMP ALARM (1ST STAGE)
49T2	TRANSFORMER OVERTEMP TRIP (2ND STAGE)
50/51	PHASE FAULT TIME OVERCURRENT RELAY (INST. AND TIME DELAY)
50N/51N	GROUND FAULT TIME OVERCURRENT RELAY (INST. AND TIME DELAY)
52	AC CIRCUIT BREAKER
59	AC OVERVOLTAGE
59B	BANK PHASE OVERVOLTAGE
64GS	GROUNDING STRUCTURE
64HS	HOT STRUCTURE
64V	NEGATIVE-TO-EARTH VOLTAGE RELAY
76	DC DIRECT ACTING OVERCURRENT TRIP DEVICE
86	AC LOCKOUT RELAY
89P	DC POSITIVE DISCONNECT SWITCH
89N	DC NEGATIVE DISCONNECT SWITCH
98R1	R1 RECTIFIER DIODE FAILURE ALARM
98R2	R2 RECTIFIER DIODE FAILURE TRIP
148	DC INCOMPLETE SEQ. RELAY
150	DC INSTANTANEOUS OVERCURRENT RELAY
151	DC TIME OVERCURRENT RELAY
172	DC CIRCUIT BREAKER
182	DC LOAD MEASURING RELAY
183	DC RECLOSING RELAY
185	TRANSFER TRIP RELAY
186	DC LOCKOUT RELAY
R2G	RAIL-TO-GROUND SYSTEM
ROR	DC RATE OF RISE RELAY

REV	DATE	DESCRIPTION	DESIGNED BY	JDW				EARLY PROCUREMENT PACKAGE 3		DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL				 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	TRACTION POWER TRACTION POWER SYMBOLS		FILENAME: G036.DWG	
			DRAWN BY	JDW								CONTRACT NO.: CONTRACT NO. ###	
			CHECKED BY	PGL								VOLUME: 1	
			APPROVED BY	NKS								DRAWING NO.: SHEET NO.:	
												G036	
PLOT DATE: 9/12/2022			5:15:24 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION						

TRACTION POWER ABBREVIATIONS

A

A AMPERE
AM AMMETER
ANSI AMERICAN NATIONAL STANDARDS INSTITUTE
APPROX APPROXIMATELY
A ANNUNCIATOR / SAS ALARM
AC ALTERNATING CURRENT / AC BREAKER
AS AMMETER SWITCH
AT CURRENT TRANSDUCER
AUX AUXILARY

B

BAL. BALANCE
BKR BREAKER
BLVD BOULEVARD

C

C CONDUIT
CB CIRCUIT BREAKER
CKT CIRCUIT
COMP COMPARATOR
CONN CONNECTION
CT CURRENT TRANSFORMER
CUB CUBICLE

D

DC DIRECT CURRENT
DR DUCTBANK/RACEWAY
DS DISCONNECT SWITCH

E

ELT EXTERIOR LIGHTS
ETS EMERGENCY TRIP STATION

F

F DC FEEDER BREAKER
FACP FIRE ALARM CONTROL PANEL
FX FAST ETHERNET

G

GFI GROUND FAULT INTERRUPTER
GL GREEN LIGHT
GND GROUND

H

HH HAND HOLE
HMI HUMAN MACHINE INTERFACE
HR HOUR
HTS HEAVY TRACTION SERVICE
HS HOT STRUCTURE
HVAC HEATING VENTING AND AIR CONDITIONING
HW HARDWIRE

I

ILT INTERIOR LIGHTS
INST. INSTANTANEOUS
I/O INPUT/OUTPUT
IOS INSULATED OVERLAP

K

K MECHANICAL KEY INTERLOCK
KCMIL THOUSANDS CIRCULAR MILS
KV KILOVOLT
KVA KILOVOLT AMPERE
KVAC KILOVOLT ALTERNATING CURRENT
KW KILOWATT

L

LMR LOAD MEASURING RESISTOR

M

MCB MAIN CIRCUIT BREAKER
MFPR MULTI-FUNCTION PROTECTION RELAY
MH MANHOLE
MOC MECHANISM OPERATED CONTACT

N

N NEGATIVE
NC NORMALLY CLOSED
NEG NEGATIVE
NO NORMALLY OPEN
NR NEGATIVE FEEDER

O

OCS OVERHEAD CONTACT SYSTEM

P

P, POS POSITIVE
PAC PROGRAMMABLE AUTOMATION CONTROLLER
PC PERSONAL COMPUTER
PF POSITIVE FEEDER
PSC PHOTOCELL SHORTING CAP
PSI POUNDS PER SQUARE INCH
PT POTENTIAL TRANSFORMER
PVC POLYVINYL CHLORIDE

R

R RECTIFIER
R2G RAIL-TO-GROUND SYSTEM
RL RED LIGHT
RT RECTIFIER TRANSFORMER
REV. REVERSE
ROR DC RATE OF RISE RELAY
RTU REMOTE TERMINAL UNIT

S

SAS SUBSTATION AUTOMATION SYSTEM
SC SIGNAL/COMMUNICATIONS
SCC STATION CONTROL CABINET
SCADA SUPERVISORY CONTROL AND DATA ACQUISITION
SD SMOKE DETECTOR
SFP SMALL FORM-FACTOR PLUGABLE
SEQ. SEQUENCE
SI SECTION INSULATOR
SPD SURGE PROTECTIVE DEVICE
STA STATIONING
SUMM SUMMARY ALARM (COMMON ALARM)

T

TB TERMINAL BLOCK
TBD TO BE DETERMINED
TD TIME DELAY
TE TRACTION ELECTRIFICATION
TOC TRUCK OPERATED CONTACT
TPD TRACTION POWER DUCTBANK
TPSS TRACTION POWER SUBSTATION
TRFY TRAFFICWAY
TT TRANSFER TRIP
TYP. TYPICAL

V

V VOLT
VM VOLTMETER
VAC VOLT ALTERNATING CURRENT
VDC VOLT DIRECT CURRENT
VT VOLTAGE TRANSDUCER

VT

VAULT

W

W WATT
WL WHITE LIGHT
WT WEIGHT

NOTES:

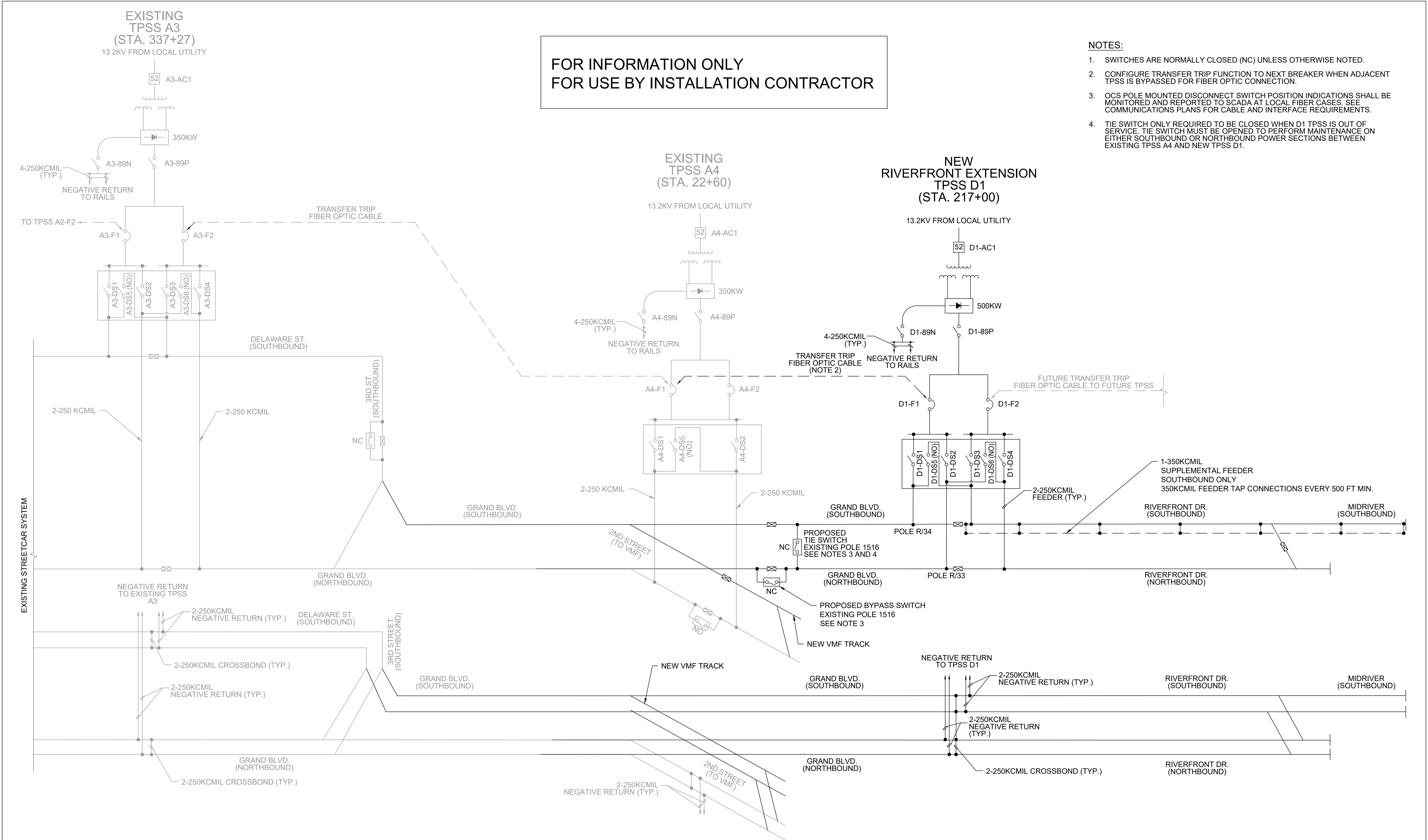
1. SEE CITY OF KANSAS CITY STANDARD PLANS FOR ADDITIONAL ABBREVIATIONS.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	  The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER ABBREVIATIONS	SCALE FOR 22"x34": NOT TO SCALE FILENAME: G037.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.:
			CHECKED BY	PGL							
			DRAWN BY	JDW							
			CHECKED BY	PGL							
			APPROVED BY	NKS							
PLOT DATE: 9/7/2022			3:17:17 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION				

FOR INFORMATION ONLY
FOR USE BY INSTALLATION CONTRACTOR

NOTES:

- SWITCHES ARE NORMALLY CLOSED (NC) UNLESS OTHERWISE NOTED.
- CONFIGURE TRANSFER TRIP FUNCTION TO NEXT BREAKER WHEN ADJACENT TPSS IS BYPASSED FOR FIBER OPTIC CONNECTION.
- OCS POLE MOUNTED DISCONNECT SWITCH POSITION INDICATIONS SHALL BE MONITORED AND REPORTED TO SCADA AT LOCAL FIBER CASES. SEE COMMUNICATIONS PLANS FOR CABLE AND INTERFACE REQUIREMENTS.
- TIE SWITCH ONLY REQUIRED TO BE CLOSED WHEN D1 TPSS IS OUT OF SERVICE. TIE SWITCH MUST BE OPENED TO PERFORM MAINTENANCE ON EITHER SOUTHBOUND OR NORTHBOUND POWER SECTIONS BETWEEN EXISTING TPSS A4 AND NEW TPSS D1.



REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	 HNTB Engineering, Inc. The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER SYSTEM MASTER SINGLE LINE DIAGRAM RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE	
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			DRAWN BY	JDW								J101.DWG	
			CHECKED BY	PGL								CONTRACT NO.:	
			APPROVED BY	NKS								CONTRACT NO. ###	
PLOT DATE: 1/17/2023			5: 42: 24 PM			NOT FOR CONSTRUCTION						VOLUME:	
			DATE 06/24/2022						1				
									DRAWING NO.:				
									SHEET NO.:				
									J101				

AC LOCKOUT (86) IS ACTIVATED BY THE FOLLOWING DEVICES:

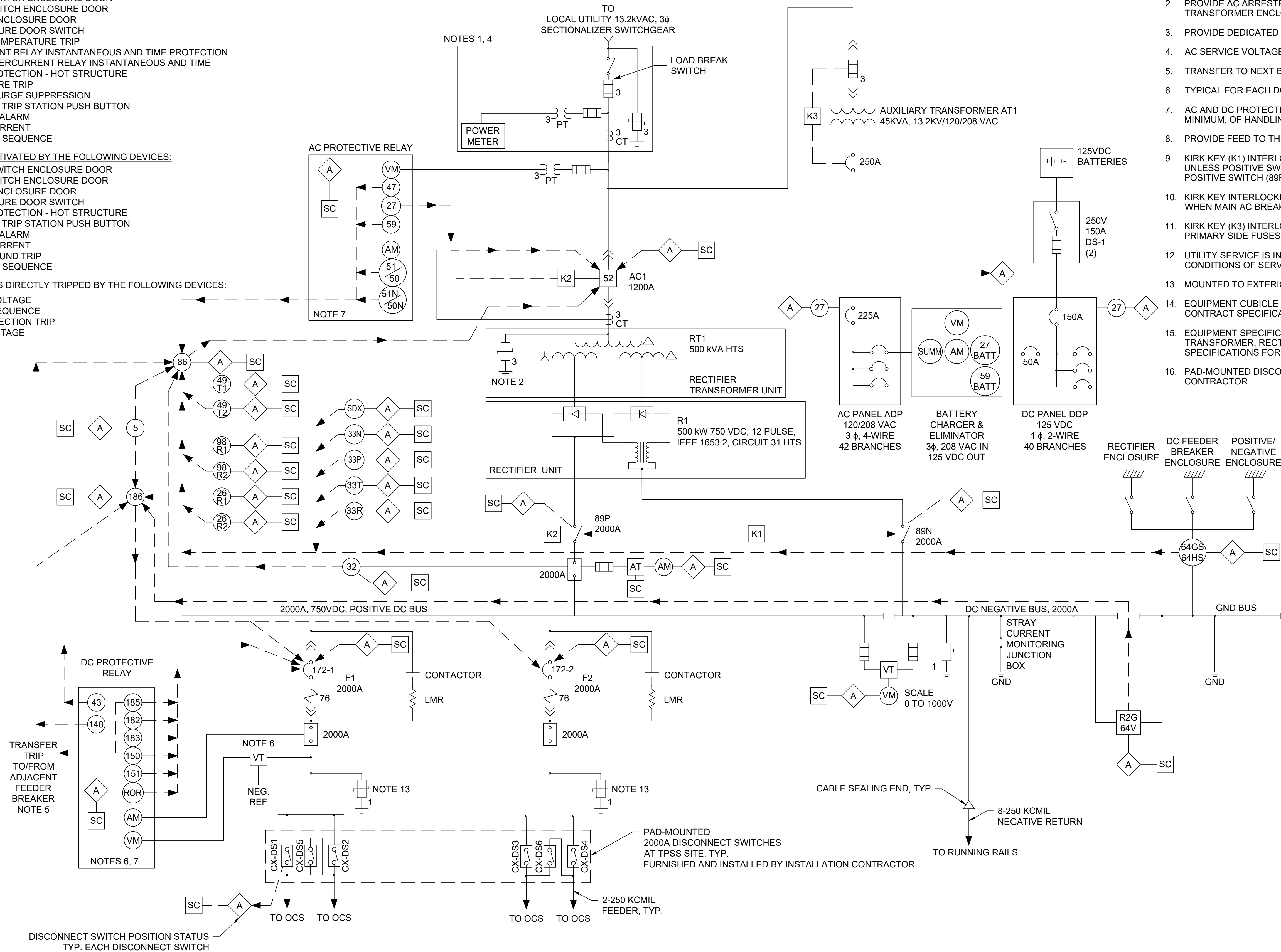
26-R2	RECTIFIER DIODE OVER TEMP TRIP
33A-X	MAIN AC BREAKER CUBICLE REAR DOOR
33F-X	DC FEEDER BREAKER CUBICLE REAR DOOR
33N-X	NEGATIVE SWITCH ENCLOSURE DOOR
33P-X	POSITIVE SWITCH ENCLOSURE DOOR
33R-X	RECTIFIER ENCLOSURE DOOR
33T-X	TPT ENCLOSURE DOOR SWITCH
49-WT2	TPT OVER TEMPERATURE TRIP
50/51	OVERCURRENT RELAY INSTANTANEOUS AND TIME PROTECTION
50N/51N	NEUTRAL OVERCURRENT RELAY INSTANTANEOUS AND TIME
64HS	GROUND PROTECTION - HOT STRUCTURE
98R2	DIODE FAILURE TRIP
99T	RECTIFIER SURGE SUPPRESSION
5	EMERGENCY TRIP STATION PUSH BUTTON
SDX	FIRE/SMOKE ALARM
32	REVERSE CURRENT
148	INCOMPLETE SEQUENCE

DC LOCKOUT (186) IS ACTIVATED BY THE FOLLOWING DEVICES:

33N-X	NEGATIVE SWITCH ENCLOSURE DOOR
33P-X	POSITIVE SWITCH ENCLOSURE DOOR
33R-X	RECTIFIER ENCLOSURE DOOR
33T-X	TPT ENCLOSURE DOOR SWITCH
64HS	GROUND PROTECTION - HOT STRUCTURE
5	EMERGENCY TRIP STATION PUSH BUTTON
SDX	FIRE/SMOKE ALARM
32	REVERSE CURRENT
R2G	RAIL TO GROUND TRIP
148	INCOMPLETE SEQUENCE

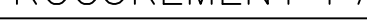
AC MAIN BREAKER (52) IS DIRECTLY TRIPPED BY THE FOLLOWING DEVICES:

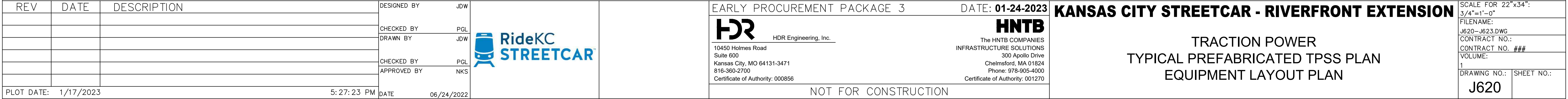
27	AC UNDERVOLTAGE
47	AC PHASE SEQUENCE
50/51	RELAY PROTECTION TRIP
59	AC OVERVOLTAGE

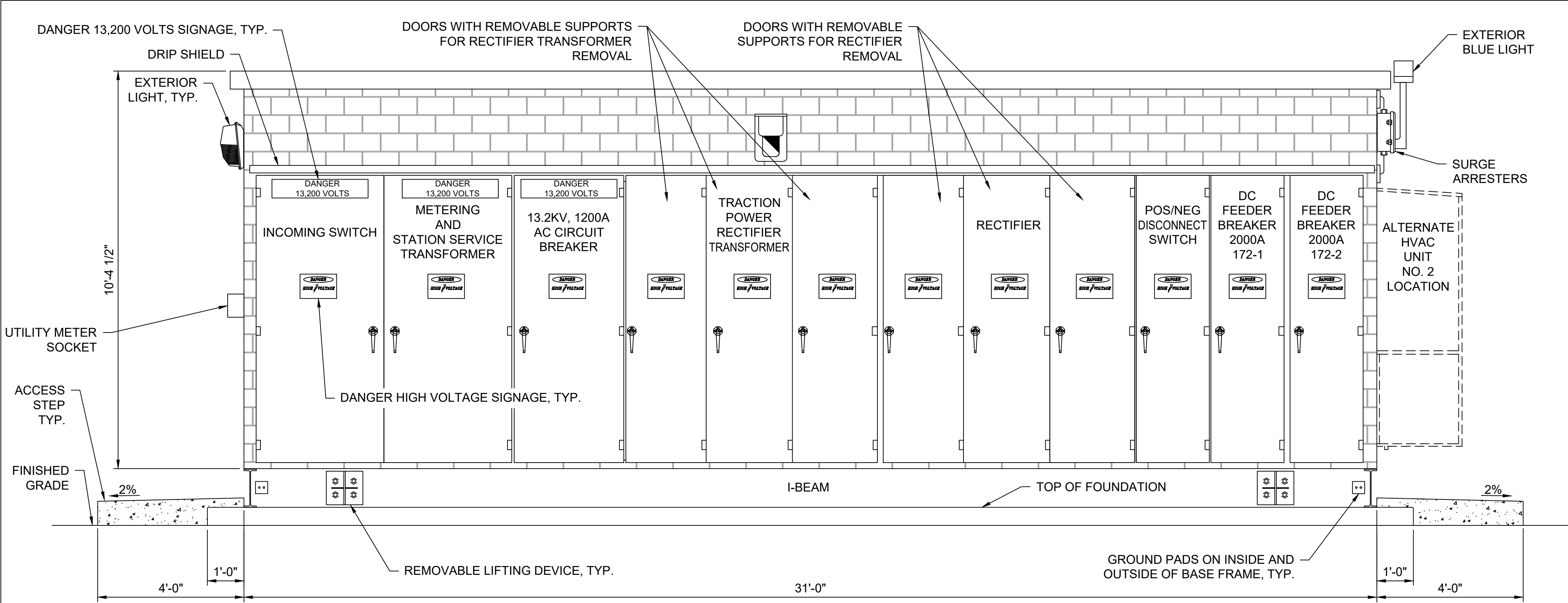


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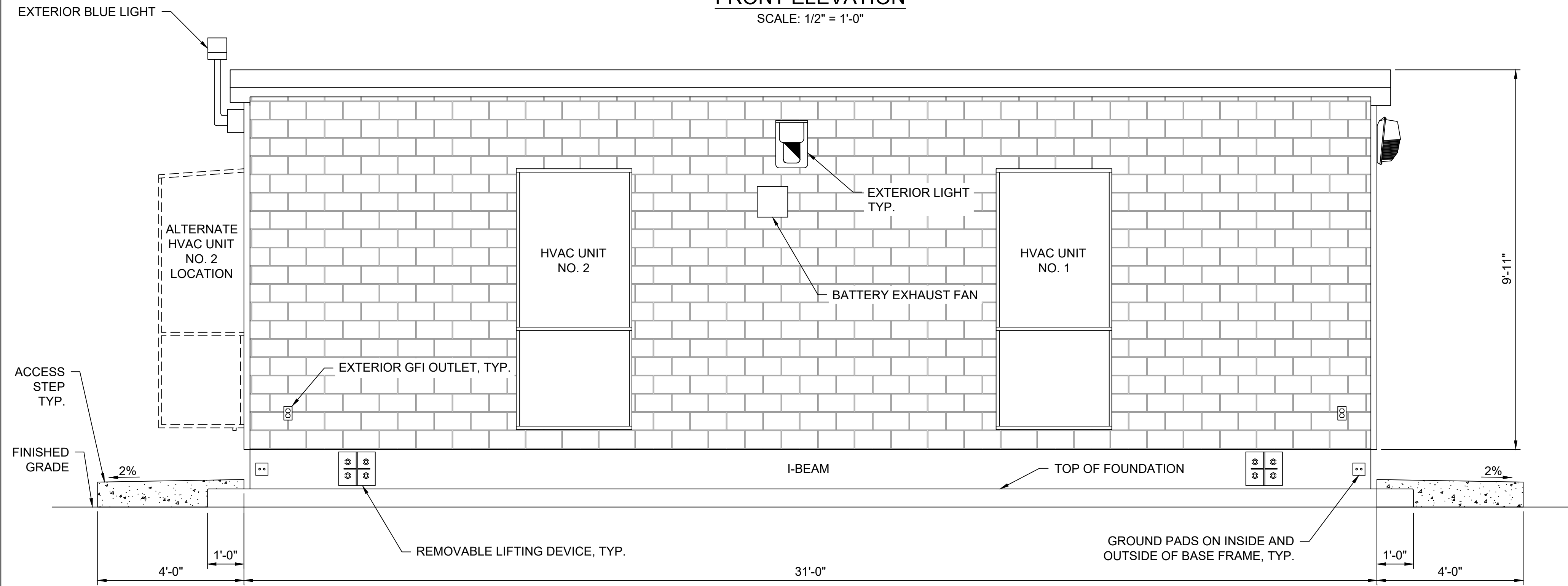
1. UTILITY METERING INSTRUMENT TRANSFORMERS AND METER PROVIDED BY LOCAL UTILITY.
2. PROVIDE AC ARRESTER IN A SEPARATE ENCLOSURE WITH BARRIER WITHIN TRANSFORMER ENCLOSURE.
3. PROVIDE DEDICATED 120V AC CIRCUIT FOR TPSS BUILDING EXTERIOR RECEPTACLES.
4. AC SERVICE VOLTAGE FOR ALL SUBSTATIONS IS 13.2KV, 3-PHASE.
5. TRANSFER TO NEXT BREAKER WHEN ADJACENT TPSS IS IN BYPASS.
6. TYPICAL FOR EACH DC FEEDER BREAKER
7. AC AND DC PROTECTIVE RELAYS SHALL BE MULTIFUNCTION AND CAPABLE, AT A MINIMUM, OF HANDLING ALL FUNCTIONS SHOWN.
8. PROVIDE FEED TO THE BATTERY CHARGER AND OTHER BUILDING AUXILIARY LOADS.
9. KIRK KEY (K1) INTERLOCK WILL PREVENT OPENING OF 89N NEGATIVE DISCONNECT UNLESS POSITIVE SWITCH (89P) IS DISCONNECTED AND SHALL PREVENT CLOSE OF THE POSITIVE SWITCH (89P) UNLESS THE 89N NEGATIVE DISCONNECT IS CLOSED.
10. KIRK KEY INTERLOCKING (K2) WILL PREVENT OPENING OF THE POSITIVE SWITCH (89P) WHEN MAIN AC BREAKER IS CLOSED AND RACKED IN.
11. KIRK KEY (K3) INTERLOCK WILL PREVENT REMOVAL OF AUXILIARY TRANSFORMER AT1 PRIMARY SIDE FUSES UNLESS SECONDARY (250A) CB IS OPEN.
12. UTILITY SERVICE IS IN ACCORDANCE WITH LOCAL UTILITY REQUIREMENTS AND CONDITIONS OF SERVICE.
13. MOUNTED TO EXTERIOR OF TPSS.
14. EQUIPMENT CUBICLE LIGHTING AND HEATING TO BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
15. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
16. PAD-MOUNTED DISCONNECT SWITCHES FURNISHED AND INSTALLED BY THE CONTRACTOR.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3		DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION TRACTION POWER TYPICAL MAINLINE TPSS SINGLE LINE SINGLE LINE DIAGRAM	SCALE FOR 22"x34": NOT TO SCALE FILENAME: J610.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: J610 SHEET NO.:	
			CHECKED BY	PGL		 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	NOT FOR CONSTRUCTION			
			DRAWN BY	JDW							
			CHECKED BY	PGL							
			APPROVED BY	NKS							
PLOT DATE: 1/17/2023			5: 21: 25 PM		DATE	06/24/2022					

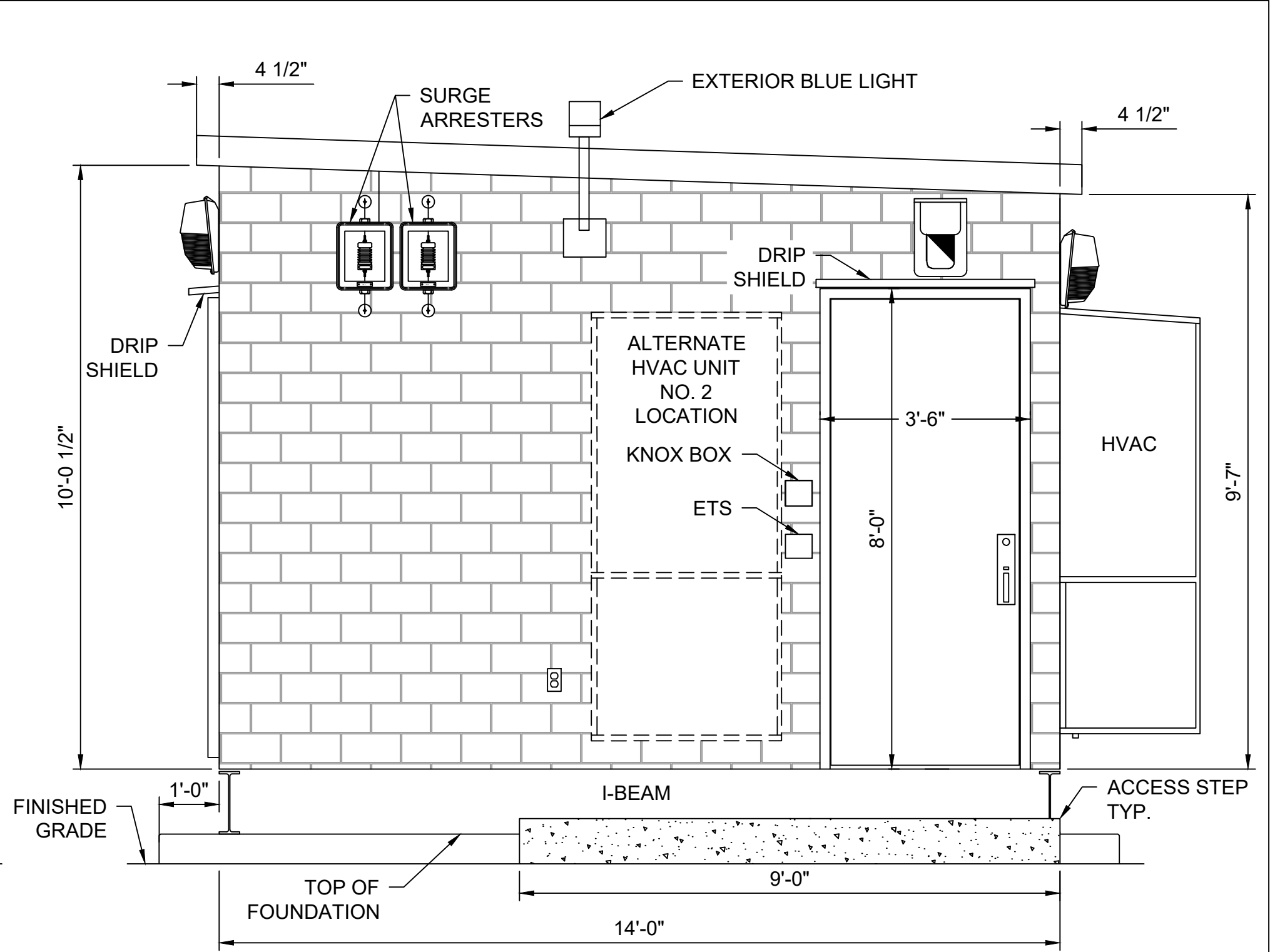




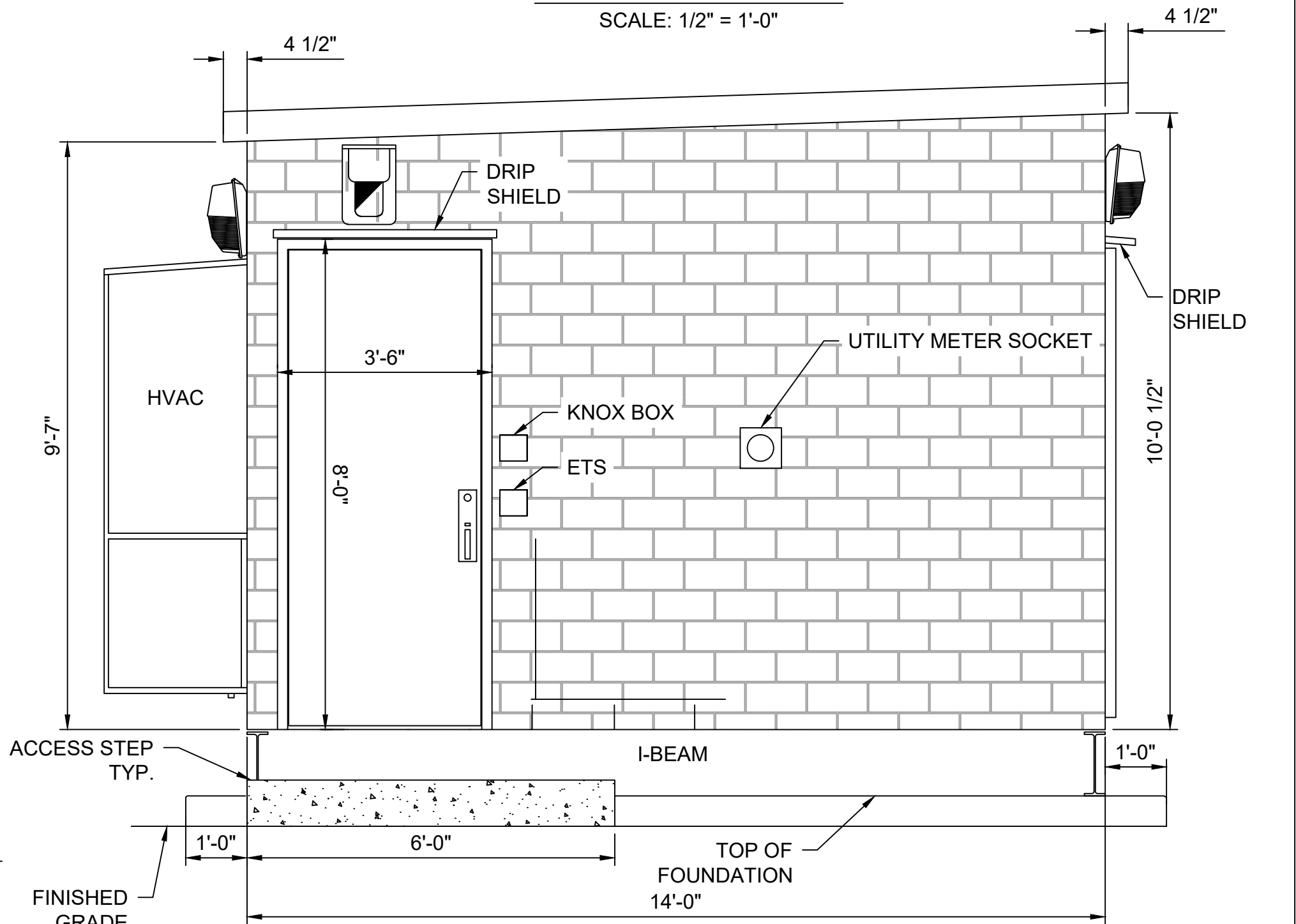
FRONT ELEVATION
SCALE: 1/2" = 1'-0"



REAR ELEVATION
SCALE: 1/2" = 1'-0"



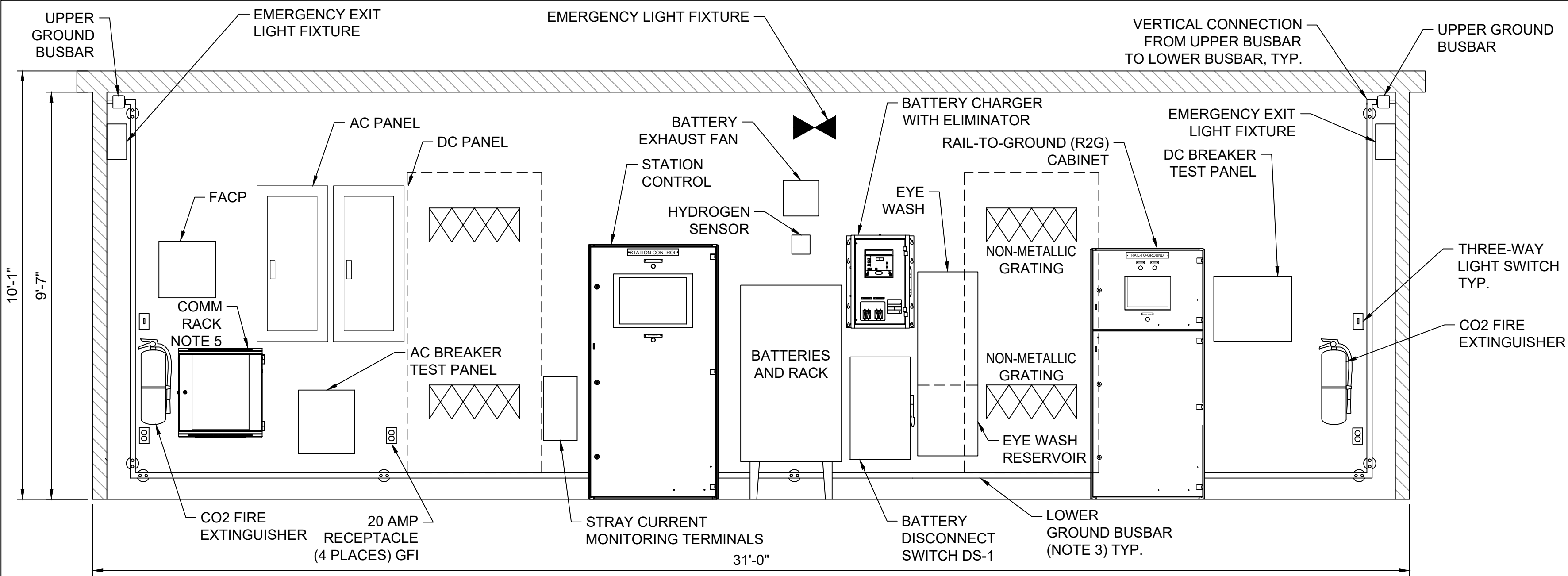
RIGHT ELEVATION
SCALE: 1/2" = 1'-0"



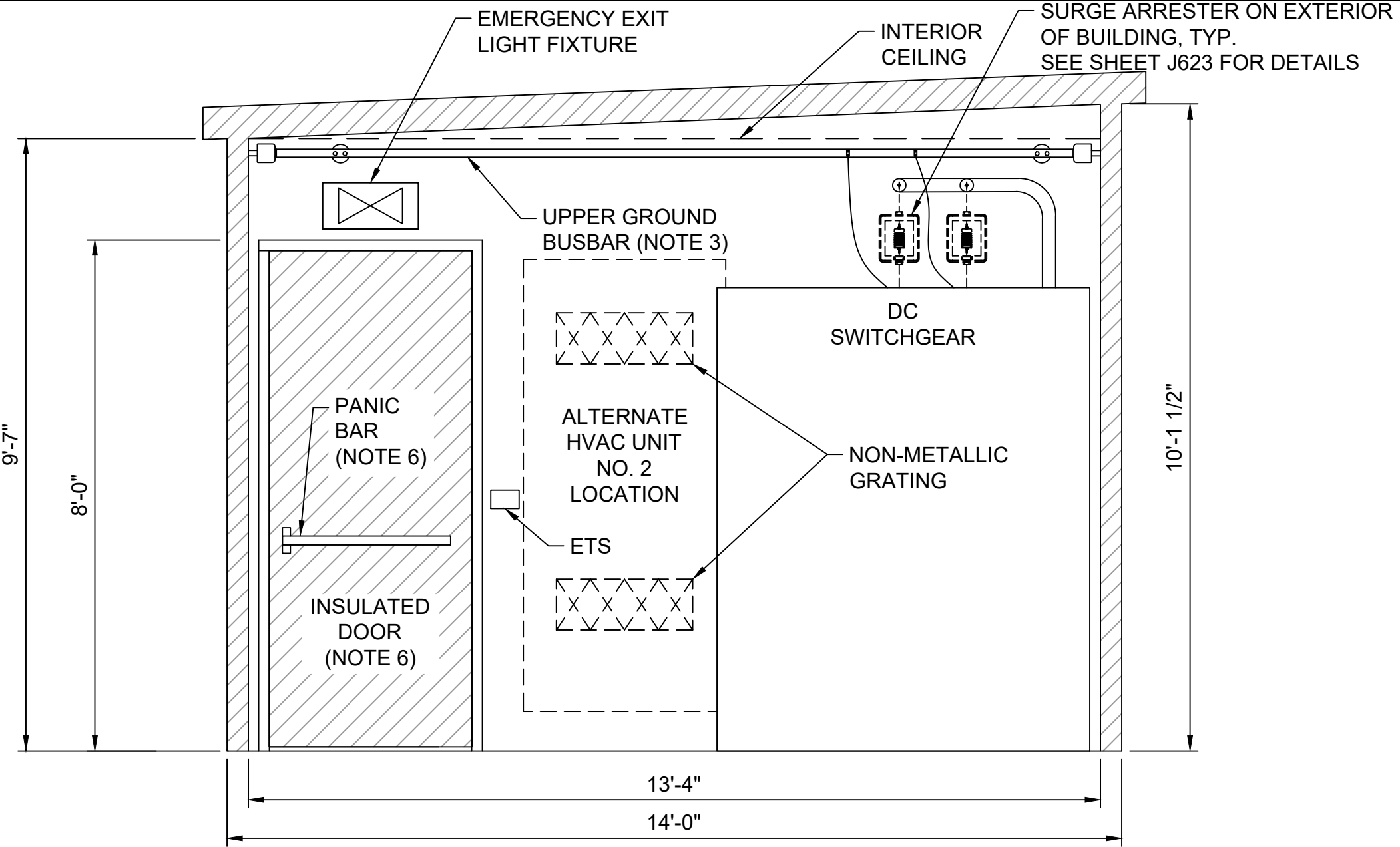
LEFT ELEVATION
SCALE: 1/2" = 1'-0"

- NOTES:
- EQUIPMENT DIMENSIONS ARE APPROXIMATE. SUBMIT FINAL DIMENSIONS FOR APPROVAL.
 - NOT USED.
 - FOUNDATION DETAILS BY INSTALLATION CONTRACTOR.
 - METERING EQUIPMENT AND SOCKET DETAILS SUBJECT TO APPROVAL OF UTILITY.
 - VENDOR SHALL SIZE EXTERIOR EQUIPMENT DOORS AND SUPPORTS FOR RECTIFIER AND TRANSFORMER TO ALLOW FOR REMOVAL FROM OUTSIDE THE TPSS.
 - EXTERIOR OF TPSS SHALL HAVE A BRICK FASCAD. SEE CONTRACT SPECIFICATIONS FOR DETAILS.

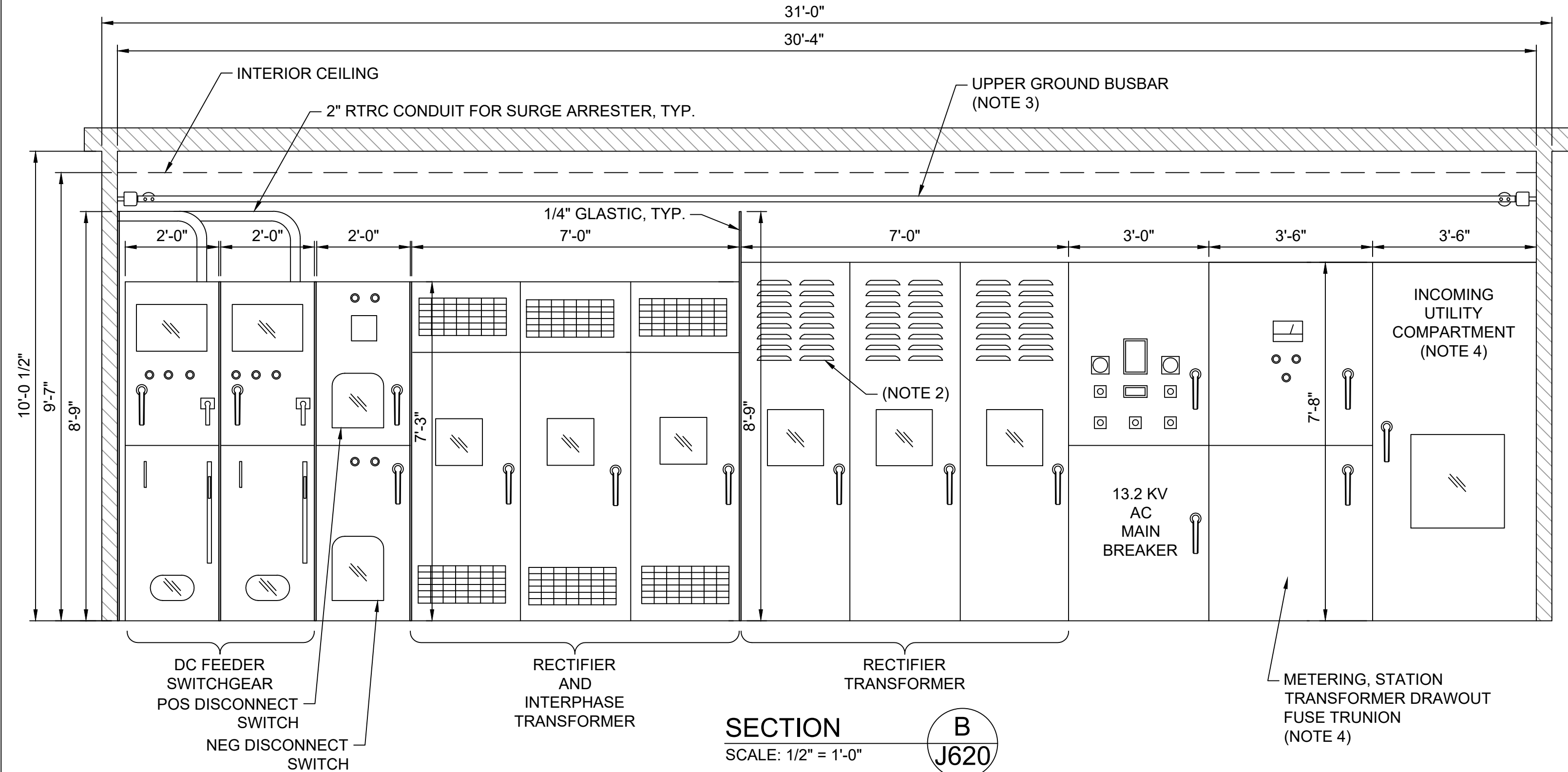
REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER TYPICAL PREFABRICATED TPSS - EXTERIOR ELEVATIONS ELEVATION VIEW	SCALE FOR 22"x34": 1/2"=1'-0" FILENAME: J620-J623.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.: J621
			CHECKED BY	PGL								
			DRAWN BY	JDW								
			CHECKED BY	PGL								
			APPROVED BY	NKS								
PLOT DATE: 1/17/2023			5:27:23 PM									



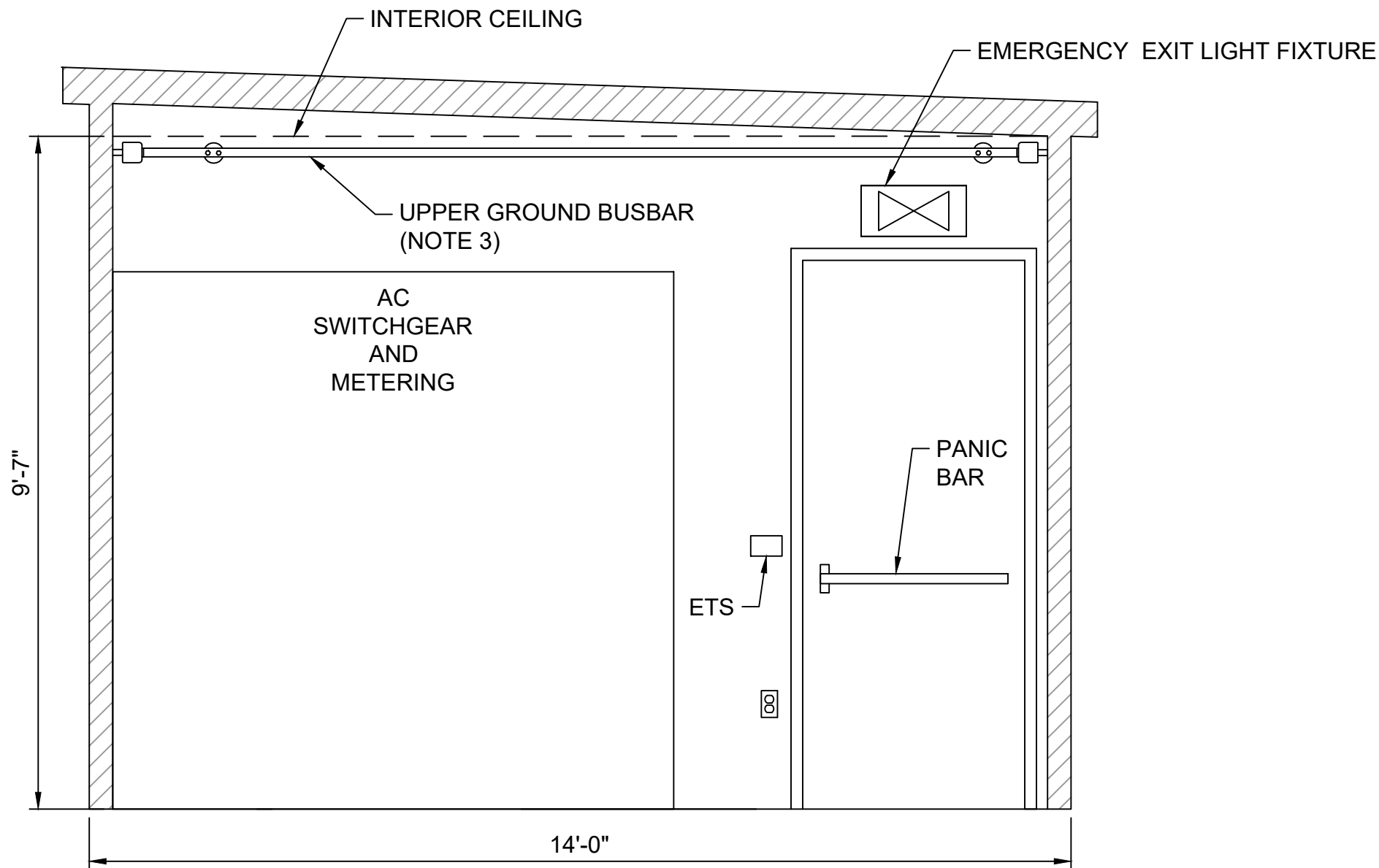
SECTION A
SCALE: 1/2" = 1'-0"
J620



SECTION C
SCALE: 1/2" = 1'-0"
J620

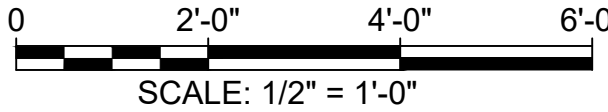


SECTION B
SCALE: 1/2" = 1'-0"
J620



SECTION D
SCALE: 1/2" = 1'-0"
J620

- NOTES:
- 1. ALL DIMENSIONS ARE APPROXIMATE. SUBMIT FINAL DIMENSIONS FOR APPROVAL.
 - 2. VENDOR TO DETERMINE SIZE AND LOCATION OF TRANSFORMER AND RECTIFIER VENTILATION.
 - 3. INSTALL 2" X 1/4" CONTINUOUS GROUND BUSBAR AROUND ENTIRE TPSS - CONNECT EQUIPMENT GROUNDS DIRECTLY TO GROUND BUSBAR. BUSBAR SHALL BE CONNECTED TO ALL FRAME GROUND PADS.
 - 4. INCOMING SWITCH, METERING EQUIPMENT, AND SOCKET DETAILS SUBJECT TO APPROVAL OF UTILITY.
 - 5. REFER TO SPECIFICATIONS FOR COMMUNICATIONS RACK REQUIREMENTS.
 - 6. PROVIDE 1/4" GLASTIC ON INTERIOR OF DOOR AND INSULATE OVER PANIC BARS.
 - 7. INSTALL RECTIFIER AND DC SWITCHGEAR 2" OFF OF REAR WALL. THERE SHALL BE NO GAP BEHIND THE AC SWITCHGEAR.
 - 8. A MOBILE WORKSTATION/CART SHALL BE PROVIDED. REFER TO SPECIFICATION 34 21 17 FOR DETAILS.



REV	DATE	DESCRIPTION	DESIGNED BY	JDW
			CHECKED BY	PGL
			DRAWN BY	JDW
			CHECKED BY	PGL
			APPROVED BY	NKS
PLOT DATE: 1/17/2023			DATE	06/24/2022



EARLY PROCUREMENT PACKAGE 3

DATE: 01-24-2023

HDR Engineering, Inc.
10450 Holmes Road
Suite 600
Kansas City, MO 64131-3471
816-360-2700
Certificate of Authority: 000856

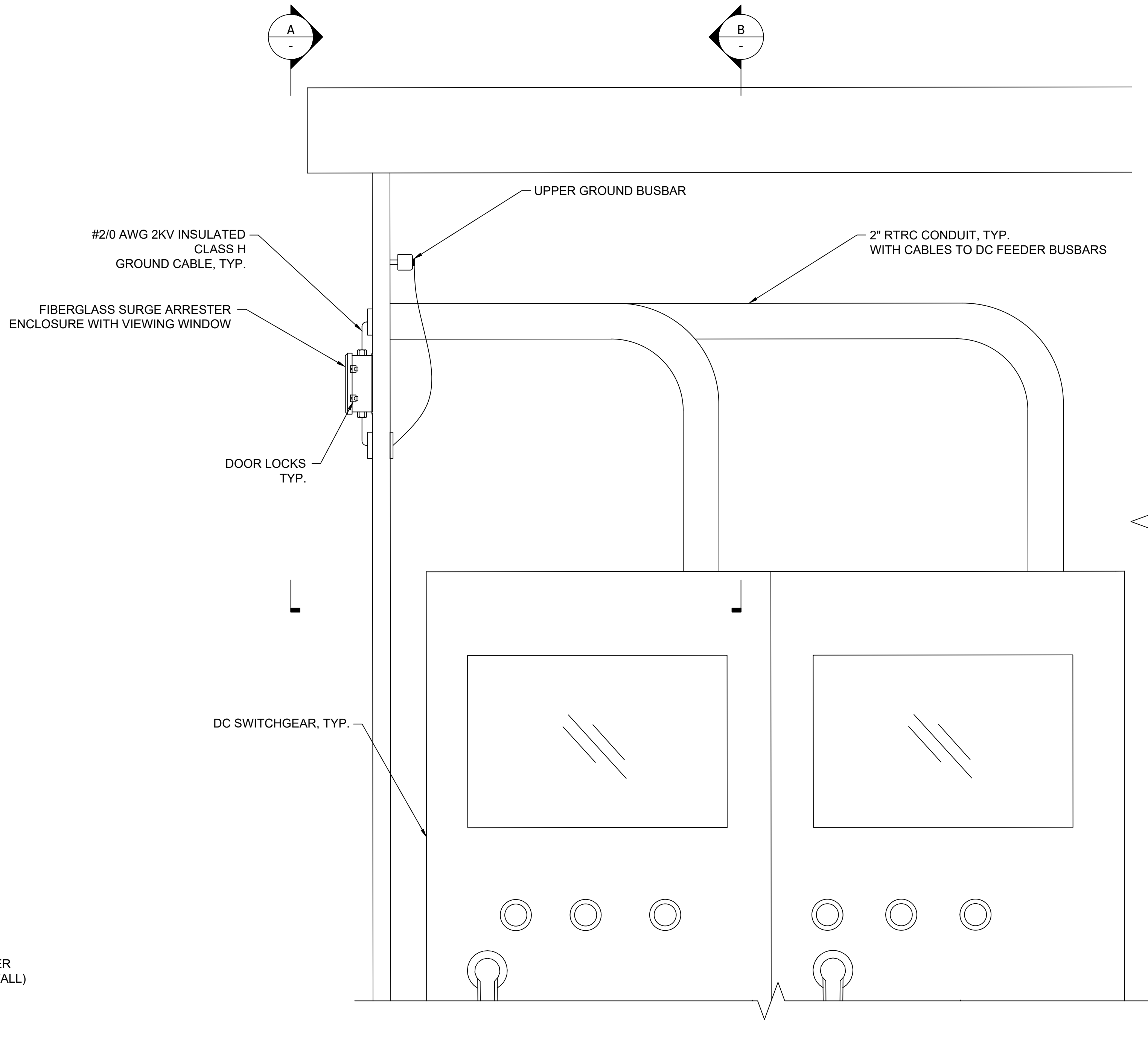
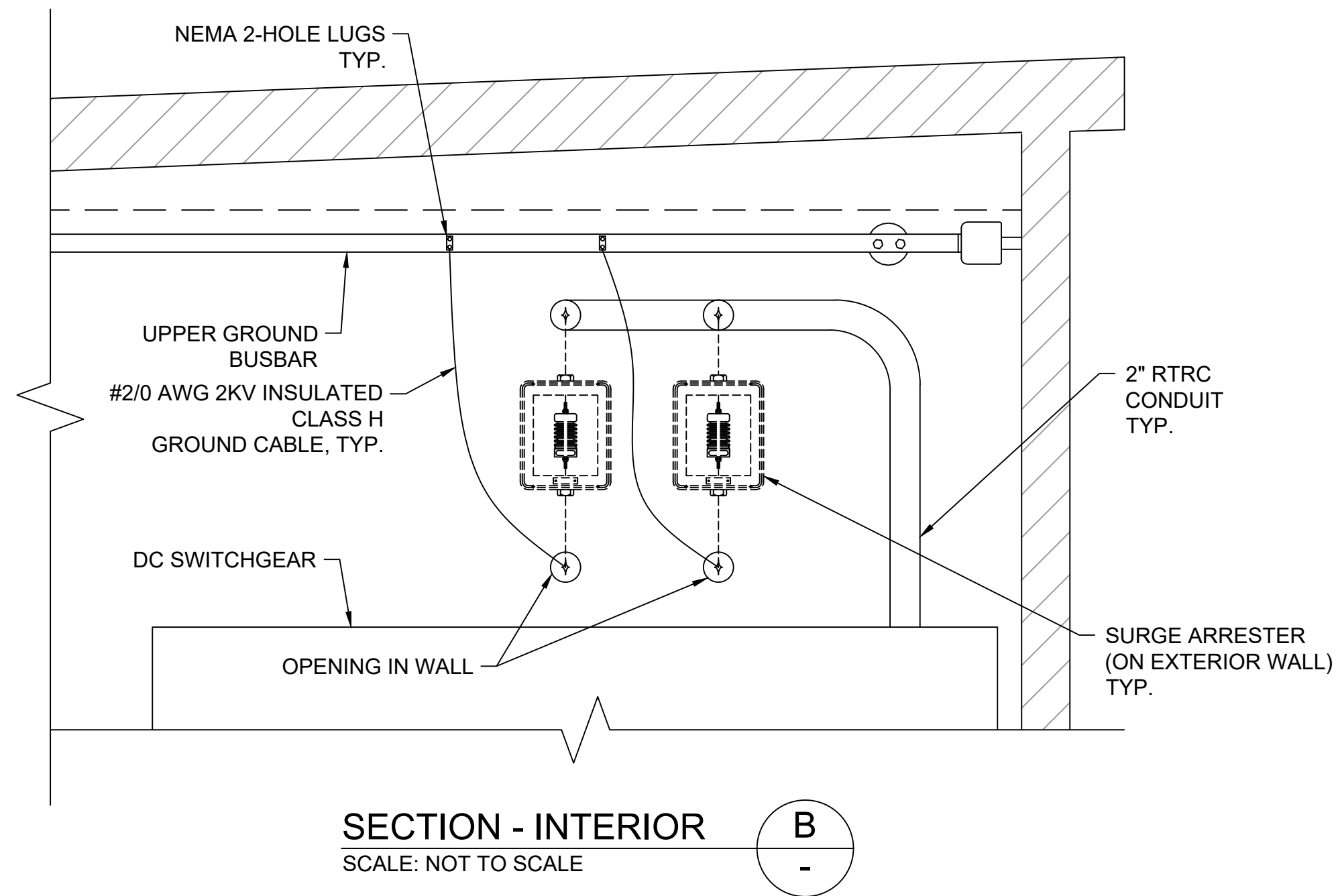
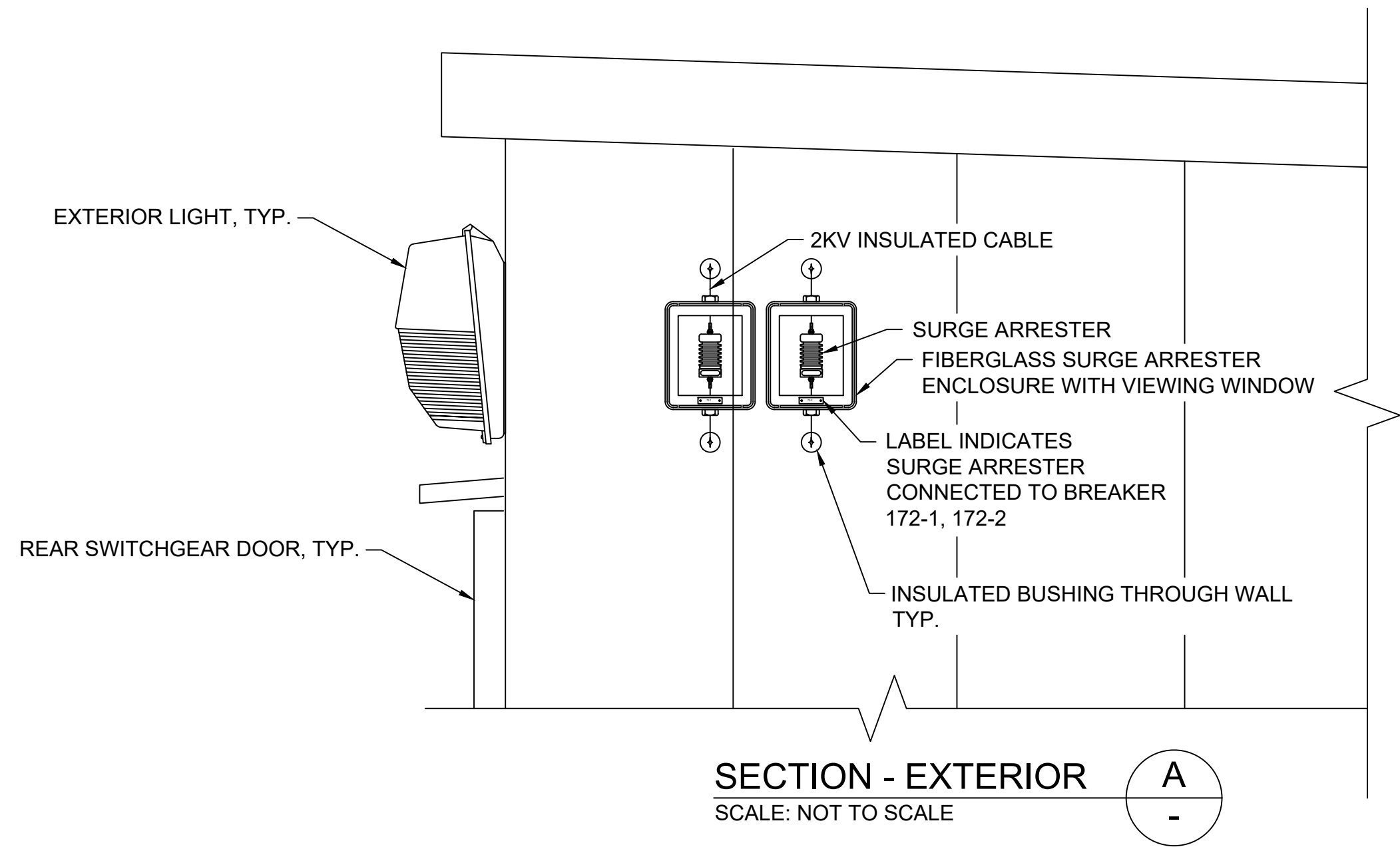
The HNTB COMPANIES
INFRASTRUCTURE SOLUTIONS
300 Apollo Drive
Chelmsford, MA 01824
Phone: 978-905-4000
Certificate of Authority: 001270

NOT FOR CONSTRUCTION

KANSAS CITY STREETCAR - RIVERFRONT EXTENSION

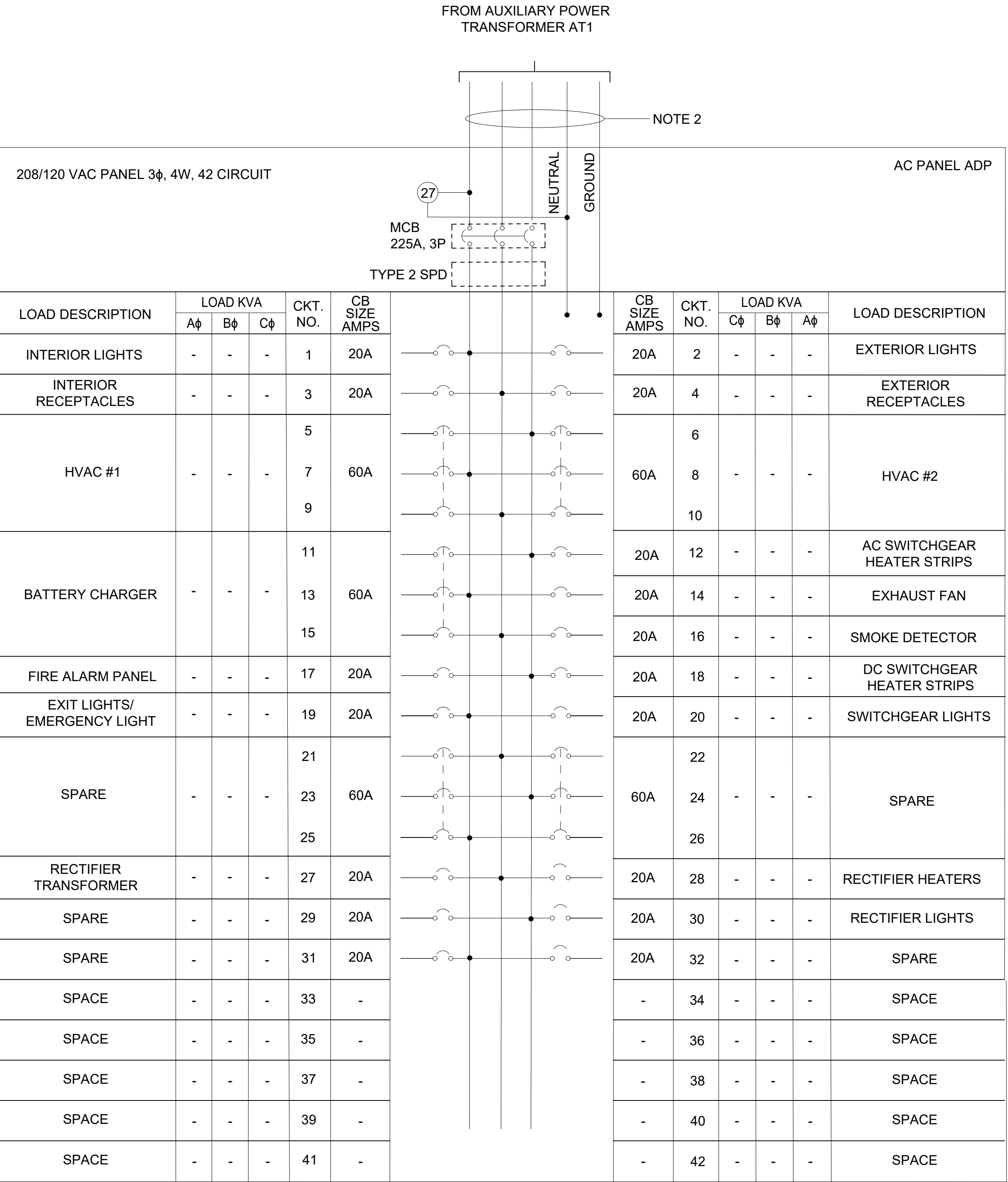
TRACTION POWER
TYPICAL PREFABRICATED TPSS INTERIOR ELEVATIONS

SCALE FOR 22"x34": 1/2"=1'-0"	
FILENAME: J620-J623.DWG	
CONTRACT NO.: CONTRACT NO. ###	
VOLUME: 1	
DRAWING NO.:	SHEET NO.:
J622	



- NOTES:
1. SECURE CABLES ALONG THE BRACKET.
 2. PROVIDE ENOUGH SLACK IN CABLE FOR SURGE ARRESTER TO FALL AWAY FROM BRACKET.
 3. PROVIDE FIBERGLASS ENCLOSURE WITH VIEWING WINDOW AND DOOR LOCKS.
 4. SURGE ARRESTERS SHALL BE MOUNTED AT A MINIMUM OF 9'-6" ABOVE FINISHED GRADE.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW				EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE		
			CHECKED BY	PGL							FILENAME:		
			DRAWN BY	JDW							J620-J623.DWG		
											CONTRACT NO.:		
			CHECKED BY	PGL							CONTRACT NO. ###		
			APPROVED BY	NKS							VOLUME:		
PLOT DATE: 1/17/2023			5: 27: 23 PM		DATE		06/24/2022				DRAWING NO.: SHEET NO.:		
										NOT FOR CONSTRUCTION		J623	



AC PANEL ADP - PANEL SCHEDULE

SCALE: NOT TO SCALE

NOTES:

1. NOT FOR CONSTRUCTION: FOR INFORMATIONAL PURPOSES ONLY. REFER TO VENDOR'S AC PANELBOARD DRAWING FOR AC PANEL LAYOUT
2. ALL INTERNAL BUILDING WIRING AND FINAL BREAKER SIZES TO BE DETERMINED BY VENDOR.

REV

DATE

DESCRIPTION

DESIGNED BY

JDW

CHECKED BY

PGL

DRAWN BY

JDW

CHECKED BY

PGL

APPROVED BY

NKS

PLOT DATE:

9/12/2022

5:18:33 PM

DATE

06/24/2022

RideKC

STREETCAR

EARLY PROCUREMENT PACKAGE 3

DATE: 01-24-2023

HDR

HDR Engineering, Inc.

10450 Holmes Road
Suite 600
Kansas City, MO 64131-3471
816-360-2700
Certificate of Authority: 000856

HNTB

The HNTB COMPANIES

INFRASTRUCTURE SOLUTIONS

300 Apollo Drive
Chelmsford, MA 01824
Phone: 978-905-4000
Certificate of Authority: 001270

NOT FOR CONSTRUCTION

KANSAS CITY STREETCAR - RIVERFRONT EXTENSION

TRACTION POWER

120/208V AC PANEL ADP

PANEL SCHEDULE

SCALE FOR 22"x34":

NOT TO SCALE

FILENAME:

J642.DWG

CONTRACT NO.:

CONTRACT NO. ###

VOLUME:

1

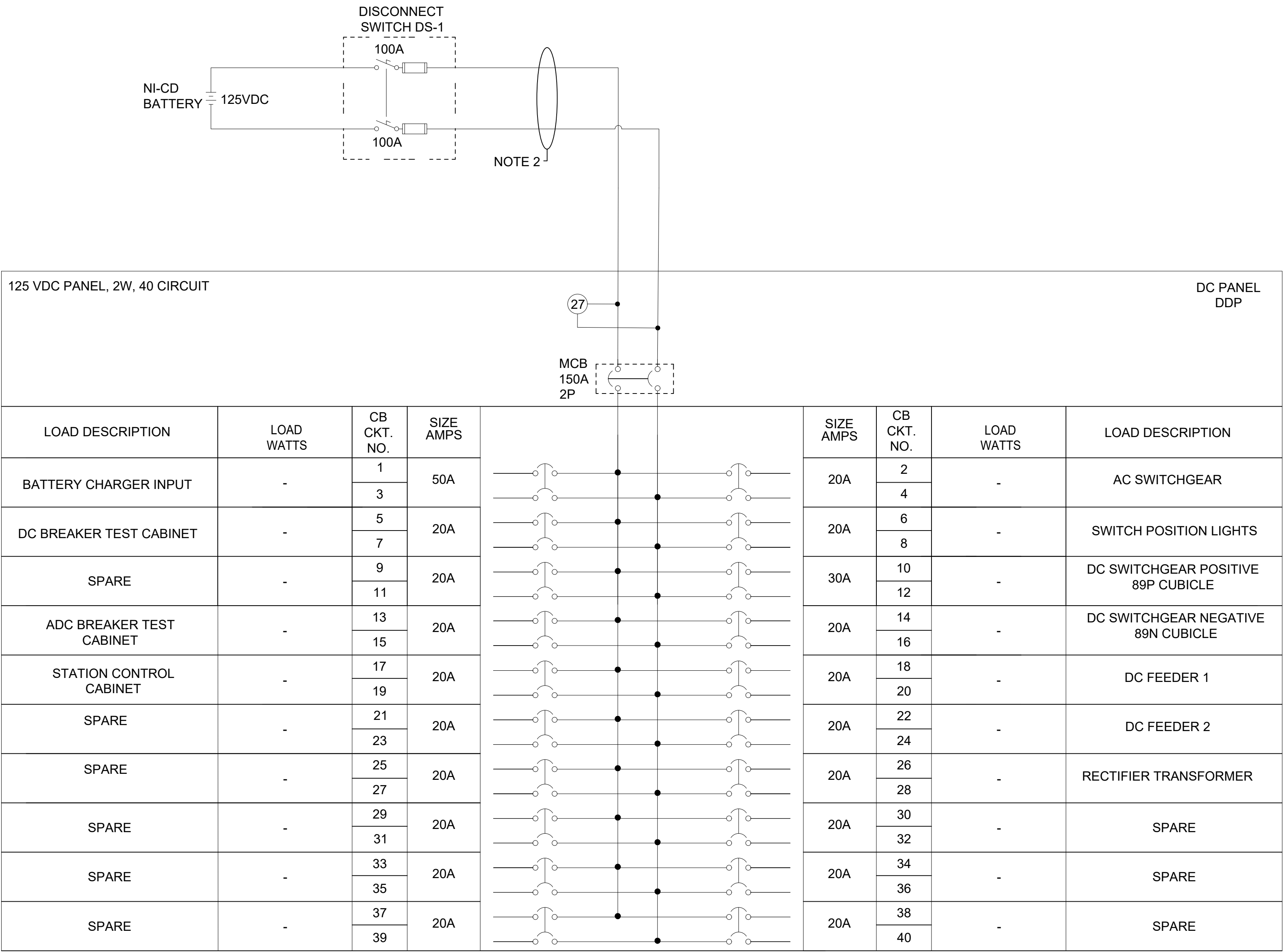
DRAWING NO.:

SHEET NO.:

J642

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304465



DC PANEL DDP - PANEL SCHEDULE
SCALE: NOT TO SCALE

NOTES:

1. NOT FOR CONSTRUCTION: FOR INFORMATIONAL PURPOSES ONLY. REFER TO VENDOR'S DC PANELBOARD DRAWING FOR DC PANEL LAYOUT
2. ALL INTERNAL BUILDING WIRING AND FINAL BREAKER SIZES TO BE DETERMINED BY VENDOR.
3. FOR THE DC DISTRIBUTION PANEL: AUXILIARY CONTACTS OF THE MAIN AND EACH BRANCH CIRCUIT BREAKER SHALL BE FACTORY WIRED TO A TERMINAL STRIP FOR CONNECTION TO THE ANNUNCIATOR AND SUPERVISORY CIRCUITS. TRIPPED OR OPEN CIRCUIT BREAKERS SHALL BE ANNUNCIATED.

REV

DATE

DESCRIPTION

DESIGNED BY

CHECKED BY

DRAWN BY

CHECKED BY

APPROVED BY

JDW

PGL

JDW

PGL

NKS

DATE

5:18:58 PM

06/24/2022



EARLY PROCUREMENT PACKAGE 3

DATE: 01-24-2023



HDR Engineering, Inc.

10450 Holmes Road
Suite 600
Kansas City, MO 64131-3471
816-360-2700
Certificate of Authority: 000856



The HNTB COMPANIES

INFRASTRUCTURE SOLUTIONS

300 Apollo Drive
Chelmsford, MA 01824
Phone: 978-905-4000
Certificate of Authority: 001270

NOT FOR CONSTRUCTION

KANSAS CITY STREETCAR - RIVERFRONT EXTENSION

TRACTION POWER
125V DC PANEL DDP
PANEL SCHEDULE

SCALE FOR 22"x34":
NOT TO SCALE

FILENAME:
J643.DWG

CONTRACT NO.:
CONTRACT NO. ###

VOLUME:
1

DRAWING NO.:
J643

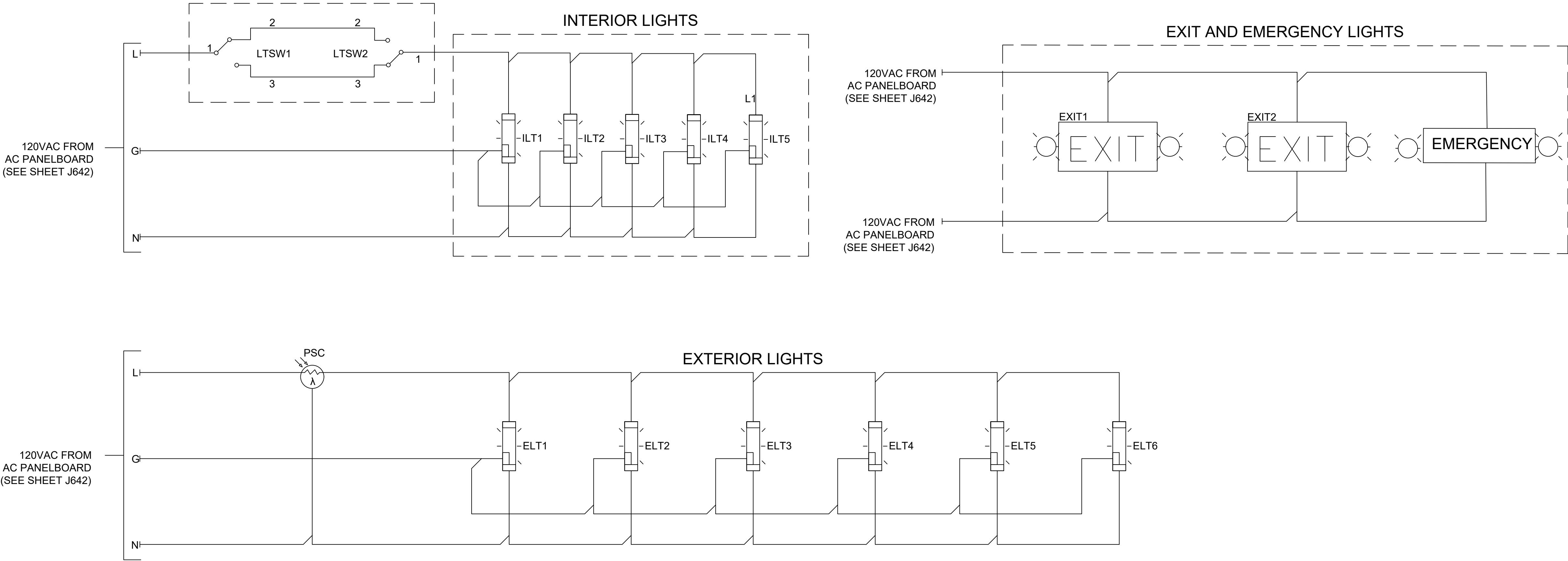
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Page 124 of 142

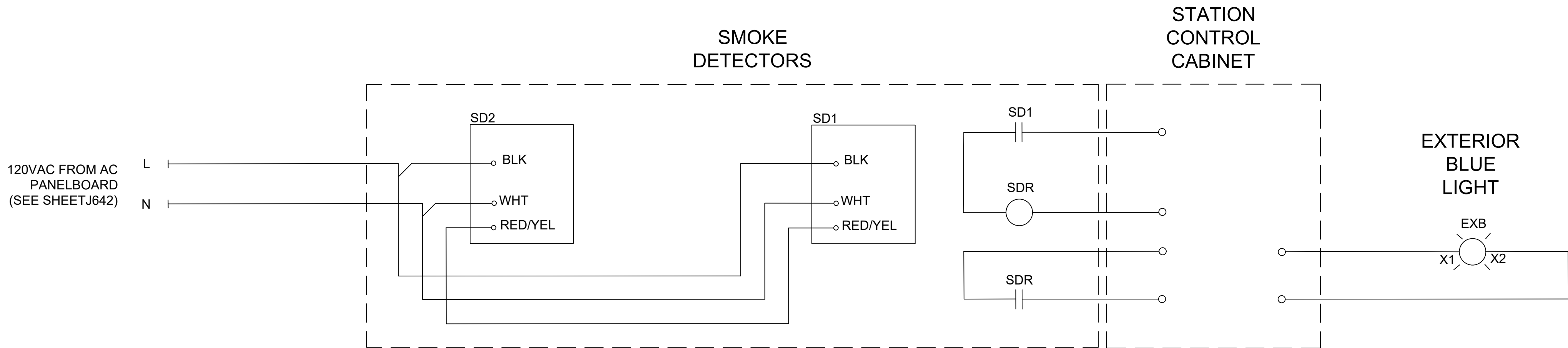
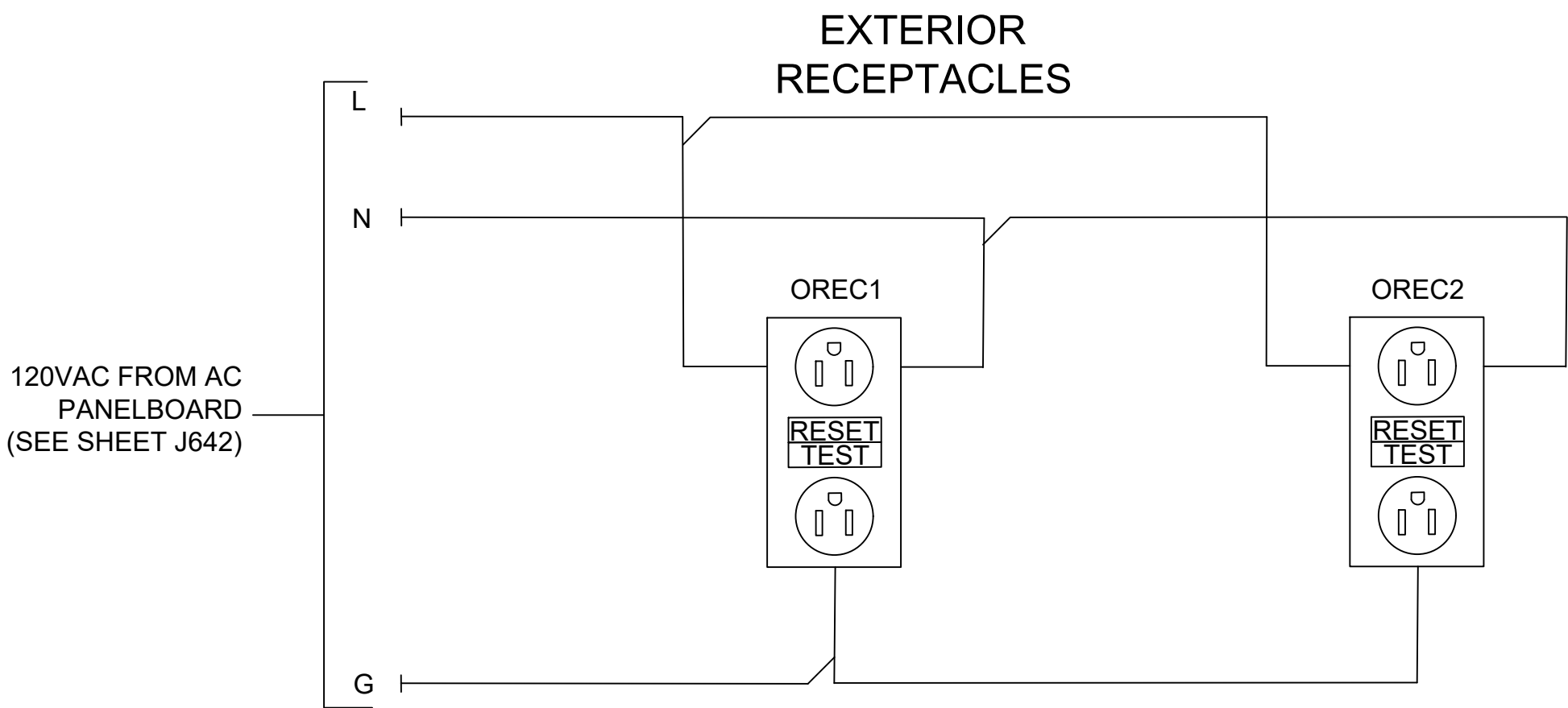
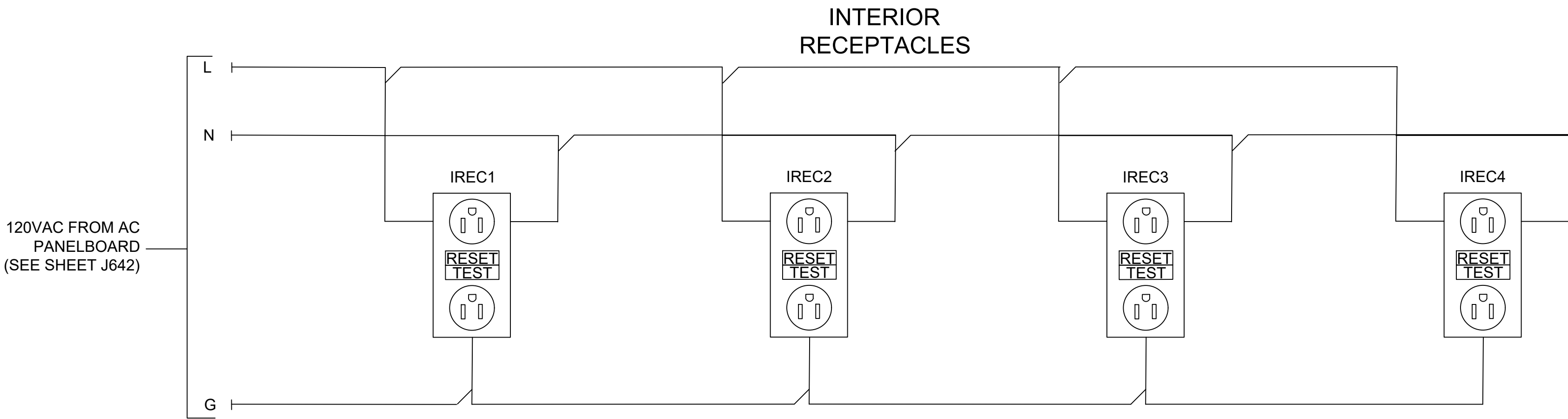
304466

NOTES:

- 1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.
- 2. EQUIPMENT CUBICLE LIGHTING AND HEATING TO BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
- 3. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.



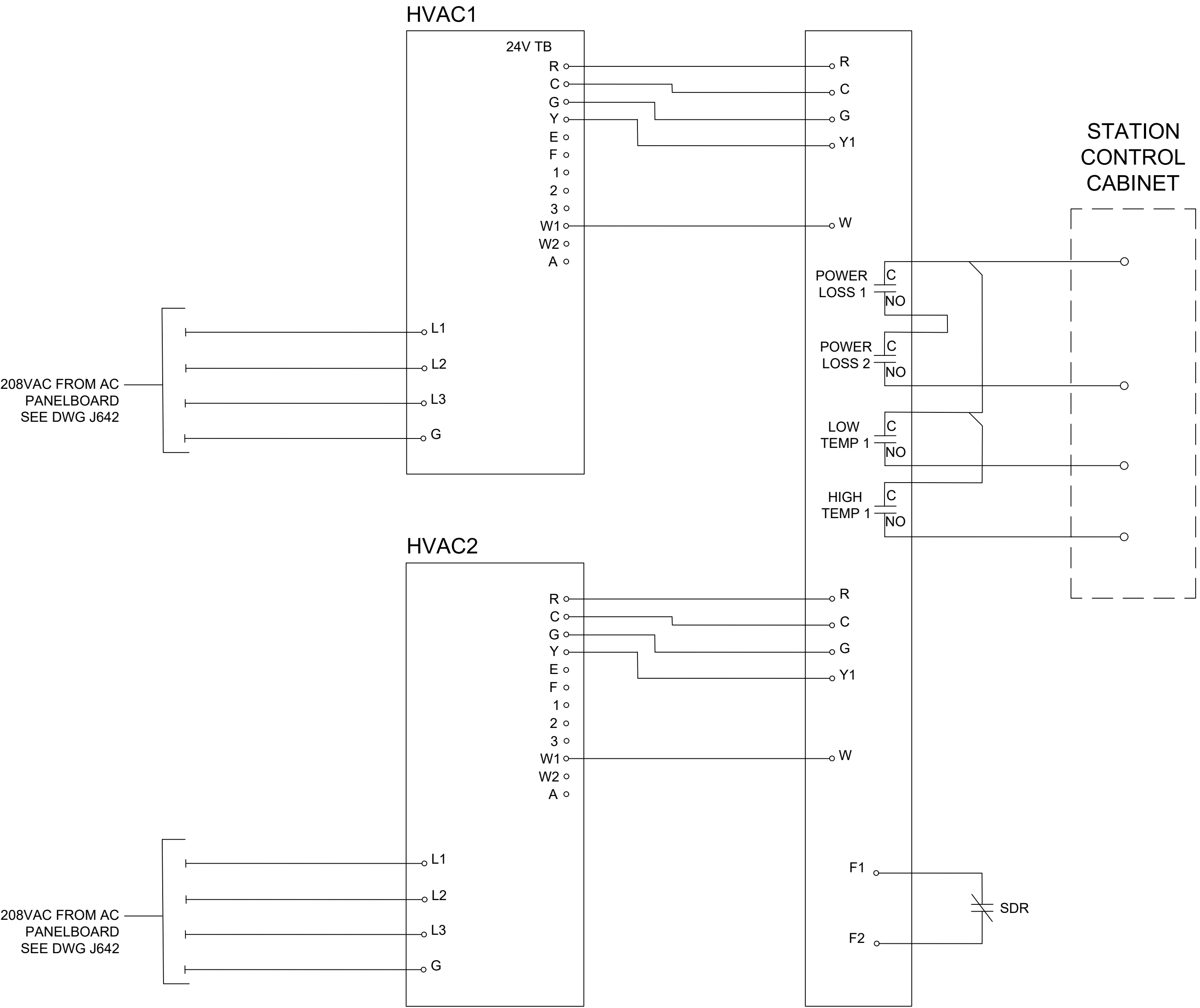
REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3 DATE: 01-24-2023  HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856  The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270 NOT FOR CONSTRUCTION	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION TRACTION POWER TYPICAL TPSS LIGHTING SCHEMATIC	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL				FILENAME: J644.DWG	
			DRAWN BY	JDW				CONTRACT NO.: CONTRACT NO. ###	
			CHECKED BY	PGL				VOLUME: 1	
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PLOT DATE: 9/12/2022			5:31:17 PM		DATE	06/24/2022			



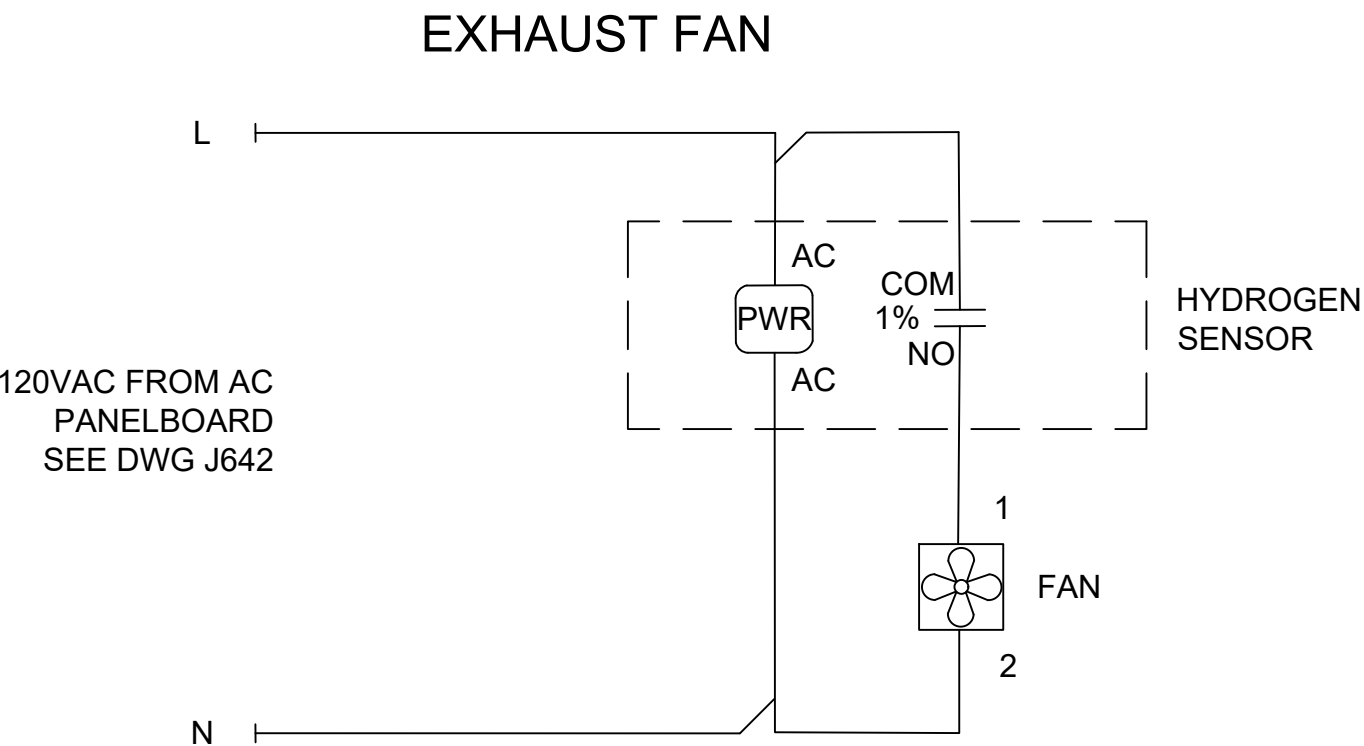
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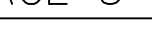
1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.
2. EQUIPMENT CUBICLE LIGHTING AND HEATING TO BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
3. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	 HNTB Engineering, Inc. The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE FILENAME: J645.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.: J645
			CHECKED BY	PGL							
			DRAWN BY	WAC							
			CHECKED BY	PGL							
			APPROVED BY	NKS							
PLOT DATE: 9/12/2022			5:32:18 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION		TRACTION POWER TYPICAL TPSS RECEPTACLES AND SMOKE DETECTOR SCHEMATIC		



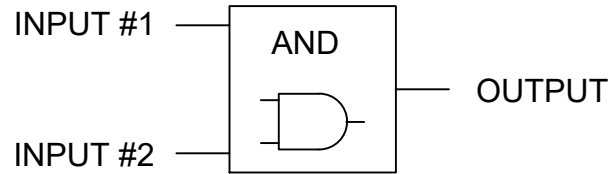
- NOTES:
1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.
 2. EQUIPMENT CUBICLE LIGHTING AND HEATING TO BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 3. EQUIPMENT SPECIFIC SCHEMATICS (AC SWITCHGEAR, DC SWITCHGEAR, RECTIFIER TRANSFORMER, RECTIFIER, ETC.) SHALL BE PROPOSED BY VENDOR. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.



REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3		DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL		 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	TRACTION POWER TYPICAL TPSS HVAC AND VENTILATION SCHEMATIC		FILENAME: J646.DWG	
			DRAWN BY	WAC						CONTRACT NO.: CONTRACT NO. ###	
			CHECKED BY	PGL						VOLUME: 1	
			APPROVED BY	NKS						DRAWING NO.:	SHEET NO.:
PLOT DATE: 9/12/2022			5: 32: 36 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION		J646		

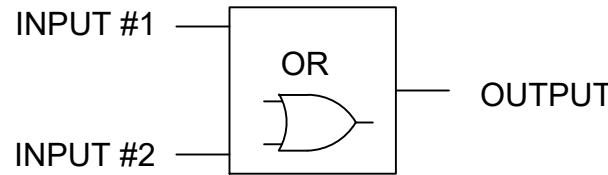
- NOTES:
1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

AND GATE



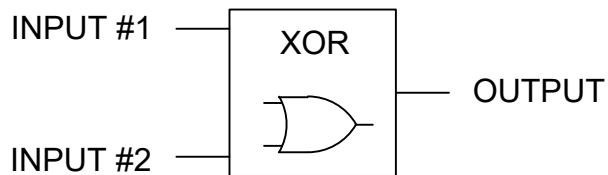
INPUT #1	INPUT #2	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

OR GATE



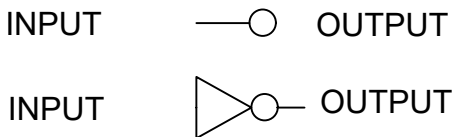
INPUT #1	INPUT #2	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	1

EXCLUSIVE OR GATE



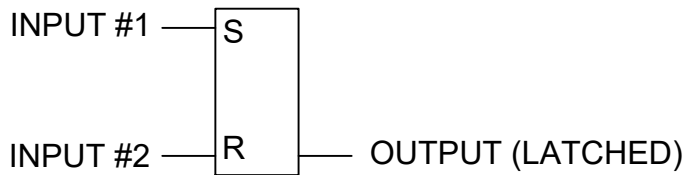
INPUT #1	INPUT #2	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	0

SIGNAL INVERSION



INPUT	OUTPUT
0	1
1	0

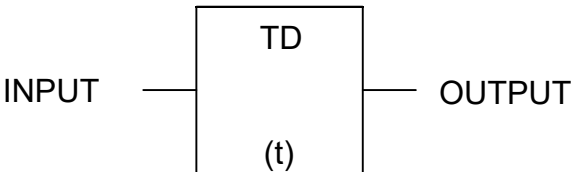
SET OVER RESET OPERATOR



INPUT #1	INPUT #2	OUTPUT (LATCHED)
0	0	PREVIOUS STATE
0	1	0
1	0	1
1	1	PREVIOUS STATE

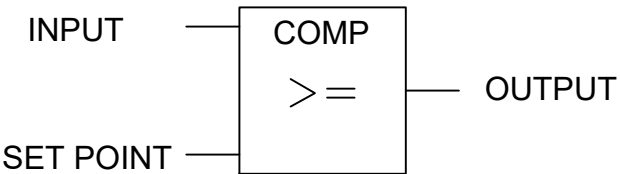
OUTPUT CHANGES STATE ONLY UPON RISING EDGE OF INPUT SIGNAL

TIME DELAY



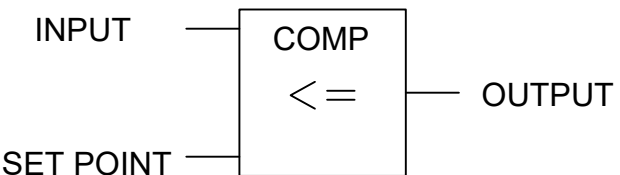
A RISING EDGE ON THE INPUT STARTS THE TIMER(t). THE TIMER COUNTS AS LONG AS THE INPUT IS HIGH. IF THE TIMER EXPIRES WHILE THE INPUT IS HIGH THE OUTPUT BECOMES ACTIVE. A FALLING INPUT EDGE RESETS THE TIMER.

GREATER THAN COMPARATOR



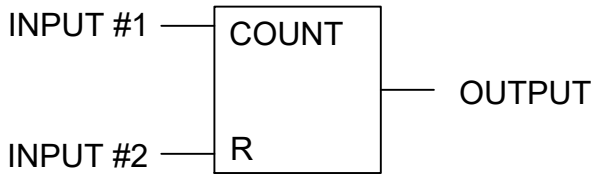
IF THE INPUT VALUE IS GREATER THAN OR EQUAL TO THE SET POINT, THE OUTPUT BECOMES ACTIVE.

LESS THAN COMPARATOR



IF THE INPUT VALUE IS LESS THAN OR EQUAL TO THE SET POINT, THE OUTPUT BECOMES ACTIVE.

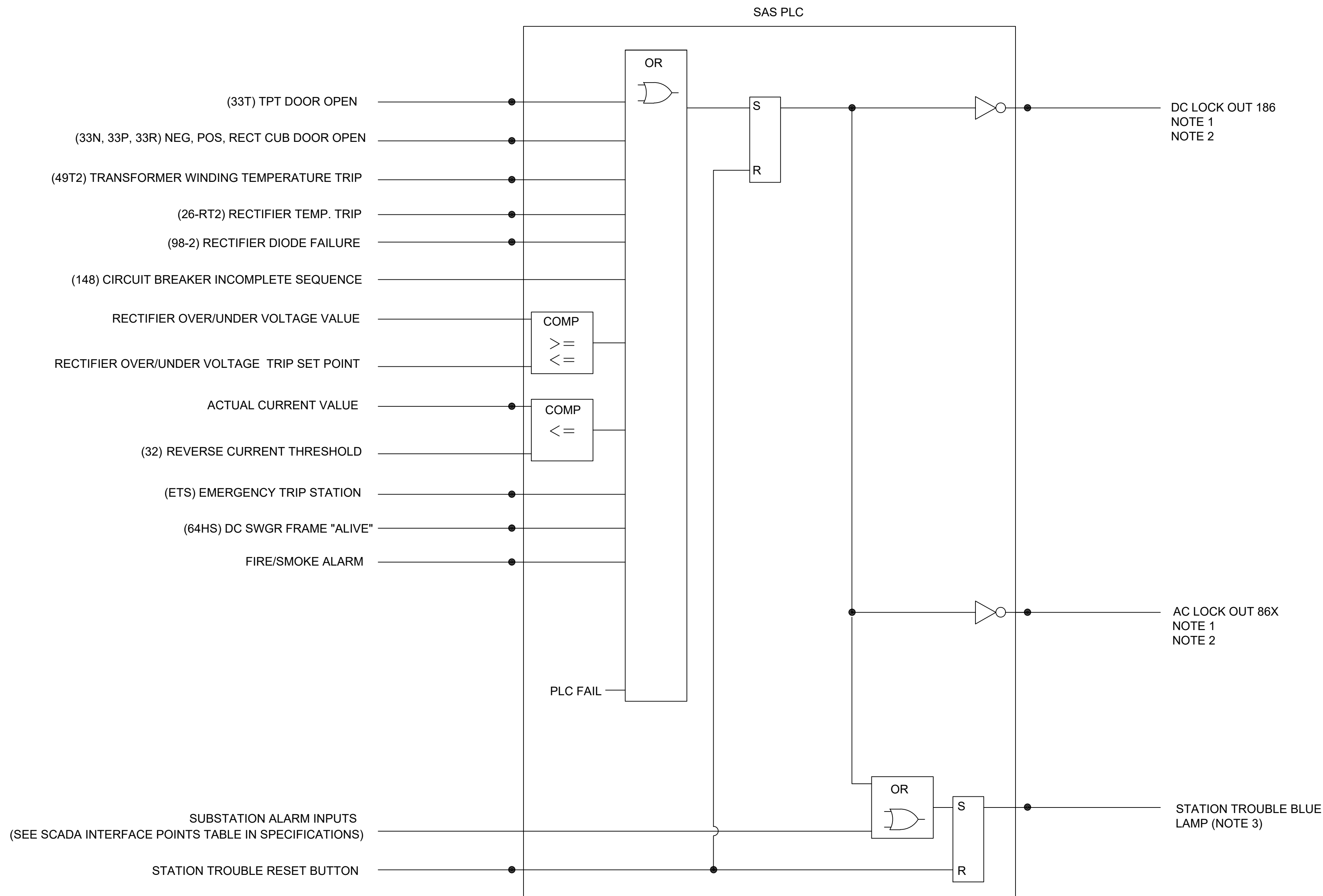
COUNTER



EACH TIME INPUT #1 IS PULSED HIGH THE COUNTER INCREMENTS AND THE OUTPUT REFLECTS THE COUNT VALUE. WHEN INPUT #2 IS PULSED HIGH THE COUNT VALUE IS RESET.

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3		DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION		SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL		 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	NOT FOR CONSTRUCTION	TRACTION POWER LOGIC DIAGRAMS SYMBOLS AND LEGEND		FILENAME: J648.DWG	
			DRAWN BY	WAC							CONTRACT NO.: CONTRACT NO. ###	
			CHECKED BY	PGL							VOLUME: 1	
			APPROVED BY	NKS							DRAWING NO.: SHEET NO.:	
											J648	
PLOT DATE: 9/12/2022			5: 33: 08 PM		DATE	06/24/2022						

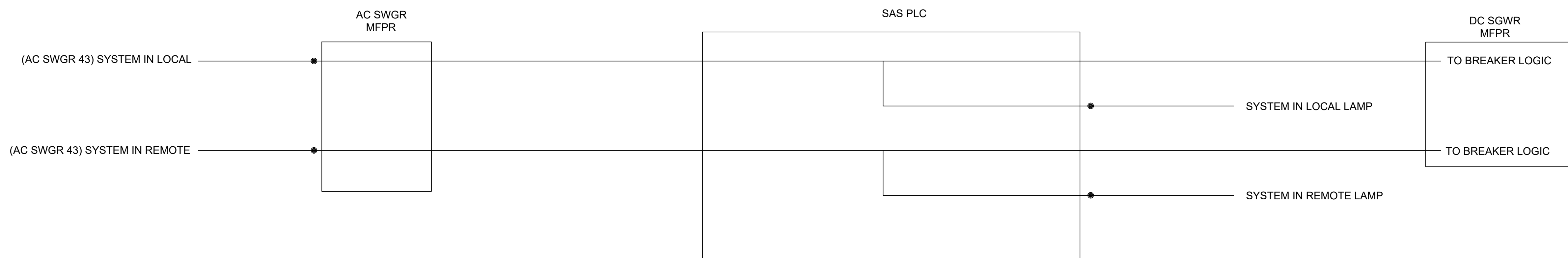
SUBSTATION LOCKOUT AND ALARM LOGIC



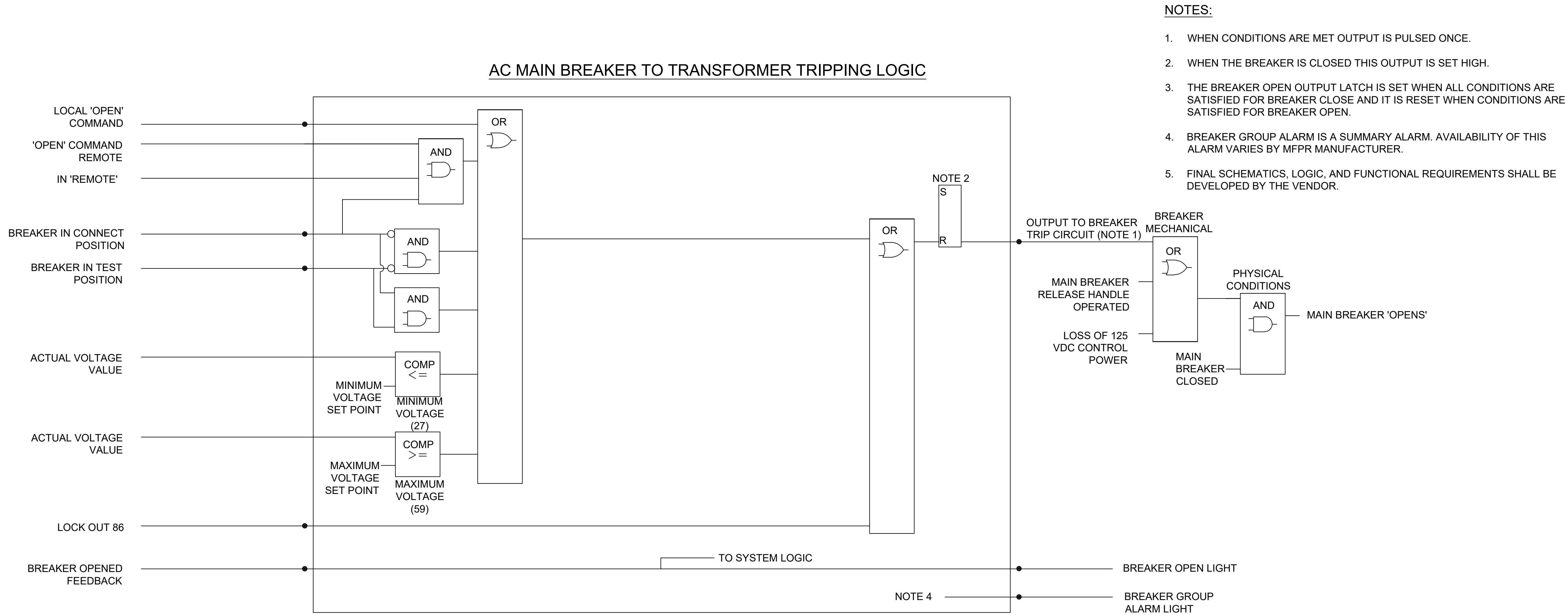
NOTES:

1. PLC OUTPUT ACTIVATES LOCKOUT RELAY 186 & 86X.
2. THIS SIGNAL IS ACTIVE LOW.
3. FLASHING BLUE LIGHT (NEW UNACKNOWLEDGED ALARM)
SOLID BLUE LIGHT (ACTIVE ACKNOWLEDGED ALARMS)
BLUE LIGHT OFF (NO ACTIVE ALARMS).
4. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL
REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

LOCAL / REMOTE LOGIC



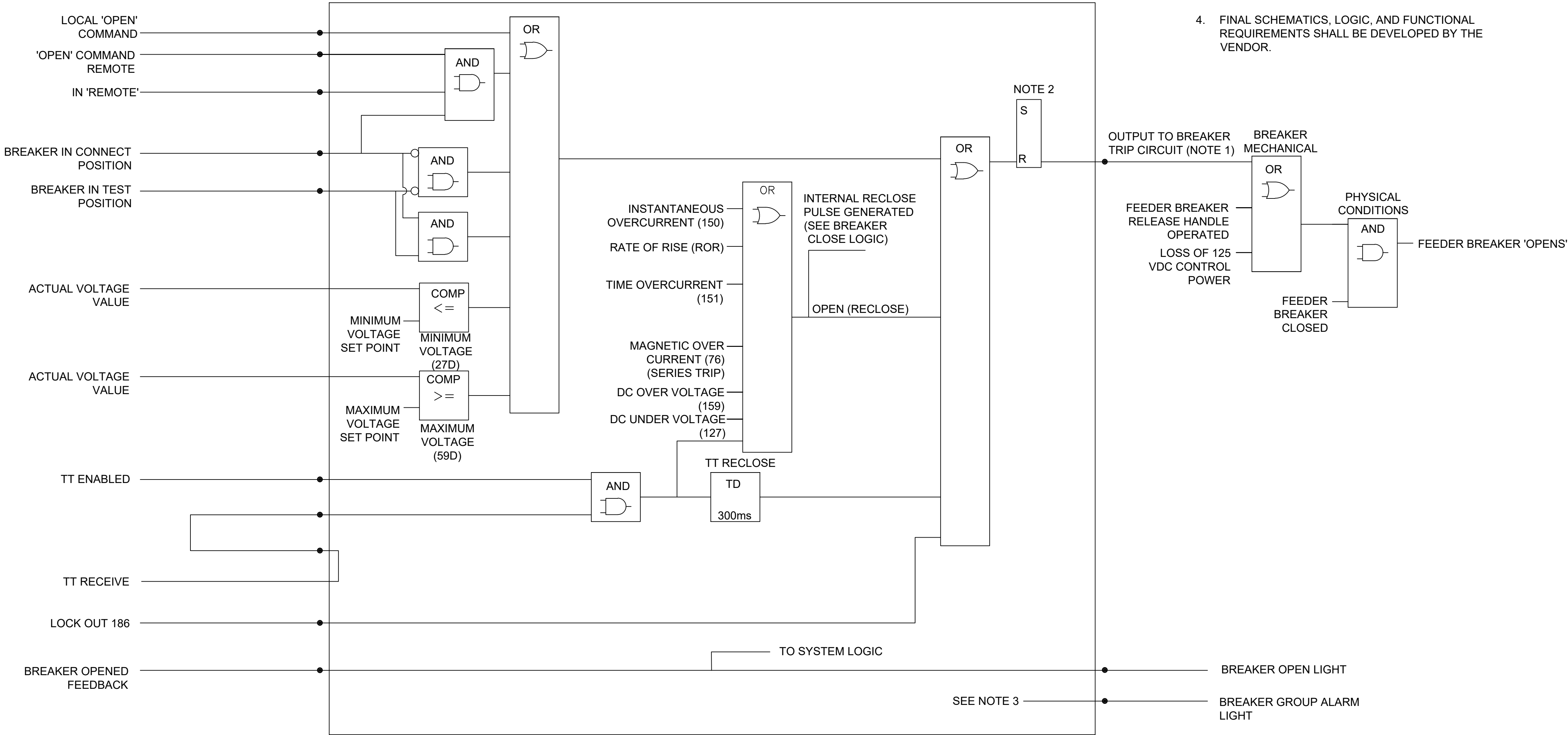
REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION TRACTION POWER SUBSTATION LOCKOUT AND ALARM LOGIC DIAGRAM	SCALE FOR 22"x34": NOT TO SCALE FILENAME: J649.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: J649 SHEET NO.:
			CHECKED BY	PGL		 HNTB The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	NOT FOR CONSTRUCTION		
			DRAWN BY	WAC					
			CHECKED BY	PGL					
			APPROVED BY	NKS					
PLOT DATE: 9/12/2022		5:33:18 PM		DATE	06/24/2022				



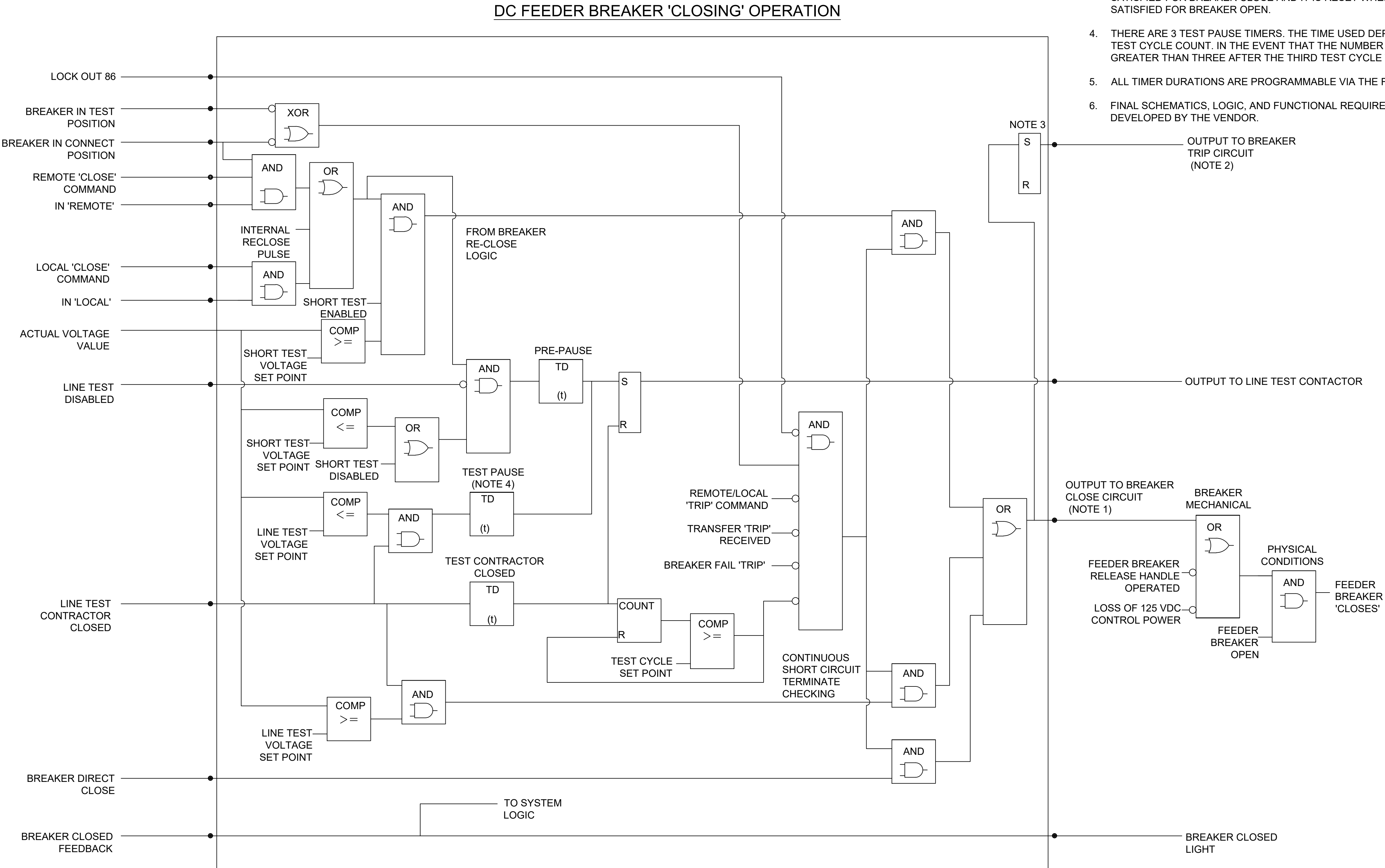
NOTES:

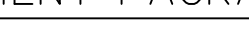
1. WHEN THE BREAKER IS CLOSED THIS OUTPUT IS SET HIGH.
2. THE BREAKER OPEN OUTPUT LATCH IS SET WHEN ALL CONDITIONS ARE SATISFIED FOR BREAKER CLOSE AND IT IS RESET WHEN CONDITIONS ARE SATISFIED FOR BREAKER OPEN.
3. BREAKER GROUP ALARM IS A SUMMARY ALARM. AVAILABILITY OF THIS ALARM VARIES BY MFPR MANUFACTURER.
4. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

DC FEEDER BREAKER 'TRIPPING' OPERATION



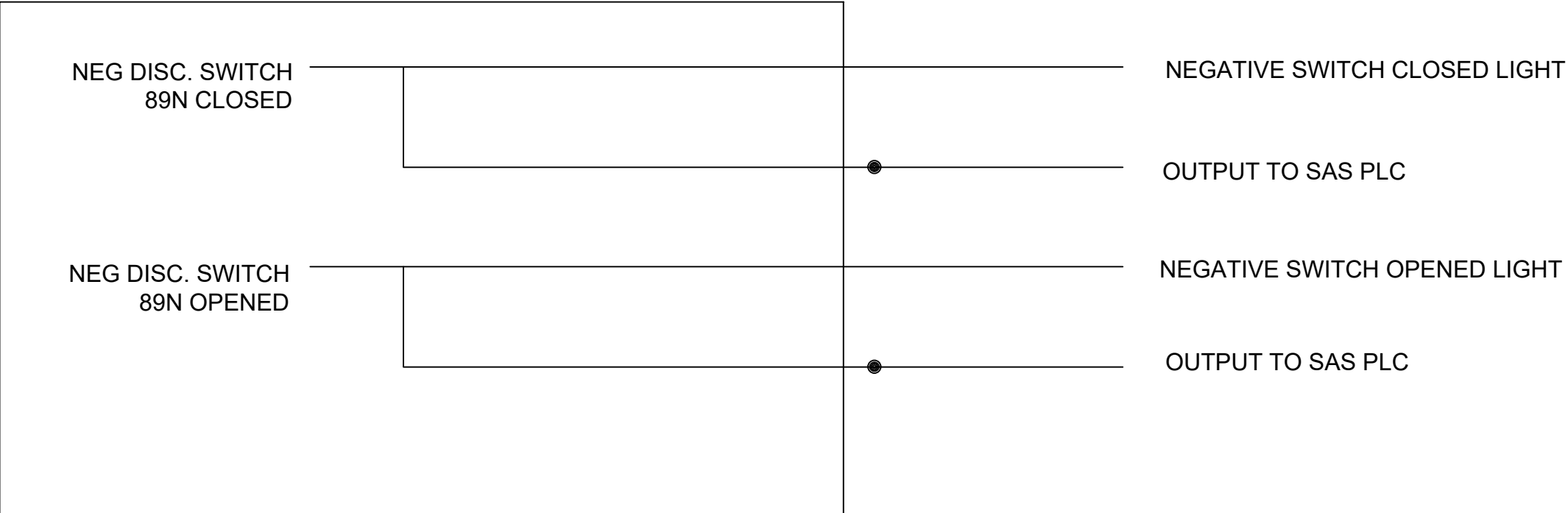
REV	DATE	DESCRIPTION	DESIGNED BY	JDW			EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER TYPICAL DC FEEDER CUBICLE LOGIC DIAGRAM SHEET 1 OF 2	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL			 HNTB Engineering, Inc.	The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856			300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	FILENAME: J652.DWG
			DRAWN BY	JDW								CONTRACT NO.: CONTRACT NO. ###
			CHECKED BY	PGL								VOLUME: 1
			APPROVED BY	NKS								DRAWING NO.: J652
												SHEET NO.:
PLOT DATE: 9/12/2022			5: 33: 38 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION					



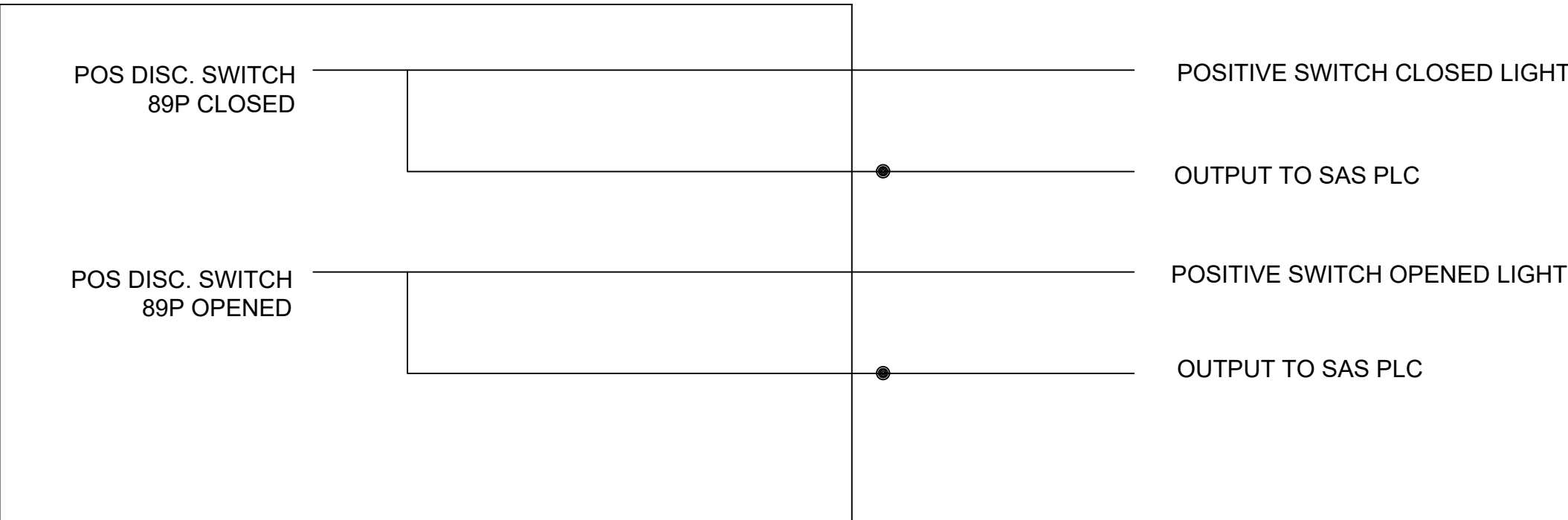
REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER TYPICAL DC FEEDER CUBICLE LOGIC DIAGRAM SHEET 2 OF 2	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL		 HNTB Engineering, Inc. The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 HNTB The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270			FILENAME:	
			DRAWN BY	JDW						CONTRACT NO.:	
			CHECKED BY	PGL						CONTRACT NO. ###	VOLUME:
			APPROVED BY	NKS						1	DRAWING NO.:
PLOT DATE: 9/12/2022			5: 33: 50 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION			J653	SHEET NO.:

- NOTES:
1. FINAL SCHEMATICS, LOGIC, AND FUNCTIONAL REQUIREMENTS SHALL BE DEVELOPED BY THE VENDOR.

NEGATIVE DISCONNECT SWITCH LOGIC

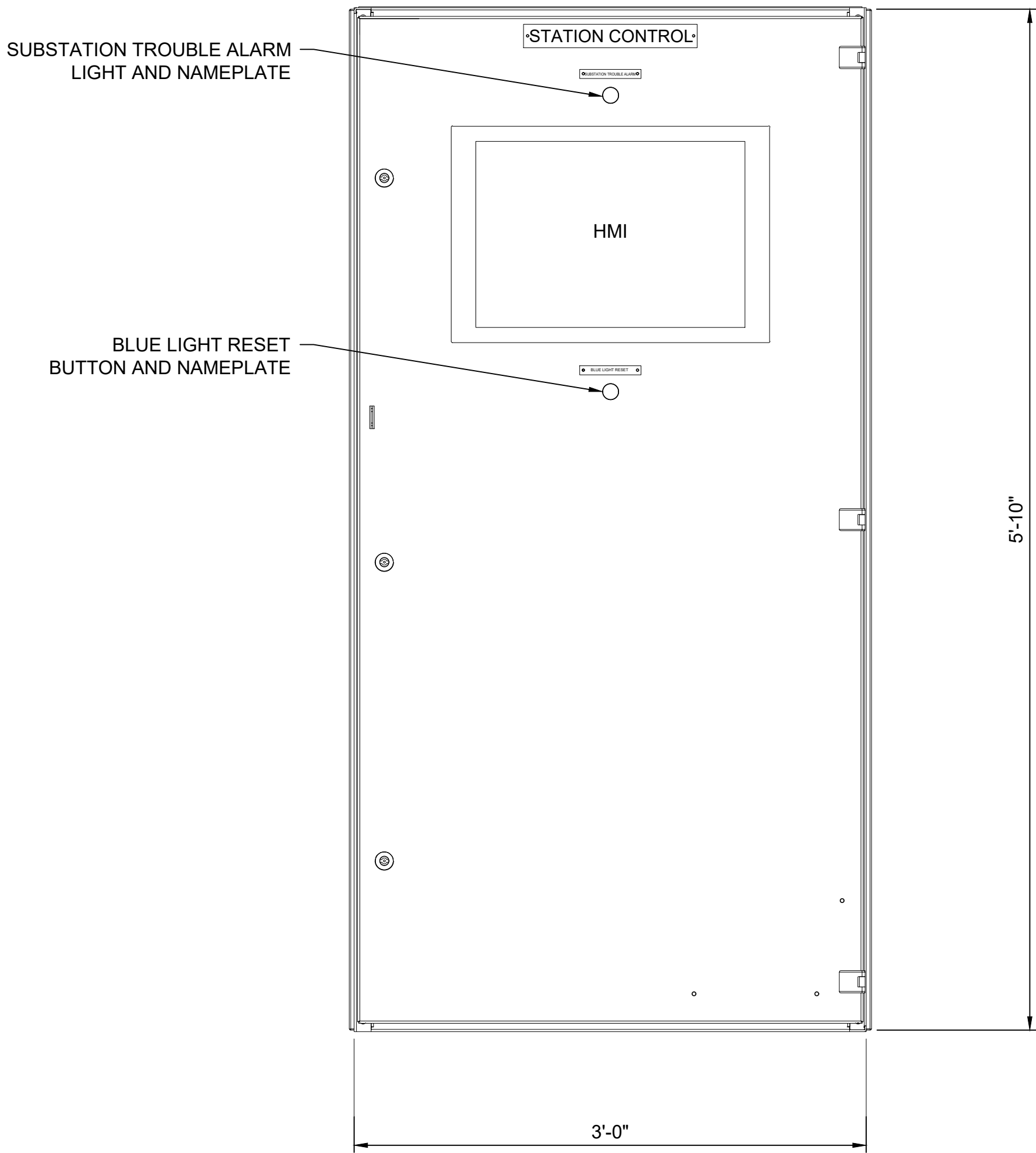


POSITIVE DISCONNECT SWITCH LOGIC

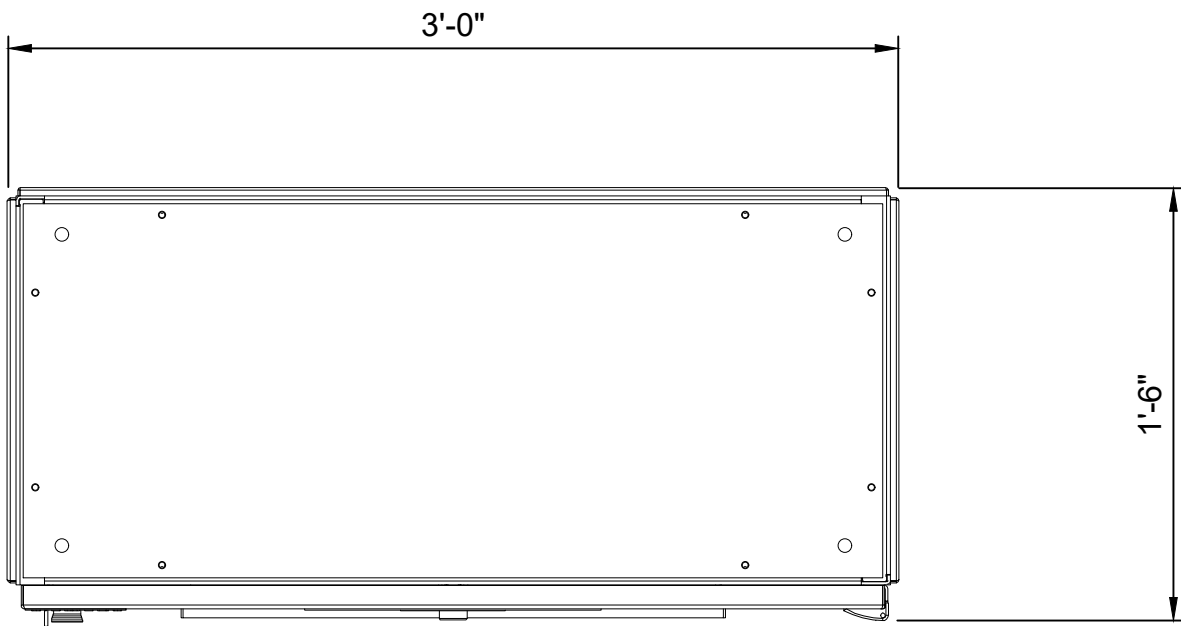


REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER NEGATIVE AND POSITIVE DISCONNECT SWITCH LOGIC DIAGRAM	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL								FILENAME:	
			DRAWN BY	WAC								CONTRACT NO.:	
			CHECKED BY	PGL								CONTRACT NO. ###	
			APPROVED BY	NKS								VOLUME:	
PLOT DATE: 9/12/2022			5: 33: 57 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION		DRAWING NO.:		SHEET NO.:		
												J654	

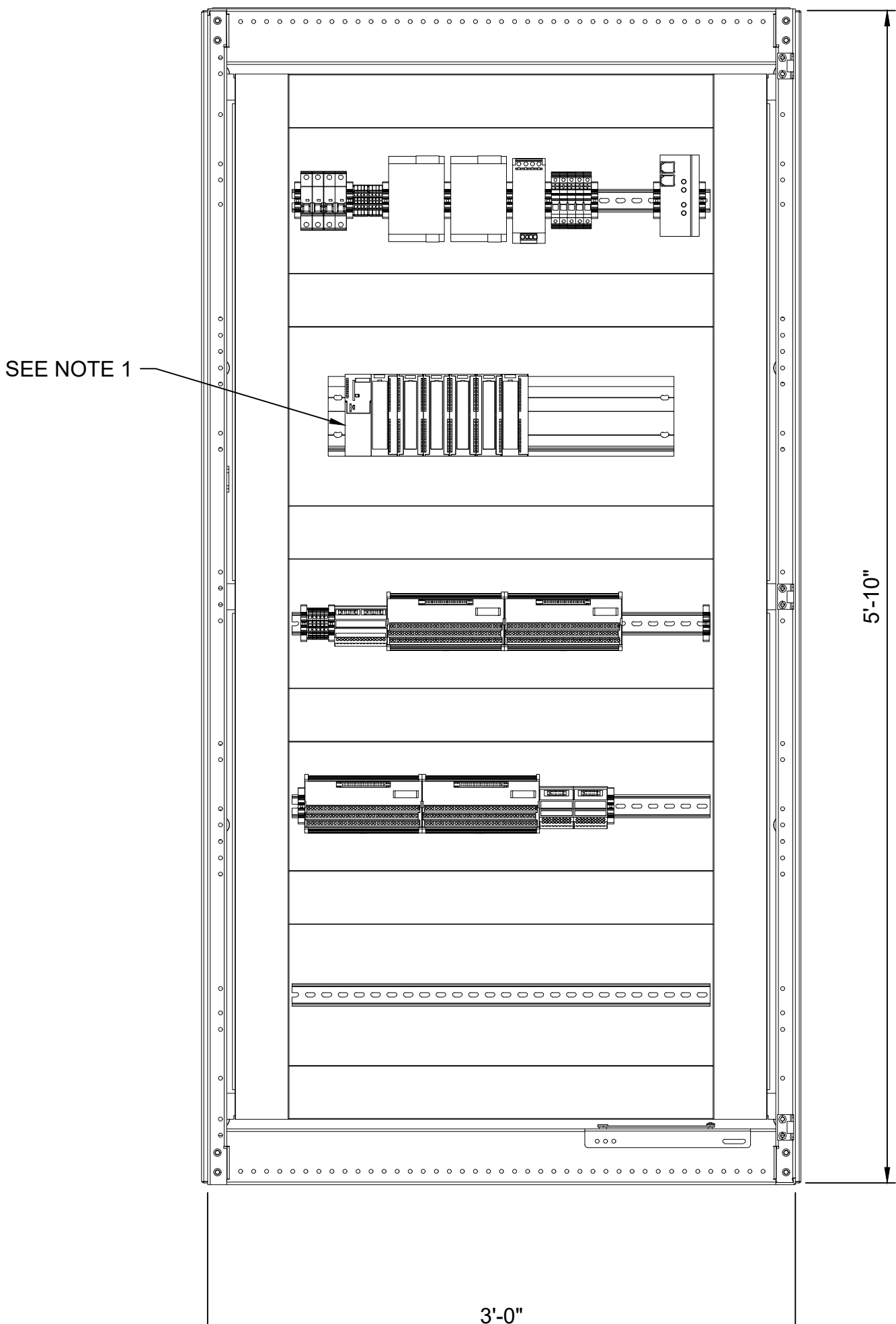
- NOTES:
- SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 - FINAL DIMENSIONS SHALL BE DETERMINED BY VENDOR.



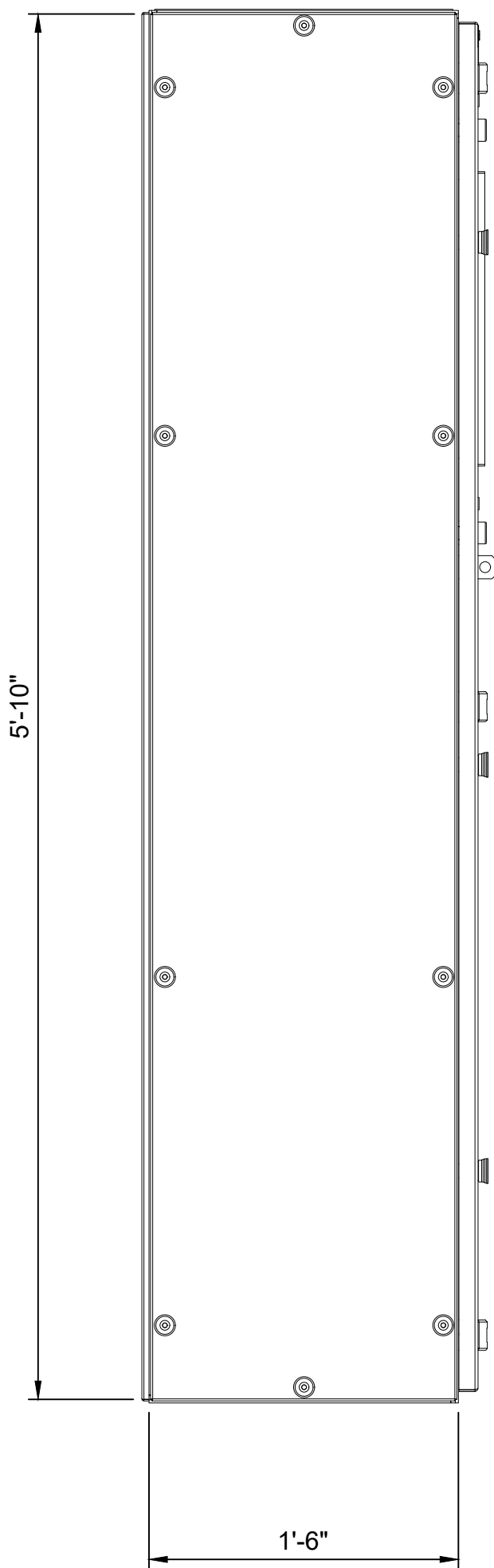
FRONT VIEW
SCALE: NOT TO SCALE



TOP VIEW
SCALE: NOT TO SCALE

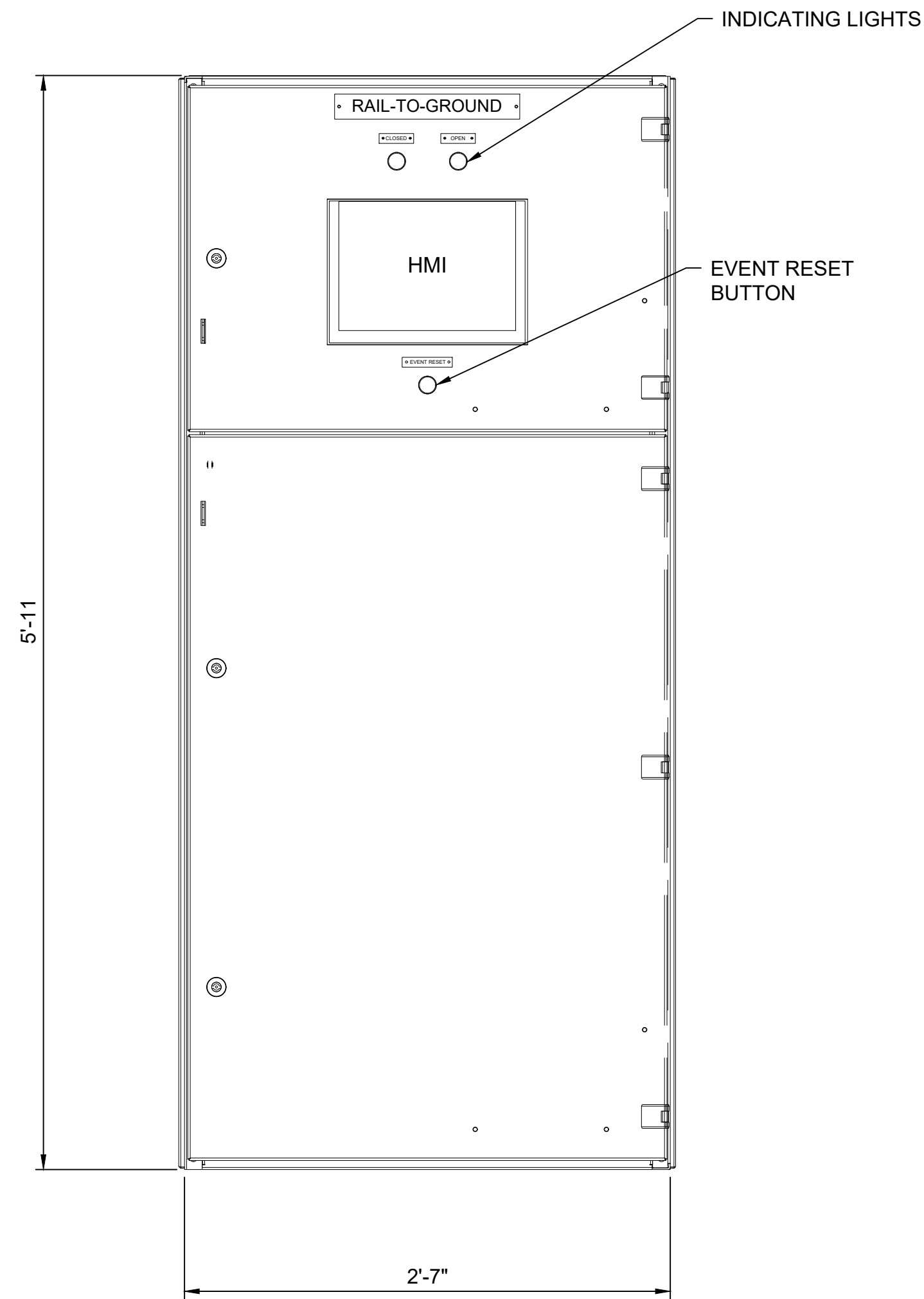


FRONT VIEW
(WITHOUT DOORS AND TRUCK)
SCALE: NOT TO SCALE

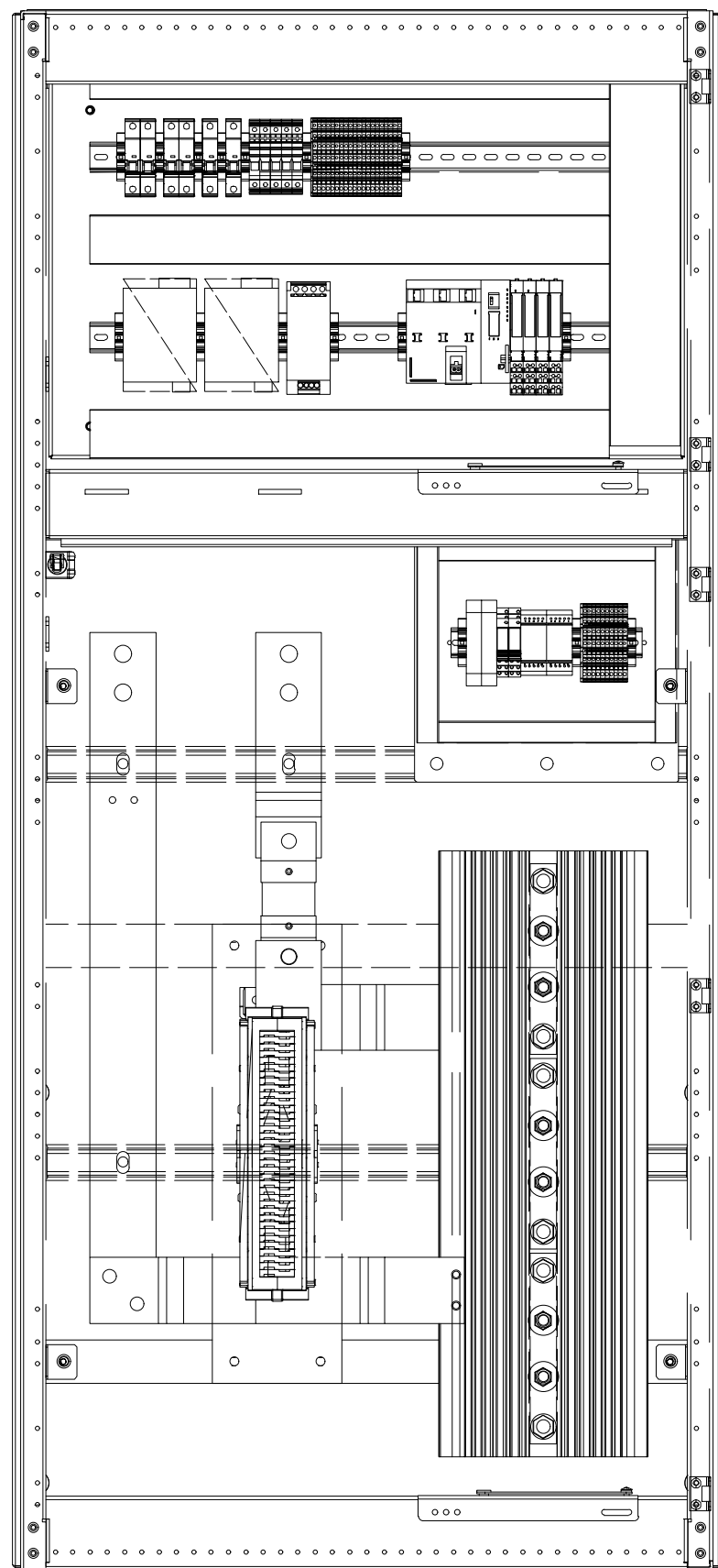


SIDE VIEW
SCALE: NOT TO SCALE

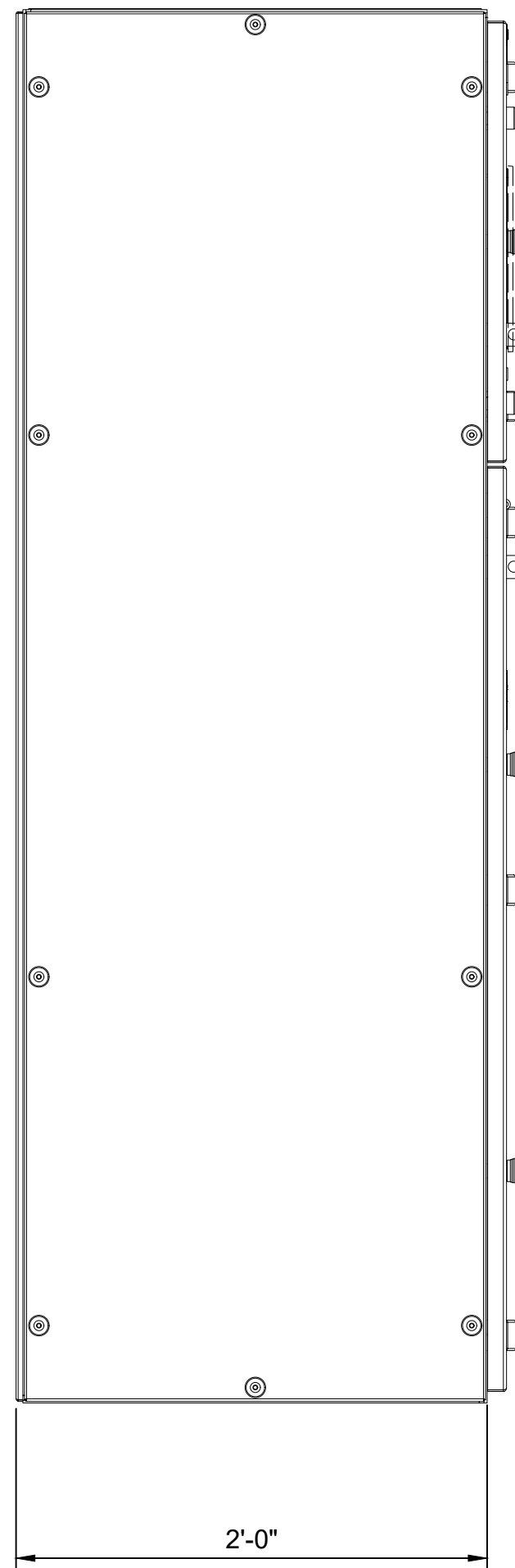
REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER STATION CONTROL CABINET TYPICAL LAYOUT	SCALE FOR 22"x34": NOT TO SCALE FILENAME: J660.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.:	
			CHECKED BY	PGL									
			DRAWN BY	JDW									
			CHECKED BY	PGL									
			APPROVED BY	NKS									
PLOT DATE: 9/12/2022			5: 34: 07 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION						J660



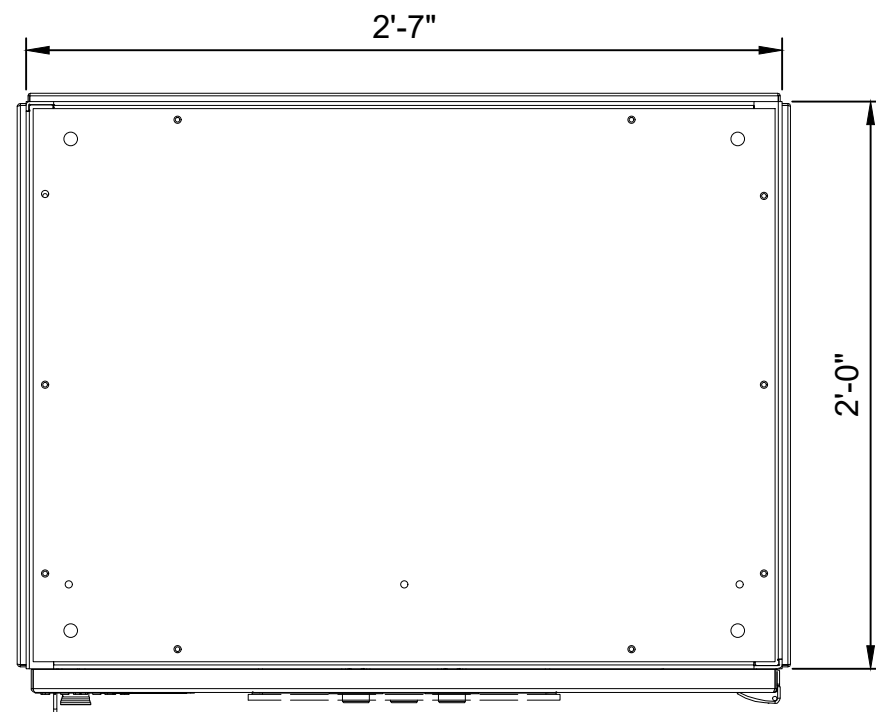
FRONT VIEW
SCALE: NOT TO SCALE



FRONT VIEW
(WITHOUT DOORS AND TRUCK)
SCALE: NOT TO SCALE



SIDE VIEW
SCALE: NOT TO SCALE

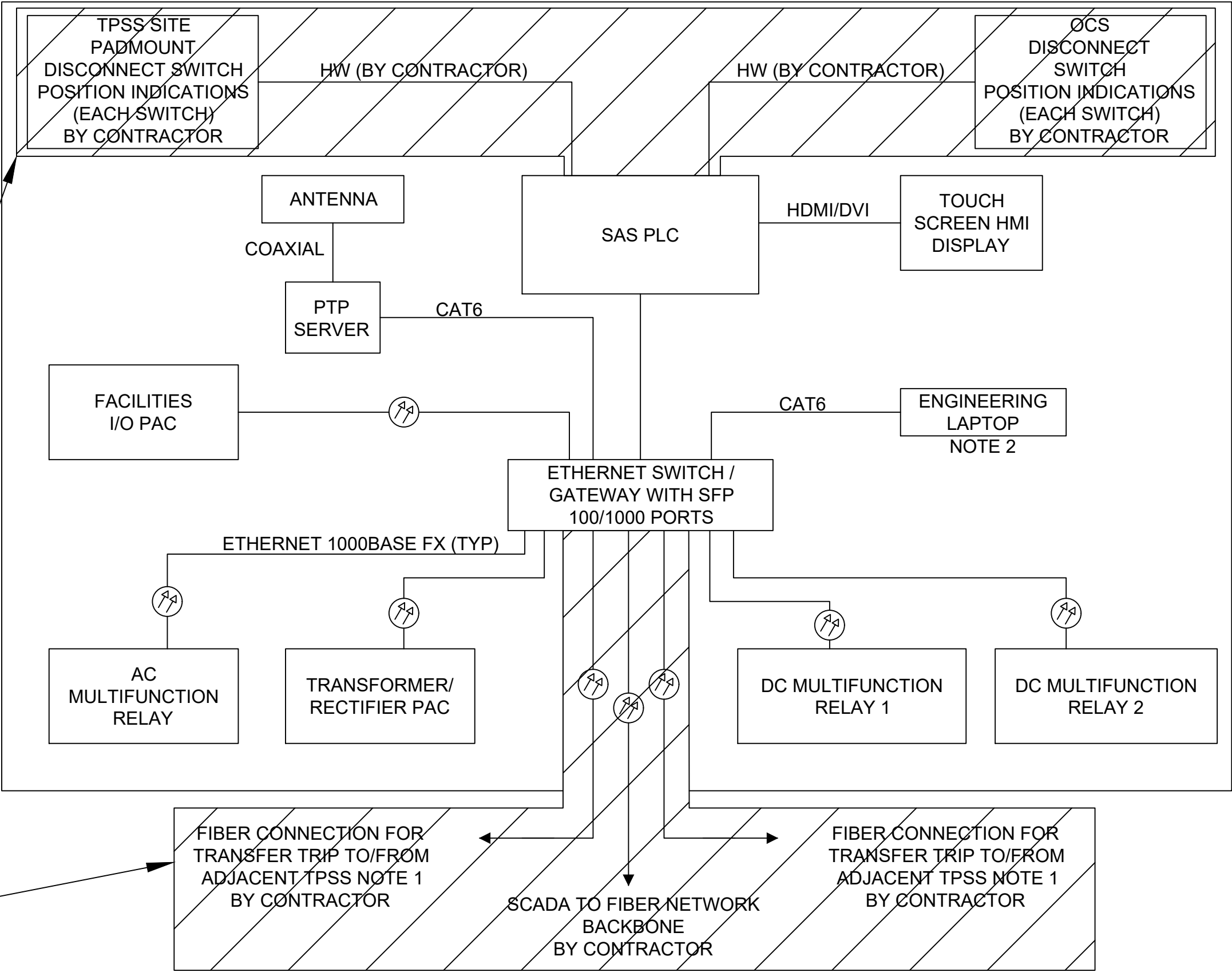


TOP VIEW
SCALE: NOT TO SCALE

- NOTES:
- SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 - FINAL DIMENSIONS AND CABINET CONFIGURATION SHALL BE DETERMINED BY VENDOR.

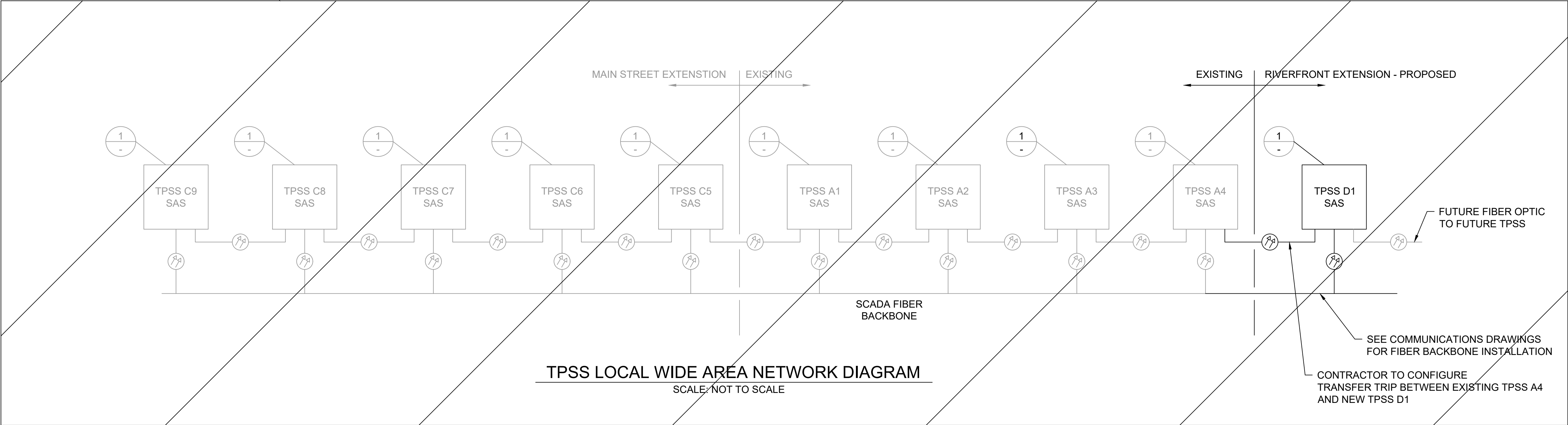
REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3 DATE: 01-24-2023  HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856  The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270 NOT FOR CONSTRUCTION <th data-cs="3" data-kind="parent">KANSAS CITY STREETCAR - RIVERFRONT EXTENSION</th><th data-kind="ghost"></th><th data-kind="ghost"></th><th data-cs="2" data-kind="parent">TRACTION POWER RAIL-TO-GROUND (R2G) CABINET TYPICAL LAYOUT</th><th data-kind="ghost"></th><th>SCALE FOR 22"x34": NOT TO SCALE FILENAME: J661.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.: J661</th>	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION			TRACTION POWER RAIL-TO-GROUND (R2G) CABINET TYPICAL LAYOUT		SCALE FOR 22"x34": NOT TO SCALE FILENAME: J661.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.: J661
			CHECKED BY	PGL								
			DRAWN BY	JDW								
			CHECKED BY	PGL								
			APPROVED BY	NKS								
PLOT DATE: 9/12/2022		5:34:18 PM	DATE	06/24/2022								

FOR INFORMATION ONLY
FOR USE BY INSTALLATION
CONTRACTOR



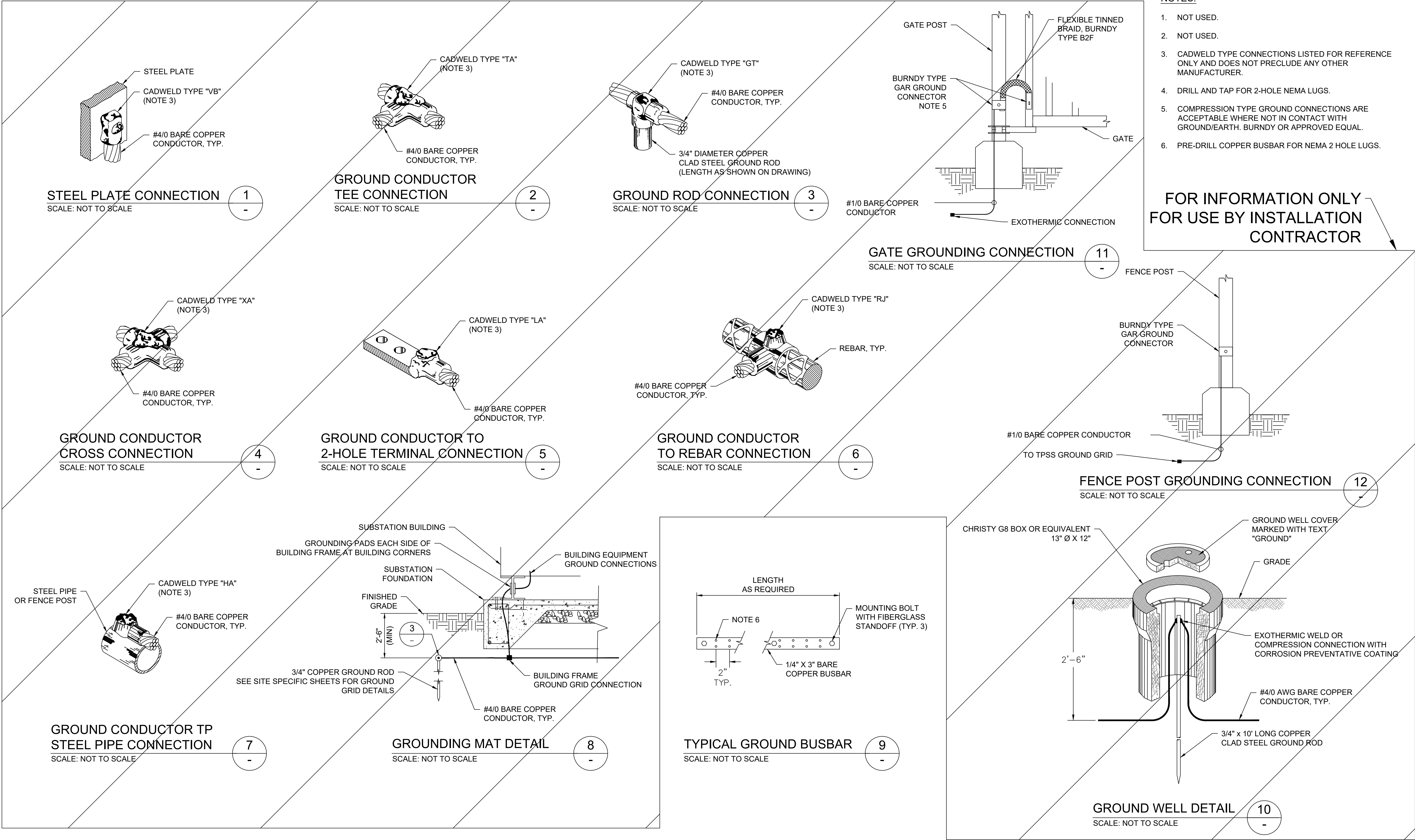
TYPICAL TPSS SAS LOCAL AREA NETWORK DIAGRAM 1
SCALE: NOT TO SCALE

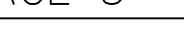
- NOTES:
- 1. CONTRACTOR SHALL CONFIGURE TRANSFER TRIP FUNCTION BETWEEN ADJACENT TPSS DC MULTIFUNCTION RELAYS USING THE COMMUNICATIONS SYSTEM FOR FIBER OPTIC CONNECTION. SEE SPECIFICATIONS FOR ADDITIONAL DETAILS.
 - 2. PROVIDE ONE ENGINEERING LAPTOP PER THE SPECIFICATIONS.



TPSS LOCAL WIDE AREA NETWORK DIAGRAM
SCALE: NOT TO SCALE

REV	DATE	DESCRIPTION	DESIGNED BY	JDW			EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER TPSS COMMUNICATIONS BLOCK DIAGRAM	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL			 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270			FILENAME:	
			DRAWN BY	JDW							CONTRACT NO.:	
			CHECKED BY	PGL							CONTRACT NO. ###	VOLUME:
			APPROVED BY	NKS							1	DRAWING NO.:
PLOT DATE: 1/17/2023			5:36:15 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION				SHEET NO.:	
											J665	



REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	TRACTION POWER TYPICAL GROUNDING DETAILS	SCALE FOR 22"x34": NOT TO SCALE FILENAME: J673.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.:	
			CHECKED BY	PGL									NOT FOR CONSTRUCTION
			DRAWN BY	JDW									
			CHECKED BY	PGL									
			APPROVED BY	NKS									
PLOT DATE: 9/12/2022			5:55:17 PM										DATE

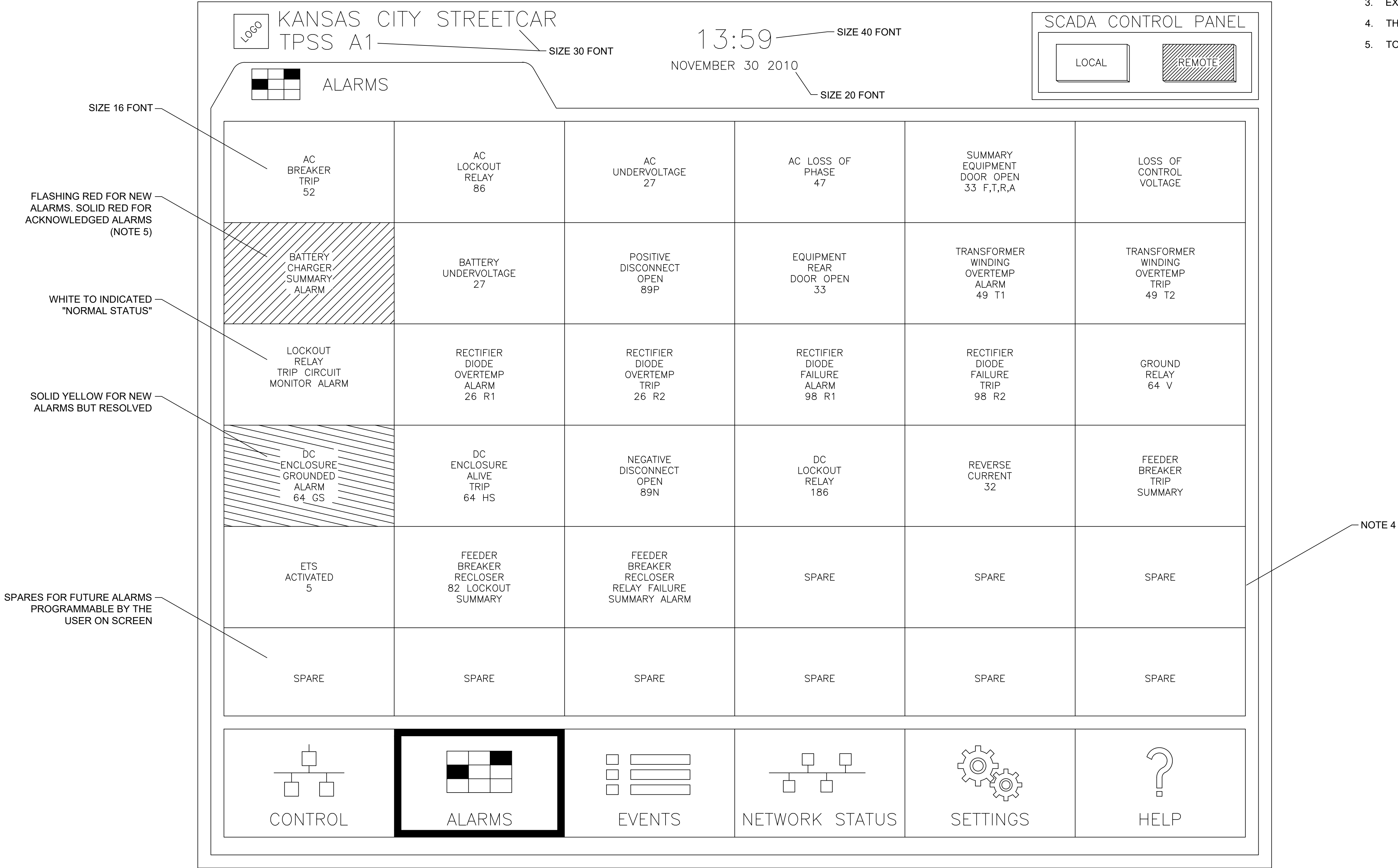
FOR INFORMATION ONLY
FOR USE BY INSTALLATION CONTRACTOR

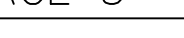
NOTES:
1. SEE SHEET J630 FOR TPSS D1 SITE RACEWAY LAYOUT.

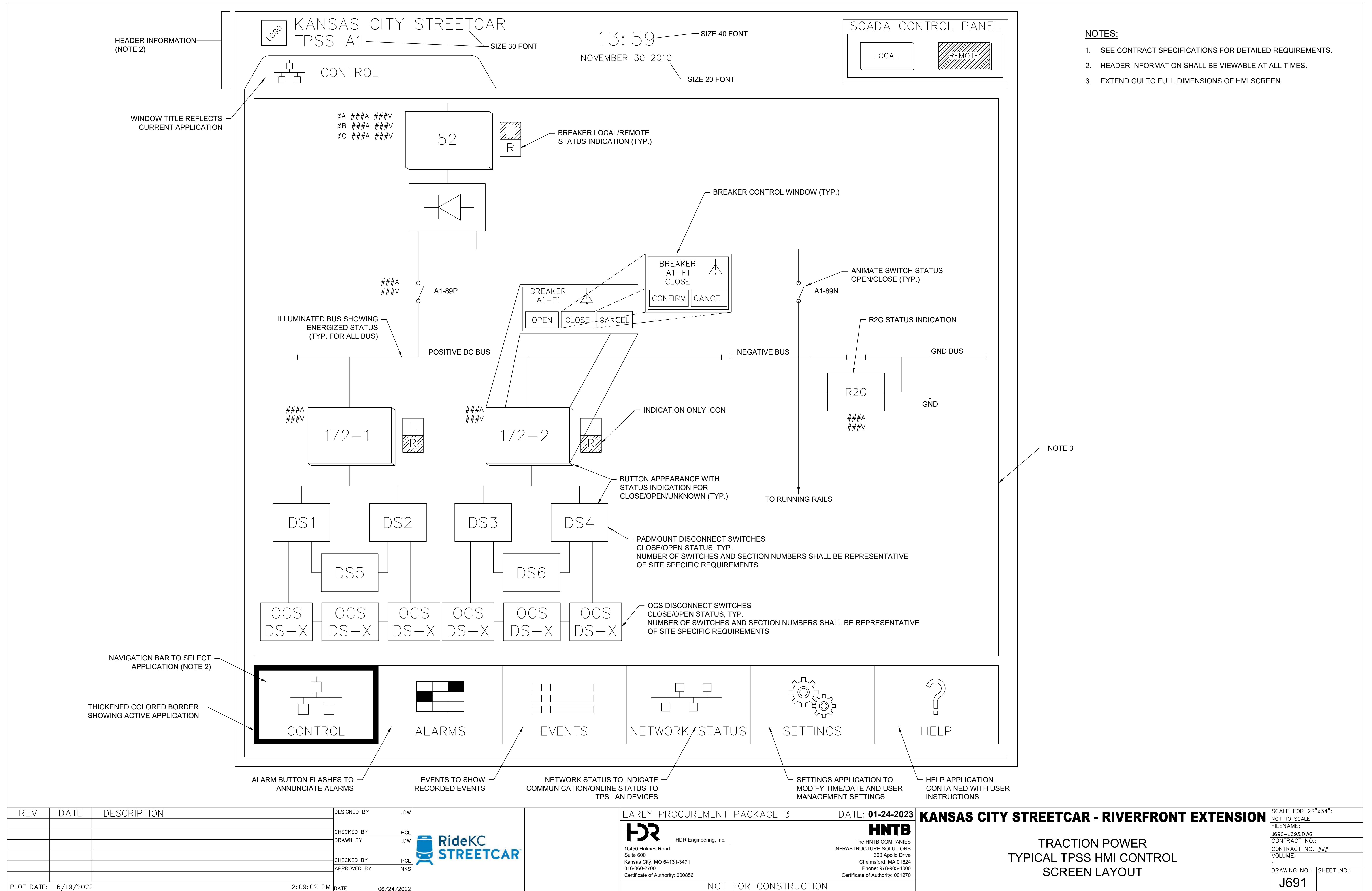
TPSS D1 - CONDUCTOR SCHEDULE											
FEEDER NUMBER	FROM	TO	VIA DUCTBANK/CONDUIT	DUCTBANK SECTION	CABLE DESCRIPTION					DRAWING NUMBER	COMMENTS
					QUANTITY	SIZE	TYPE	VOLTAGE RATING	TEMPERATURE RATING		
D1-PF1	D1-F1	D1-DS1	TPD-D1P1	2A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	POSITIVE FEEDER
	D1-DS1	TE-MH-D101	TPD-D1P5	2A / C404 10A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	
	TE-MH-D101	OCS FEEDER POLE R/34 (SB)			2	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-PF2	D1-F1	D1-DS2	TPD-D1P2	2A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	POSITIVE FEEDER
	D1-DS2	TE-MH-D101	TPD-D1P6	2A / C404 10A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	
	TE-MH-D101	OCS FEEDER POLE R/33 (NB)			2	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-PF3	D1-F2	D1-DS3	TPD-D1P3	2A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	POSITIVE FEEDER
	D1-DS3	TE-MH-D101	TPD-D1P7	2A / C404 10A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	
	TE-MH-D101	OCS FEEDER POLE R/34 (SB)			2	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-PF4	D1-F2	D1-DS4	TPD-D1P4	2A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	POSITIVE FEEDER
	D1-DS4	TE-MH-D101	TPD-D1P8	2A / C404 10A / C404	2	250 KCMIL	EPR	2000 V	90° C	J630	
	TE-MH-D101	OCS FEEDER POLE R/33 (NB)			2	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-NR1	DC NEGATIVE BUS	TE-MH-D102	TPD-D1N1	4A / C404	4	250 KCMIL	EPR	2000 V	90° C	J630	NEGATIVE RETURN
	TE-MH-D102	TRACK BLOCKOUT (SB)			4	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-NR2	DC NEGATIVE BUS	TE-MH-D102	TPD-D1N1	4A / C404	4	250 KCMIL	EPR	2000 V	90° C	J630	NEGATIVE RETURN
	TE-MH-D102	TRACK BLOCKOUT (NB)			4	250 KCMIL	EPR	2000 V	90° C		SEE SYSTEMWIDE ELECTRICAL PLAN
D1-HV1	FUSED LOAD BREAK FUSED /METERING CABINET	LOCAL UTILITY SECTIONALIZER SWITCHGEAR	TPD-D1U1	2A / C404	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	J630	COORDINATE CABLE AND DUCTBANK REQUIREMENTS WITH LOCAL UTILITY
D1-HV2	LOCAL UTILITY SECTIONALIZER SWITCHGEAR	LOCAL UTILITY MANHOLE / SPLICE	TPD-D1U2	2A / C404	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	BY LOCAL UTILITY	J630	COORDINATE CABLE AND DUCTBANK REQUIREMENTS WITH LOCAL UTILITY
D1-SS1	HMI PAC I/O MODULE	D1-DS1, D1-DS2, D1-DS3, D1-DS4, D1-DS5, D1-DS6 OPEN/CLOSE AUX CONTACTS	TPD-D1S1	2B / C404	2	12/C - #12 AWG	XLPE	600 V	90° C	J630	SWITCH STATUS INDICATIONS
FIBER	COMMUNICATIONS RACK	FIBER BACKBONE SEE COMMUNICATIONS PLANS	TPD-D1C1	2B / C404 4C / C404	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS	SEE COMMUNICATIONS PLANS

REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3	DATE: 01-24-2023	 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE FILENAME: J680.DWG CONTRACT NO.: CONTRACT NO. ### VOLUME: 1 DRAWING NO.: SHEET NO.:	
			CHECKED BY	PGL								
			DRAWN BY	JDW								
			CHECKED BY	PGL								
			APPROVED BY	NKS								
PLOT DATE: 1/17/2023			5: 29: 04 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION					J680

- NOTES:
- 1. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 - 2. HEADER INFORMATION SHALL BE VIEWABLE AT ALL TIMES.
 - 3. EXTEND GUI TO FULL DIMENSIONS OF HMI SCREEN.
 - 4. THERE SHALL BE A MINIMUM OF 36 WINDOWS.
 - 5. TOUCH WINDOW TO ACKNOWLEDGE ALARMS.



REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3		DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL		 HDR Engineering, Inc.				TRACTION POWER TYPICAL TPSS HMI ALARM SCREEN LAYOUT	FILENAME:
			DRAWN BY	JDW		10450 Holmes Road		INFRASTRUCTURE SOLUTIONS			J690-J693.DWG
						Suite 600		300 Apollo Drive			CONTRACT NO.:
			CHECKED BY	PGL		Kansas City, MO 64131-3471		Chelmsford, MA 01824			CONTRACT NO. ###
			APPROVED BY	NKS		816-360-2700		Phone: 978-905-4000			VOLUME:
PLOT DATE: 6/19/2022			2: 09: 02 PM			DATE	06/24/2022		1		
						NOT FOR CONSTRUCTION				DRAWING NO.: J690	
										SHEET NO.:	



- NOTES:
- 1. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 - 2. HEADER INFORMATION SHALL BE VIEWABLE AT ALL TIMES.
 - 3. EXTEND GUI TO FULL DIMENSIONS OF HMI SCREEN.

Logo

KANSAS CITY STREETCAR

TPSS A1

13:59

NOVEMBER 30 2010

SCADA CONTROL PANEL

LOCAL

REMOTE

EVENTS

NO.	EVENT	DESCRIPTION	TIME DATE	STATUS
1	AC BREAKER TRIP 52	OVER CURRENT 50/51	11:20:02 11/29/10	
2				
3				
4				
5				
6				
7				
8				
9				
10				

PRINT TO EXTERNAL PRINTER

EXPORT TO USB DRIVE

SCROLL BACK ONE PAGE

SCROLL BACK TO FIRST PAGE

PAGE BACK

EXPORT

PRINT

PAGE 1 OF 20

PAGE FORWARD

SCROLL FORWARD ONE PAGE

SCROLL FORWARD TO LAST PAGE

CONTROL

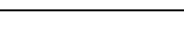
ALARMS

EVENTS

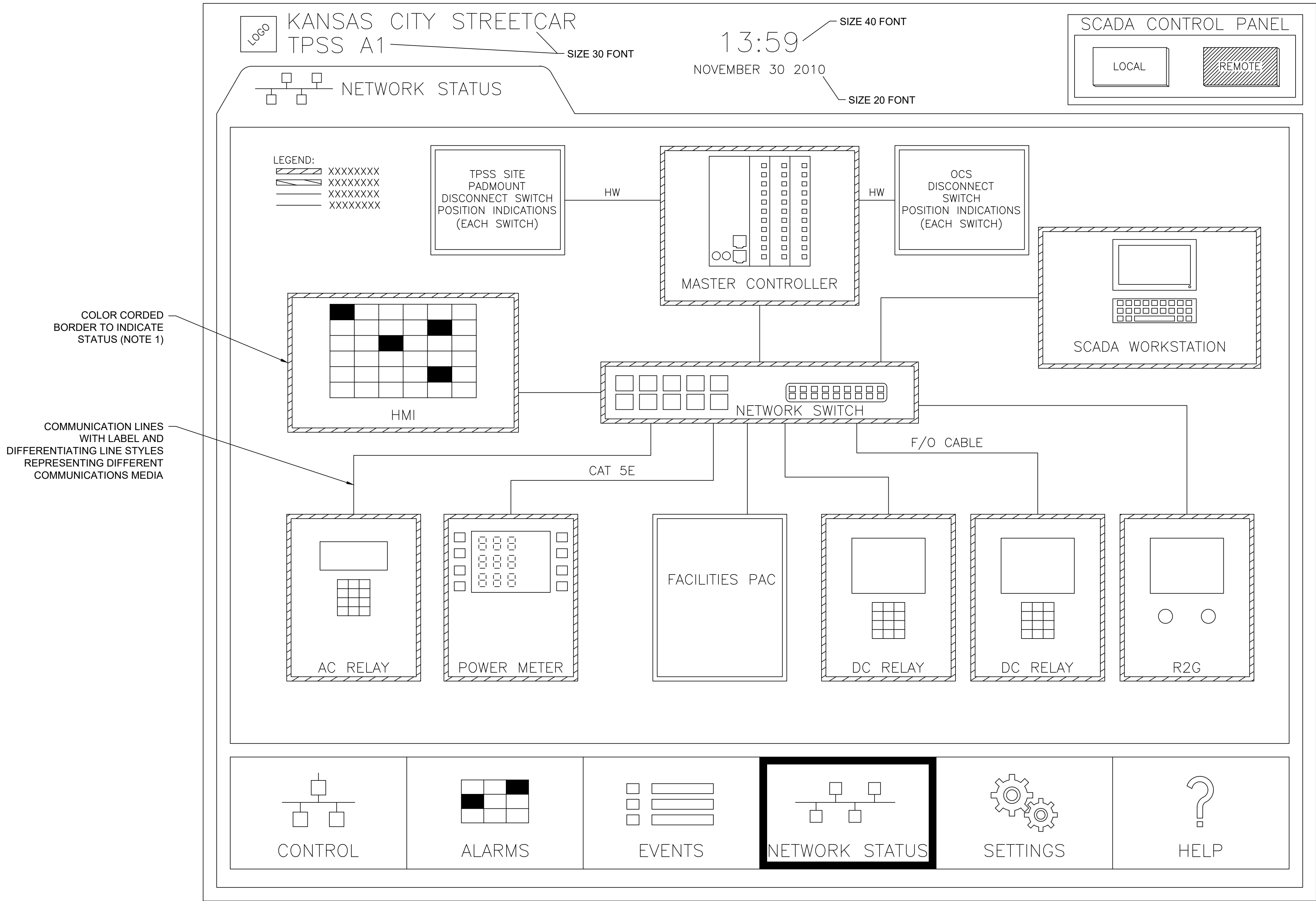
NETWORK STATUS

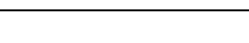
SETTINGS

HELP

REV	DATE	DESCRIPTION	DESIGNED BY	JDW			EARLY PROCUREMENT PACKAGE 3		DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE		
			CHECKED BY	PGL			 HDR Engineering, Inc.	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS	TRACTION POWER TYPICAL TPSS HMI EVENT LOG SCREEN LAYOUT		FILENAME:		
			DRAWN BY	JDW							10450 Holmes Road	300 Apollo Drive	J690-J693.DWG
			CHECKED BY	PGL							Suite 600	Chelmsford, MA 01824	CONTRACT NO.:
			APPROVED BY	NKS							Kansas City, MO 64131-3471	Phone: 978-905-4000	CONTRACT NO. ###
											816-360-2700	Certificate of Authority: 001270	VOLUME:
PLOT DATE: 6/19/2022			2: 09: 02 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION			DRAWING NO.: J692	SHEET NO.:		

- NOTES:
1. SEE CONTRACT SPECIFICATIONS FOR DETAILED REQUIREMENTS.
 2. HEADER INFORMATION SHALL BE VIEWABLE AT ALL TIMES.
 3. EXTEND GUI TO FULL DIMENSIONS OF HMI SCREEN.



REV	DATE	DESCRIPTION	DESIGNED BY	JDW		EARLY PROCUREMENT PACKAGE 3		DATE: 01-24-2023	KANSAS CITY STREETCAR - RIVERFRONT EXTENSION	SCALE FOR 22"x34": NOT TO SCALE	
			CHECKED BY	PGL		 HDR Engineering, Inc. 10450 Holmes Road Suite 600 Kansas City, MO 64131-3471 816-360-2700 Certificate of Authority: 000856	 The HNTB COMPANIES INFRASTRUCTURE SOLUTIONS 300 Apollo Drive Chelmsford, MA 01824 Phone: 978-905-4000 Certificate of Authority: 001270	TRACTION POWER TYPICAL TPSS HMI NETWORK STATUS SCREEN LAYOUT		FILENAME:	
			DRAWN BY	JDW						J690-J693.DWG	
			CHECKED BY	PGL						CONTRACT NO.:	
			APPROVED BY	NKS						CONTRACT NO. ###	
										VOLUME:	
PLOT DATE: 6/19/2022		2:09:02 PM		DATE	06/24/2022	NOT FOR CONSTRUCTION			DRAWING NO.:	SHEET NO.:	
										J693	