

Contract T202007301
REPLACEMENT OF BR 3-164 ON SR36 CEDAR BEACH ROAD

SPECIAL PROVISIONS

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851502-20	ALUMINUM LIGHTING SINGLE DAVIT ARM, 8' ARM SPREAD

401502 - ASPHALT CEMENT COST ADJUSTMENT

For Sections 304, 401, 402, 403, 404, and 405, payments to the Contractor shall be adjusted to reflect increases or decreases in the Delaware Posted Asphalt Cement Price when compared to the Project Asphalt Cement Base Price, as defined in these Special Provisions.

The Delaware Posted Asphalt Cement Price will be issued monthly by the Department and will be the industry posted price for Asphalt Cement, F.O.B. Philadelphia, Pennsylvania. The link for the posting is https://deldot.gov/Business/bids/index.shtml?dc=asphalt_cement_english.

The Project Asphalt Cement Base Price will be the Delaware Posted Asphalt Cement Price in effect on the date of advertisement.

All deviations of the Delaware Posted Asphalt Cement Price from the Project Asphalt Cement Base Price are eligible for cost adjustment. No minimum increases or decreases or corresponding percentages are required to qualify for cost adjustment.

Actual quantity of asphalt cement qualifying for any Asphalt Cement Cost Adjustment will be computed using the weight of eligible asphalt that is shown on the QA/QC pay sheets as a percentage for the delivered material.

If the mix was not inspected and no QA/QC pay sheet was generated, then the asphalt percentage will be obtained from the job mix formula for that mix ID. The asphalt percentage eligible for cost adjustment shall only be the virgin asphalt cement added to the mix.

There shall be no separate payment per ton cost of asphalt cement. That cost shall be included in the various unit prices bid per ton for those bid items that contain asphalt cement (mentioned above).

The Asphalt cement cost adjustment will be calculated on grade PG 64-22 asphalt regardless of the actual grade of asphalt used.

If the Contractor exceeds the authorized allotted completion time, the price of asphalt cement on the last authorized allotted workday, shall be the prices used for cost adjustment during the time liquidated damages are

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assessed. However, if the industry posted price for asphalt cement goes down, the asphalt-cement cost shall be adjusted downward accordingly.

NOTE:

Application of Asphalt Cement Cost Adjustment requirements as indicated above shall apply only to those contracts involving items related to bituminous base and pavements, and with bitumen, having a total of 1,000 tons or more of hot-mix bid quantity in case of Sections 401, 402 and 403; and 15,000 gallons or more in case of Sections 304, 404 and 405.

12/14/2020

401580 - RIDE QUALITY OF BITUMINOUS PAVEMENT

Description:

This specification outlines requirements for an acceptable ride surface in addition to requirements established in DelDOT Standard Specifications. The Contractor is responsible for providing smoothness characteristics that meet these requirements. The Contractor is responsible for providing equipment, maintenance of traffic (MOT) as required by the Delaware MUTCD, and performing testing in accordance to this specification. All costs for testing and MOT are incidental to this item. Both the International Roughness Index (IRI) and deviations located within a 10' straightedge are used to characterize smoothness in this Special Provision.

Definitions:

Class 1 Project - a project that consists of full depth construction. Full depth construction is considered to be when contract documents or modifications provide opportunity for preparation of the subgrade prior to paving.

Class 2 Project - a project that consists of a minimum of two smoothness opportunities.

Class 3 Project - a project that consists of one smoothness opportunity.

Deviation - a hump or depression that exceeds defined tolerances.

Smoothness Opportunity - a smoothness opportunity is considered to be any of the following; roadway milling, placement of a leveling course, in-place recycling, or placement of a lift of bituminous concrete. The final wearing surface is considered one smoothness opportunity.

Equipment:

The Contractor must have a 10' straightedge available during all paving operations.

The Contractor must also have a high speed or lightweight inertial profiling system that meets requirements of AASHTO M328 capable of collecting data in both wheelpaths simultaneously.

Prior to the start of corrective actions, the Contractor must provide to the Engineer:

1. Manufacturer, Make, and Model of the test system
2. Equipment Owner,
3. Relevant Certifications,
4. Manufacturer Calibration Procedures, and
5. Relevant Operator Training information.

Testing:

The Contractor is responsible for testing the pavement surface using an approved inertial profiler in accordance to manufacturer and AASHTO R57 from the start of paving limits to the end of pavement limits. Testing must be performed 3 times in each lane paved in the direction of traffic flow. Testing must be performed within seven (7) days of completion of project paving operations in each location.

The Contractor is responsible for providing information relative to locations that are to be excluded from calculation of the International Roughness Index. These areas must still meet 10' straightedge requirements.

Areas that are to be tested but will be removed prior to IRI analysis are:

1. 50 feet prior to the first bridge deck expansion joint and 50 feet after the last expansion joint if a bridge deck is excluded from smoothness operations.
2. 50' longitudinally from the center of an existing obstruction within the test area such as a manhole, water main, or catch basin that impedes paving operations.
3. 50' longitudinally from transverse joints that separate it from existing pavement not included on this contract.

Areas that are not to be profiled but are still subject to 10' straightedge requirements are:

1. Shoulder areas
2. Parking lots
3. Ramps, Streets, or Acceleration / Deceleration lanes less than 1000' in length.

Submission Requirements:

Test results must be submitted to the Engineer within five working days of completion of testing. Results not received within the allotted time frame will be assessed a charge of \$1,000.00 per day at the discretion of the Engineer.

The Contractor is required to submit summary table IRI reports from their test equipment for 1 run for each lane and direction of paving. This report must also include:

1. Profiling Company Name
2. Date of Test
3. Contract Number
4. Location Description
5. Testing Personnel

The Contractor is required to submit ERD files for each of the 3 tests run in each lane and direction of paving to the Engineer for analysis. The Contractor must provide to the Engineer written documentation indicating the start and end of bridges and the center of obstructions relative to the stationing used on the testing that are not subject to IRI analysis.

Acceptance and Payment:

Acceptance of the final pavement will be based on Engineer calculated IRI values using ProVAL software upon removal of allowable areas of exemption and the number of deviations found in the pavement surface. The IRI measurements will be calculated in 0.1 mile (528 foot) sections for payment purposes. The average value of the three test runs will be used and the average value will be rounded to the nearest tenth. Payments for each section will be based on estimated tonnage calculated from plan thickness and widths using the average maximum specific gravity ("Rice") for all surface mix used at that location.

Deviations equal to or in excess of 0.25" in 10' are to be corrected at the Contractor's expense or will have a discount charge of \$200.00 per deviation.

$$\text{Estimated Tonnage} = [L * W * T] * \text{Rice} * 62.4 \text{ (lb/ft}^3\text{)} * (0.0005 \text{ tons} / 12 \text{ in.})$$

Where: L = Length Segment (ft.)

W = Lane Width (ft.)

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T = Plan Thickness (in.)

$$IRI \text{ Incentive / Disincentive} = \text{Estimated Tonnage} * UP * (PA-100)/100$$

Where: UP = Contract Unit Price (Dollars)

PA = Pay Adjustment (Table A)

The total pay adjustment for paving work performed on each location is:

$$(\sum IRI \text{ adj for each section}) - \text{Total Deviations} * 200$$

It is possible to receive incentive for IRI measurements and a discount charge for excessive deviations on the same project. If a 528' section has an IRI value resulting in a deduction of at least 84% of the section pay, the deviation discount charge for that section is disregarded and the IRI discount charge is the only action taken for that section.

Table A: Payment Adjustments for IRI	
Class 1	
IRI per 0.1 mile Segment (in./mi.)	Pay Adjustment
≤ 50	103%
$> 50 \text{ and } < 145$	$100 + 0.2(65 - IRI)$
≥ 145	84%
Class 2	
IRI per 0.1 mile Segment (in./mi.)	Pay Adjustment
≤ 60	106%
$> 60 \text{ and } < 170$	$100 + 0.2(90 - IRI)$
≥ 170	84%

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Correction to the paving surface, such as diamond grinding with approved equipment, patching, or other measures may be taken at the Contractor's expense and at the Engineers discretion to correct pavement surfaces assessed a discount charge. The Engineer may require corrective actions including remove & replace if the deviation discount charge exceeds 50% of the cost of materials or the IRI pay adjustment is 84%. Deviations must be corrected if it is determined that they are at a height or depth that may create a safety concern.

4/10/2019

401699 - QUALITY CONTROL/QUALITY ASSURANCE OF BITUMINOUS CONCRETE

.01 Description

This item shall govern the Quality Assurance Testing for supplying bituminous asphalt plant materials and constructing bituminous asphalt pavements and the calculation for incentives and disincentives for materials and construction. The Engineer will evaluate all materials and construction for acceptance. The procedures for acceptance are described in this Section. Include the costs for all materials, labor, equipment, tools, and incidentals necessary to meet the requirements of this specification in the bid price per ton for the bituminous asphalt. Payment to the Contractor for the bituminous asphalt item(s) will be based on the Contract price per ton and the pay adjustments described in this specification.

.02 Bituminous Concrete Production – Quality Acceptance

(a) Material Production - Tests and Evaluations.

All acceptance tests shall be performed by qualified technicians at qualified laboratories following AASHTO or DelDOT procedures and shall be evaluated using Quality Level Analysis. The Engineer will conduct acceptance tests. The Engineer will directly base acceptance on the acceptance test results, the asphalt cement quality, the Contractor's QC Plan work, and the comparisons of the acceptance test results to the QC test results. The Engineer may elect to utilize test results of the Contractor in some situations toward judging acceptance.

Supply and capture samples, as directed by the Engineer under the purview of the Engineer from delivery trucks before the trucks leave the production plant. Hand samples to the Engineer to be marked accordingly. The sample shall represent the material produced by the Contractor and shall be of sufficient size to allow the Engineer to complete all required acceptance tests. The Engineer will direct the Contractor when to capture these samples, on a statistically random, unbiased basis, established before production begins each day based upon the anticipated production tonnage. The captured sample shall be from the Engineer specified delivery truck. The Contractor may visually inspect the specified delivery load during sampling and elect to reject the load. If the contractor elects to reject the specified delivery truck, each subsequent load will be inspected until a visually acceptable load is produced for acceptance testing. All visually rejected loads shall not be sent to a Department project.

The first sample of the production day will be randomly generated by the Engineer between loads 0 and 12 (0-250 tons). Subsequent samples will be randomly generated by the Engineer on 500-ton sub-lots for the production day. Samples not retrieved in accordance with the Contractor's QC plan will be deemed unacceptable and may be a basis for rejection of material produced. Parallel tests or dispute resolution tests will only be performed on material captured at the same time and location as the acceptance test sample. Parallel test samples or Dispute Resolution samples will be created by splitting a large sample or obtaining multiple samples that equally represent the material. The Engineer will perform all splitting and handling of material after it is obtained by the Contractor.

The Contractor may retain dispute resolution samples or perform parallel tests with the Engineer on any acceptance sample.

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The Engineer will evaluate and accept the material on a lot basis. All the material within a lot shall have the same JMF (mixture ID). The lot size shall be targeted for 2000 tons or a maximum period of three days, whichever is reached first. If the 2000th ton target lot size is achieved during a production day, the lot size shall extend to the end of that production day. The Contractor may interrupt the production of one JMF in order to produce different material; this type of interruption will not alter the determination of the size or limits of material represented by a lot. The Engineer will evaluate each lot on a subplot basis. The size for each subplot shall be 100 to 500 tons and testing for the sub lots will be completed on a daily basis. For each subplot, the Engineer will evaluate one sample.

The target size of sub-lots within each lot, except for the first sample of the production day, is equal-sized 500 ton sub lots and will be based upon anticipated production, however, more or fewer sublots, with differing sizes, may result due to the production schedule and conditions. If the actual production is less than anticipated, and it's determined a sample will not be obtained (based upon the anticipated tonnage), a new sample location will be determined on a statistically random, unbiased basis based upon the new actual production. If the actual production is going to be 50 tons or greater over the anticipated sub lot production, a new sample location will be determined on a statistically random, unbiased basis based upon the new actual production. The Engineer will combine the evaluation and test results for all of the applicable sublots in order to evaluate each individual lot.

If the Engineer is present, and the quantity exceeds 25 tons, a statistically random sample will be used for analysis. When the anticipated production is less than 100 tons and greater than 25 tons, and the Engineer is not present, the contractor shall randomly select a sample using the Engineer's random location program. The captured sample shall be placed in a suitable box, marked to the attention of the Engineer, and submitted to the Engineer for testing. A box sample shall also be obtained by the contractor at the same time and will be used as the Dispute Resolution sample if requested by the Engineer. The Contractor shall also obtain one liquid asphalt sample (1 pint) per grade of asphalt used per day and properly label it with all pertinent information.

The Engineer will conduct the following tests in order to characterize the material for the pavement compaction quality and to judge acceptance and the pay adjustment for the material:

- AASHTO T312 - Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
- AASHTO T166, Method C (Rapid Method) - Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface Dry Specimens
- AASHTO T308 - Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
- AASHTO T30 - Mechanical Analysis of Extracted Aggregate
- AASHTO T209 - Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt (HMA)
- ASTM D7227 - Standard Practice for Rapid Drying of Compacted Asphalt Specimens using Vacuum Drying Apparatus

(b) Pavement Construction - Tests and Evaluations.

The Engineer will directly base acceptance on the compaction acceptance test results, and on the inspection of the construction, the Contractor's QC Plan work, ride smoothness as referenced in the contract documents, lift thickness as referenced in the contract documents, joint quality as referenced in the contract documents, surface texture as referenced in the contract documents, and possibly the comparisons of the acceptance test results to the independent test results. For the compaction acceptance testing, the Engineer will sample the work on a statistically random basis and will test and evaluate the work based on daily production.

Notify the Engineer of any locations within that road segment that may not be suitable to achieve minimum (93%) compaction due to existing conditions prior to paving the road segment. Schedule and hold a meeting in the field with the Engineer in order to discuss all areas that may potentially be applicable to Table 5a before paving starts. Areas that will be considered for Table 5a will be investigated in accordance to the method described in Appendix B. If this meeting is not held prior to paving, no areas will be considered for Table 5a. Areas of allowable exemptions that will not be cored include the following: partial-depth patch areas, driveway entrances, paving locations of less than 100 tons, areas around manholes and driveway entrances, and areas of paving that are under 400 feet in continuous total length and/or 5 feet in width.

The exempt areas around manholes will be a maximum of 4 feet transversely on either side from the center of the manhole, and 20 feet longitudinally on either side from the center of the manhole. The exempt areas around driveway entrances shall be the entire width of the driveway, and 3 feet from the edge of the longitudinal joint next to the driveway. Areas of exemption that will be cored for informational purposes only include: areas where the mat thickness is less than three times the nominal maximum aggregate size as directed by the Engineer, violations of Section 401.08 in the Standard Specifications as directed by the Engineer, and areas shown to contain questionable subgrade properties as proven by substantial yielding under a fully legally loaded truck. Failure to obtain core samples in these areas will result in zero payment for compaction regardless of the exempt status.

The Engineer will evaluate and accept the compaction work on a daily basis. Payment for the compaction will be calculated by using the material production lots as referenced in **.02 Acceptance Plan (a) Material Production - B Tests and Evaluation** and analyzing the compaction results over the individual days covered in the material production lot. The compaction results will be combined with the material results to obtain a payment for this item.

The minimum size of a compaction lot shall be 100 tons. If the compaction lot is between 101 and 1000 tons, the Engineer shall randomly determine four compaction acceptance test locations. If the compaction lot is between 1001 and 1500 tons, the Engineer shall randomly determine six compaction acceptance test locations. If the compaction lot is between 1501 and 2000 tons, the Engineer shall randomly determine eight compaction acceptance test locations. If the compaction lot is greater than 2000 tons, the Engineer shall randomly determine two compaction acceptance test locations per 500 tons.

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If a randomly selected area falls within an Engineer approved exemption area, the Engineer will select one more randomly generated location to be tested per the requirements of this Specification. If that cannot be accomplished, or if an entire location has been declared exempt, the compaction testing shall be performed as per these Specifications, but a note will be added to the results that the location was an Engineer approved exempt location.

Testing locations will be a minimum of 1.0 feet from the newly placed longitudinal joint and 50 feet from a new transverse joint. Cut one six (6) inch diameter core through the full lift depth at the exact location marked by the Engineer. Cores submitted that are not from the location designated by the Engineer will not be tested and will be paid at zero pay.

Notify the Engineer prior to starting paving operations with approximate tonnage to be placed. The Contractor is then responsible for notifying the appropriate Engineer test personnel within 12 hours of material placement. The Engineer will mark core locations within 24 hours of notification. After determination of locations, the Contractor shall complete testing within two operational days of the locations being marked. If the cores are not cut within two operational days, the area in question will be paid at zero pay for compaction testing.

Provide any traffic control required for the structural number investigation, sampling, and testing work at no additional cost to the Department.

Commence coring of the pavement after the pavement has cooled to a temperature of 140°F or less. Cut each core with care in order to prevent damaging the core. Damaged cores will not be tested. Label each core with contract number, date of construction, and number XX of XX upon removal from the roadway. Place cores in a 6-inch diameter plastic concrete cylinder mold or approved substitute for protection. Separate cores in the same cylinder mold with paper. Attach a completed QC test record for the represented area with the corresponding cores. The Engineer will also complete a test record for areas tested for the QA report and provide to Materials & Research. Deliver the cores to the Engineer for testing, processing, and report distribution at the end of each production day. Repair core holes per Appendix A, Repairing Core Holes in Bituminous Asphalt Pavements. Core holes shall be filled immediately. Failure to repair core holes at the time of coring will result in zero pay for compaction testing for the area in question.

The Engineer will conduct the following tests on the applicable portion of the cores in order to evaluate their quality:

- AASHTO T166, Method C (Rapid Method) B Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface Dry Specimens
- AASHTO T209 - Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt
- ASTM D7227 - Standard Practice for Rapid Drying of Compacted Asphalt Specimens using Vacuum Drying Apparatus

The Engineer will use the average of the last five test values of the same JMF (mixture ID) material at the production plant in order to calculate the average theoretical maximum specific gravity of the cores. The average will be based on the production days test results and as many test results needed from previous days production to have an average of five samples. If there are less than five values available, the Engineer will use the JMF design value in addition to the available values to calculate the average theoretical maximum specific gravity.

.03 Payment and Pay Adjustment Factors

The Engineer will determine pay adjustments for the bituminous asphalt item(s) in accordance with this specification. The Engineer will determine a pay adjustment factor for the material produced and a pay adjustment factor for the pavement construction. Pay adjustments for material and construction will be calculated independently. When the pay adjustment calculation for either material or construction falls to zero payment per tables 4, 5, or 5a, the maximum pay adjustment for the other factor will not exceed 100.

Pay Adjustment factors will only be calculated on in place material. Removed material will not be used in payment adjustment calculations. Material Production Pay Adjustments will be calculated based upon 70% of the contract unit price and calculated according to section .03(a) of this specification. Pavement construction Pay Adjustments will be calculated based upon 30% of the contract unit price and calculated according to section .03(b) of this specification.

(a) Material Production - Pay Adjustment.

Calculate the material pay adjustment by evaluating the production material based on the following parameters:

Table 2 - Material Parameter Weight Factors		
Material Parameter	Single Test Tolerance (+/-)	Weight Factor
Asphalt Content	0.4	0.30
#8 Sieve (≥ 19.0 mm)	7.0	0.30
#8 Sieve (≤ 12.5 mm)	5.0	0.30
#200 Sieve (0.075mm Sieve)	2.0	0.30
Air Voids (4.0% Target)	2.0	0.10

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Using the JMF target value, the single test tolerance (from Table 2), and the test values, the Engineer will use the following steps to determine the material pay adjustment factor for each lot of material:

1. For each parameter, calculate the mean value and the standard deviation of the test values for the lot to the nearest 0.1 unit.
2. For each parameter, calculate the Upper Quality Index (QU):
$$QU = ((\text{JMF target}) + (\text{single test tolerance}) - (\text{mean value})) / (\text{standard deviation}).$$
3. For each parameter, calculate the Lower Quality Index (QL):
$$QL = ((\text{mean value}) - (\text{JMF target}) + (\text{single test tolerance})) / (\text{standard deviation}).$$
4. For each parameter, locate the values for the Upper Payment Limit (PU) and the Lower Payment Limit (PL) from Table 3 - Quality Level Analysis by the Standard Deviation Method. (Use the column for "n" representing the number of sublots in the lot. Use the closest value on the table when the exact value is not listed).
5. Calculate the PWL for each parameter from the values located in the previous step:
$$PWL = PU + PL - 100.$$
6. Calculate each parameter's contribution to the payment adjustment by multiplying its PWL by the weight factor shown in Table 2 for that parameter.
7. Add the calculated adjustments of all the parameters together to determine the Composite PWL for the lot.
8. From Table 4, locate the value of the Pay Adjustment Factor corresponding to the calculated PWL. When all properties of a single test are within the single test tolerance of Table 2, Pay Adjustment factors shall be determined by Column B. When any property of a single test is outside of the Single Test Tolerance parameters defined in Table 2, the Material Pay Adjustment factor shall be determined by Column C.
9. For each lot, determine the final material price adjustment:

Final Material Pay Adjustment =

(Lot Quantity) x (Item Bid Price) x (Pay Adjustment Factor) x 70%. This final pay calculation will be paid to the cent.

In lieu of being assessed a pay adjustment penalty, the Contractor may choose to remove and replace the material at no additional cost to the Department. When the PWL of any material parameter in Table 2 is below 60, the Engineer may require the removal and replacement of the material at no additional cost to the Department. Test results on removed material shall not be used in calculation of future PWL calculations for Mixture ID.

The test results from the Engineer on production that is less than 100 tons will be combined with the two most recently completed Engineer tests with the same Mixture ID to calculate payment for the lot encompassing the single test. If that cannot be accomplished, the approved JMF will be used to calculate payment for the lot encompassing the single test. Payment for previously closed lots will not be affected by the analysis.

When a sample is outside of the allowable single test tolerance for any Materials criteria in Table 2, that sample will be isolated. For payment purposes, the test result of the out of acceptable tolerance sample will be combined with the two previous acceptable samples of the same JMF and analyzed per this specification. The material that is considered out of the acceptable tolerance will only include the material within the represented sub-lot (i.e., a maximum of 500 tons). If the previous acceptable test result is from the previous production day, only the material produced on the second production day will be considered out of tolerance. All future sub lots will not include the isolated test. The pay factors for the out of tolerance sample lot will be calculated using column C of table 4.

If, during production, a QA sample test result does not meet the acceptable tolerances and the Contractors QC sample duplicates the QA sample test result, the Contractor can make an appropriate change to the mixture (within the JMF boundaries), and request to have that sample further isolated. After the Contractor has made appropriate changes, the Contractor will visually inspect each produced load. The first visually acceptable load will be sampled and tested. If that sample test result shows compliance with the specifications, the material that is considered out of the acceptable tolerance will include the material from the previous acceptable test result to the third load after the initially sampled and tested sample. If the sample does not meet the specification requirements, the Engineer will no longer accept material. Production may resume when changes have been made and an acceptable sample and test result is obtained.

Table 3 B Quality Level Analysis by the Standard Deviation Method							
PU or PL	QU and QL for An@ Samples						
	n = 3	n = 4	n = 5	n = 6	n = 7	n = 8	n = 9
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53
99	-	1.47	1.67	1.80	1.89	1.95	2.00
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84
97	-	1.41	1.54	1.62	1.67	1.70	1.72
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63

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95	-	1.35	1.44	1.49	1.52	1.54	1.55
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48
93	-	1.29	1.35	1.38	1.40	1.41	1.42
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21
88	1.07	1.14	1.15	1.16	1.16	1.16	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93
81	0.96	0.93	0.91	0.90	0.90	0.89	0.89
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79

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77	0.87	0.81	0.78	0.77	0.76	0.76	0.76
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66
73	0.75	0.69	0.66	0.65	0.64	0.63	0.63
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32

Table 3 B Quality Level Analysis by the Standard Deviation Method							
PU or PL	QU and QL for An@ Samples						
	n = 3	n = 4	n = 5	n = 6	n = 7	n = 8	n = 9
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24

Table 4 - PWL Pay Adjustment Factors		
PWL	Pay Adjustment Factor (%) Column B	Pay Adjustment Factor (%) Column C
100	+5	0
99	+4	-1
98	+3	-2
97	+2	-3
96	+1	-4
95	0	-5
94	-1	-6
93	-2	-7
92	-3	-8
91	-4	-9
PWL<91	PWL - 100	PWL - 100

(b) Pavement Construction - Pay Adjustments.

The Engineer will determine the pavement construction pay adjustment by evaluating the construction of the pavement, based on the following parameter:

- Degree of compaction of the in-place material

Using the test values for the cores, the Engineer will use the following steps to determine the pavement construction pay adjustment for each lot of work.

1. Calculate the core bulk specific gravity values from the subplot tests values, to the nearest 0.001 unit. Obtain the Theoretical maximum Specific Gravity values from the corresponding laboratory subplot tests.
2. Calculate the Degree of Compaction:

Degree of Compaction =

$$((\text{Core Bulk Specific Gravity}) / (\text{Theoretical Maximum Specific Gravity})) \times 100\%$$
 recorded to the nearest 0.1%.
3. The average compaction for the sublots shall be averaged together for the compaction level of the lot. The lots compaction test level shall be averaged and recorded to the nearest whole percent.
4. Locate the value of the Payment Adjustment Factor corresponding to the calculated degree of compaction from Table 5 or Table 5a.
5. Determine the pavement construction price adjustment by using the following formula:

Construction Pay adjustment = (Lot Quantity) x (Bid Price) x (Pay Adjustment Factor) x 30%.

Table 5: Compaction Price Adjustment Highway Locations		
Degree of Compaction (%)	Range	Pay Adjustment Factor (%)
≥ 97.0	≥ 96.75	-100*
96.5	96.26 – 96.74	-5
96.0	95.75 – 96.25	-3
95.5	95.26 – 95.74	-2
95.0	94.75 – 95.25	0
94.5	94.26 – 94.74	0
94.0	93.75 – 94.25	1
93.5	93.26 – 93.74	3
93.0	92.75 – 93.25	5
92.5	92.26 – 92.74	3
92.0	91.75 – 92.25	0

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91.5	91.26 – 91.74	0
91.0	90.75 – 91.25	-5
90.5	90.26 – 90.74	-15
90.0	89.75 – 90.25	-20
89.5	89.26 – 89.74	-25
89.0	88.75 – 89.25	-30
88.5	88.26 – 88.74	-50
=<88.0	=<88.25	-100*

* or remove and replace it at Engineer's discretion

Table 5A: Compaction Price Adjustment Other¹ Locations

Degree of Compaction	Range	Pay Adjustment Factor (%)
>= 97.0	>= 96.75	-100*
96.5	96.26 – 96.74	-5
96.0	95.75 – 96.25	-3
95.5	95.26 – 95.74	-2
95.0	94.75 – 95.25	0
94.5	94.26 – 94.74	0
94.0	93.75 – 94.25	0
93.5	93.26 – 93.74	1
93.0	92.75 – 93.25	3
92.5	92.26 – 92.74	1
92.0	91.75 – 92.25	0
91.5	91.26 – 91.74	0
91.0	90.75 – 91.25	0
90.5	90.26 – 90.74	0
90.0	89.75 – 90.25	0
89.5	89.26 – 89.74	0
89.0	88.75 – 89.25	-1
88.5	88.26 – 88.74	-3
88.0	87.75 – 88.25	-5
87.5	87.26 – 87.74	-10
87.0	86.75 – 87.25	-15
86.5	86.26 – 86.74	-20

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86.0	85.75 – 86.25	-25
85.5	85.26 – 85.74	-30
85.0	84.75 – 85.25	-40
84.5	84.26 – 84.74	-50
≤ 84.0	≤ 84.25	-100*

* or remove and replace at Engineer's discretion

¹ This chart is to be used for areas where the structural value of the area to be paved is less than 1.75 as determined by the Engineer. See Appendix B - Method for Obtaining Cores for Determination of Roadway Structure. This chart is applicable to rehabilitation work only; full depth construction will not be considered for Table 5a.

.04 Dispute Resolution

Disputes or questions about any test result shall be brought to the attention of the Contractor and the Engineer within two operational days of reported test results. The following dispute resolution procedures will be used. The Engineer and the Contractor will review the sample quality, the test method, the laboratory equipment, and the laboratory technician. If these factors are not the cause of the dispute, a third-party dispute resolution will be used.

Third party resolution testing can be performed at either another Contractor's laboratory, the Engineer's laboratory, or an independent accredited laboratory. Unless otherwise mutually agreed upon by DAPA and the Engineer, the Engineer's qualified laboratory in Dover and qualified personnel shall conduct the necessary testing for third party Dispute Resolution after the Engineer has provided reasonable notice to allow the Contractor to witness this testing. When disputes over production testing occur, the samples used for Dispute Resolution testing will be those samples properly captured, labeled, and stored, as described in the second paragraph of the section of these specifications titled **.02 Acceptance Plan, (a) Material Production - Tests and Evaluations**. If no samples are available, the original testing results will be used for payment calculations.

Dispute Resolution samples for air void content will be heated by a microwave oven.

If there is a discrepancy between the Engineer's acceptance test result and the Contractor's test result, the Contractor may ask for the Dispute Resolution sample to be tested. The Contractor may request up to two dispute resolution samples be tested per calendar year without charge. Any additional Dispute Resolution samples run at the Contractor's request where the results substantiate the acceptance test result will be assessed a fee of \$125. Any additional Dispute Resolution samples that substantiate the Contractor's test result will not be assessed the fee.

When disputes over compaction core test results occur, the Engineer's acceptance core will be used for the dispute resolution sample. The Contractor will be advised on when the testing will occur as referenced above to witness the testing. The results of the dispute resolution testing shall replace all of the applicable disputed test results for payment purposes.

Appendix A - Repairing Core Holes in Bituminous Asphalt Pavement

Description.

This appendix describes the procedure required to repair core holes in a bituminous concrete pavement.

Materials and Equipment.

The following material shall be available to complete this work:

- Patch Material - DelDOT approved High Performance Cold Patch material shall be used.

The following equipment shall be available to complete this work:

- Sponge or other absorbent material - Used to extract water from the hole.
- Compaction Hammer - mechanical (electrical, pneumatic, or gasoline driven) tamping device with a flat, circular tamping face smaller than 6 inches in diameter.

Construction Method.

After core removal from the hole, remove all excess water from within the hole, and prevent water from re-entering the hole.

Place the patch material in lifts no greater than 3 inches and compact with mechanical tamping device. If the hole is deeper than 3 inches, use two lifts of approximately equal depths so that optimum compaction is achieved. Make sure that the patch surface matches the grade of the existing roadway. Make every effort to achieve the greatest possible compaction

Performance Requirements.

The Engineer will judge the patch on the following basis:

- The patch shall be well compacted

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- The patch surface shall match the grade of the surrounding roadway surface.

Basis of Payment.

No measurement or payment will be made for the patching work. The Contractor must gain the Engineer's acceptance of the patching work before the Engineer will accept the material represented by the core.

Appendix B - Method for Obtaining Cores for Determination of Roadway Structure

The Contractor is responsible for obtaining cores in areas that they propose are eligible for compaction price adjustments according to Table 5a in this specification. Table 5a is not applicable for new full-depth pavement box construction. Cores submitted for this process shall be obtained according to the following process.

1. Contact Materials & Research (M&R) personnel to determine if information about the area is already available. If M&R has already obtained cores in the location that is being investigated, the contractor may opt to use the laboratory information for the investigation and not core the area on their own.
2. If M&R does not have information concerning the section of the roadway, the contractor needs to contact M&R to arrange for verification of coring operations. Arrangements shall be made to allow for an individual from M&R to be on the site when the cores are obtained. Cores will be turned over to M&R for evaluation.
3. The Contractor is responsible for providing all traffic control and repairing core holes in accordance to 401699 Appendix A - Repairing Core Holes in Bituminous Asphalt Pavements.
4. Cores are to be taken throughout the entire project for the area in question. Cores will be spaced, from the start of the project in increments determined based on field and project specifics. Cores will be evenly distributed throughout the project location. The cores will be taken in the center of the lane in question.
5. Additional cores may be taken at other locations, if surface conditions indicate that there may be a substantial difference in the underlying section. The location of these cores should be documented and submitted to M&R.
6. Cores shall be full depth and include underlying materials. If there is a stone base included in the pavement section, at a minimum 1 core must have information concerning the thickness of the base. This is determined by augering to the subgrade surface.
7. The calculations used to determine the structural capacity of the roadway is as follows. If the contractor finds, upon starting the coring process, that the areas are of greater thickness than applicable to Table 5a, they may terminate the coring process on their own and retract the request.

Structural Number Calculations

Each pavement box material is assigned a structural coefficient based upon AASHTO design guides. The structural coefficient is used to determine the total strength of the pavement section.

Materials used in older pavement sections are assigned lower structural coefficients to compensate for aging of the materials. The coefficients used to determine the structural number of an existing pavement are:

Existing Material	Structural Coefficient
HMA	0.32
Asphalt Treated Base	0.26
Soil Cement	0.16
Surface Treatment (Tar & Chip)	0.10
GABC	0.14
Concrete	0 - 0.7*

- * The Structural Coefficient of Concrete is dependent upon the condition of the concrete. Compressive strengths & ASR analysis are used to determine condition - contact the Engineer if this situation arises.

Newly placed materials use a different set of structural coefficients. They are as follows:

New Material	Structural Coefficient
HMA	0.40
Asphalt Treated Base (BCBC)	0.32
Soil Cement	0.20
GABC	0.14

Example:

Location includes placement of a 1.25" Type C overlay on 2.25" Type B. Existing roadway is cored and is shown to consist of 2" HMA on 7" GABC.

Calculation:

For the Type B lift the calculation would be:

Existing HMA	$2 * 0.32$	=	0.64
GABC	$7 * 0.14$	=	0.98
			<u>1.62</u>

For the Type C lift the calculation would be:

Newly Placed B	$2.25 * 0.4$	=	0.90
Existing HMA	$2 * 0.32$	=	0.64
GABC	$7 * 0.14$	=	0.98
			<u>2.52</u>

11/3/14

605515 - VIBRATION MONITORING

DESCRIPTION:

The work to be performed under this section includes, but is not limited to, monitoring the existing and newly constructed structures, facilities, or utilities for displacement and vibration during all construction operations that have the potential to produce vibrations at damaging levels or as directed by the Engineer. Locations to be monitored include, but are not limited to all structures, facilities, or utilities within 300 feet (Monitoring Zone) of any construction operations as described above.

MATERIALS:

- A. Equipment: The Contractor shall provide a minimum of one seismograph and optical survey target per structure, facility, or utility to be monitored to measure and record ground motion caused by construction under the Contract. The seismograph shall be attached or located immediately adjacent to the accessible portion(s) of the structure, facility, or utility closest to the proposed construction operations expected to produce vibrations.
1. The seismograph equipment shall be an InstanTel Micromate seismograph, or equivalent. All seismographs must meet the following requirements:
 - a. Built-in tri-axial transducer, containing three high output, low distortion geophones located along orthogonal axes (vertical, longitudinal, and transverse) and must be capable of measuring and recording the peak particle velocities at the 3-axes of ground vibration.
 - b. All seismographs proposed for use must include a certificate of calibration, dated within the previous 12-months of its anticipated use on the project.
 - c. Provide certificate of calibration in accordance with the requirements of the International Society of Explosive Engineers (ISEE).
 - d. The seismographs must have a visual, paper (or electronic) readout, and a web based remote access system for real time monitoring.
 - e. Where features of the project are to be monitored for greater than one year, the seismographs must be recalibrated by the manufacturer(s) on an annual basis until the monitoring work is complete.
 - i. Solid state devices may be calibrated on a less frequent basis where permitted by manufacturer recommendations and upon approval of the Engineer.

CONSTRUCTION METHODS:

A. Submittals

Provide all reports to the Engineer consisting of 8.5 x 11 inch PDF format including an index. Photographs included in reports shall be a minimum 4 x 6 inch color print and include date and location captions.

1. Vibration Monitoring and Movement Control Program

At least 45 days before work is to begin, the Contractor shall submit to the Engineer for review and approval the following:

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- a. A plan identifying all structures, facilities, and utilities to be monitored within 300 feet of any vibration producing construction activities and the locations of all proposed monitoring equipment. This plan shall establish the Monitoring Zone.
 - b. Qualifications of the monitoring firm engaged by the Contractor performing the work, including the resumes of key personnel overseeing and performing the work. Obtain approval of the monitoring firm and key personnel by the Engineer prior to commencement of any activities related to vibration monitoring.
 - i. Perform all work under the direct supervision of a Vibration Specialist who is a Professional Engineer (PE) in the State of Delaware with a minimum of 3-years of demonstrated experience in similar work with professional level capability in related geotechnical and structural evaluations and engineering. The Vibration Specialist shall be responsible for installing, operating, reading, and interpreting seismographs on the vibration-susceptible objects.
 - ii. Perform work for the installation and monitoring of optically surveyed instrumentation under the direct supervision of a Professional Surveyor registered in the State of Delaware with a minimum of 3-years of experience in design work and deformation measurements of the types and accuracies specified herein.
 - iii. The field survey party chief must have a minimum of 2-years of experience in deformation survey measurements of the types and accuracies specified herein.
 - c. Proposed list and details of monitoring equipment proposed to be used on the project.
 - d. List of all structures, facilities, and utilities to be inspected/monitored.
 - e. Schedule for the inspection/survey of all structures, facilities, and utilities with anticipated submission date for the pre-construction inspection report.
 - f. Schedule for the installation of monitoring equipment and collection of Ambient Baseline Survey data.
 - g. A description of the Contractor's proposed means and methods of construction developed to limit construction vibrations and movements below the threshold and limiting values established in this Special Provision and preclude damage to existing and newly constructed structures, facilities, and utilities within the Monitoring Zone.
 - h. A description of the Contractor's proposed course of action if the limiting value is exceeded.
2. Pre-Construction Inspection Report

At least 30 days before work is to begin, the Contractor shall submit to the Engineer for review and approval the following:

- a. Results of the inspection of all structures, facilities, and utilities identified in the Vibration Monitoring and Movement Control Plan. The Contractor shall notify the property owner and obtain a release (if required) to access the vibration-susceptible objects within the Monitoring Zone. The report should include:
 - i. Names and responsibilities of the inspection party.
 - ii. A written description of the findings of the inspection documenting all existing damage (if any), including but not limited to, cracks, crack widths, crack lengths, displacements, and other evidence of existing damage or structural deficiencies. Crack gauges shall be used to monitor cracks throughout construction.
 - iii. Color photographs with date and location captions documenting the existing condition of all structures, facilities, and utilities inspected. Photographs should provide adequate resolution and include scale and date references for future comparative purposes.

- iv. Provide a CD-ROM or USB drive with the report containing a video documenting the existing conditions of the structures along with the photos provided in the report in their original resolution.
- v. Ensure the scope and detail of the inspection survey and report is sufficient to serve as a reference for comparison should evidence of damage be observed during construction operations.

3. Ambient Baseline Survey

Before commencing any vibration producing construction activities, conduct a baseline survey of any structures, facilities, and utilities within the Monitoring Zone and submit a report to the Engineer for review and approval. The scope of the baseline survey should include, but is not limited to, the following:

- a. Develop surveying plan.
- b. Install seismographs and optical survey prisms on any structures, facilities, and utilities within the Monitoring Zone. Within two days of installing each seismograph and optical survey point, submit an installation record sheet including:
 - i. Project name;
 - ii. Contract name and number;
 - iii. Instrument type and number including readout unit;
 - iv. Planned location in horizontal position and elevation including structure number;
 - v. Planned orientation;
 - vi. Personnel responsible for installation;
 - vii. Date and time of installation start and completion;
 - viii. Spaces on record sheet for necessary measurements or readings required during installation;
 - ix. As-built location in horizontal position and elevation;
 - x. As-built orientation;
 - xi. Result of post-installation acceptance test;
 - xii. Weather conditions at the time of installation; and
 - xiii. Notes of importance on the installation including problems encountered, delays, unusual features of installation, and details of any events that may have a bearing on the instrument behavior.
- c. Set up control points and vertical datum.
- d. Take and submit readings (vibration and displacement) at the structures, facilities, and utilities within the Monitoring Zone (at accessible locations nearest the proposed construction locations) for a minimum of seven (7) days to establish ambient baseline data. Vibration shall be monitored on a continuous basis. Optical survey targets shall be monitored on a twice daily basis.
- e. Interpretation of the readings.
- f. Create a baseline survey map using a plan view or satellite view. Designate each monitoring point and control point on the survey map. Show the limits of the Monitoring Zone on the map.
- g. Any proposed changes to the specified Threshold Value and Limiting Value for the measured peak particle velocities, settlement, and horizontal displacement contained in this Special Provision.

h. Provide one portable readout unit for the Engineer's use.

4. Vibration Monitoring Reports

Perform vibration and movement monitoring and reporting within the Monitoring Zone using seismographs and horizontal and vertical measurements of optical survey targets for the full duration of construction operations at all existing and newly constructed structures, facilities, and utilities, and on a continuous basis during vibration-causing construction activities.

Evaluate the seismograph full-time by the on-site Vibration Specialist during the first day of operations and review once daily thereafter. The pre-established optical survey targets must be surveyed vertically and horizontally by a Professional Land Surveyor on a twice-daily basis.

Provide a report of all data and evaluations daily to the Engineer. Include the following in the report:

- a. Seismograph recording including the date and times.
- b. Make, model, and serial number of the seismograph.
- c. Construction activity causing the vibration readings.
- d. Changes in northing, easting, and elevation for each survey point.
- e. Submit strip chart and provide excel electronic spreadsheet of tabulated vibration monitoring data of full waveform plots of seismograph data.

5. Post-Construction Inspection Report

After the project has reached Substantial Completion, perform a detailed post-construction inspection of the structures, facilities, and utilities and report the findings to the Engineer. Perform a detailed inspection of the outside and inside of structures, facilities, and utilities. Prepare the post-construction inspection report in the same format as the pre-construction inspection report with the following inclusions:

- a. Summary of monitored features noting any changes, damage, or the absence of change or damage to the structures, facilities, or utilities monitored.
- b. Photographs taken at the same location and from the same distance and vantage point as those taken for the pre-construction inspection report.
- c. In the case of change or damage, note the cause and remedial action to be undertaken, with a discussion as to the cause of the change or damage.
- d. Submit the post-construction report a maximum of 10 days after completion of vibration producing construction activities.

B. Execution

1. General

- a. This work shall consist of the following:
 - i. Perform pre-construction and post-construction inspection surveys, including preparation and submission of reports and plans, of all existing and newly constructed vibration-susceptible objects, located within the Monitoring Zone.
 - ii. Establish survey targets on the vibration-susceptible objects within the Monitoring Zone.
 - iii. Provide monitoring and establish ambient baseline vibration and movement data at all vibration-susceptible objects within the Monitoring Zone.

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- iv. Develop and implement a vibration monitoring and movement control program to limit construction vibrations and movements (vertical settlement and lateral deformation) to preclude damage to any existing and newly constructed vibration-susceptible objects within the Monitoring Zone.
 - v. Perform vibration and movement monitoring and reporting within the Monitoring Zone using seismographs and horizontal and vertical measurements of survey targets during construction operations at all existing and newly constructed vibration-susceptible objects, and on a continuous basis during vibration-causing construction activities.
 - b. Perform construction operations, vibration monitoring, and movement monitoring in accordance with the approved program. The Engineer must approve changes in the program prior to implementation.
 - c. The proposed construction activities (installation of sheet piles, bulkhead, piles, cofferdams, casings, and operation of heavy construction equipment) that are required for the construction of this project are anticipated to produce earthborne vibrations and ground movements. The Contractor is advised that structures, facilities, and utilities are located close to the proposed work. The Contractor shall make every effort to conduct construction activities so as to preclude damage to any structures, facilities, and utilities within 300 feet of the proposed work. The Contractor is responsible for any damage caused to any structures, facilities, and utilities by the Contractor's activities at no additional cost to the Department.
 - d. Protect seismographs and optical survey targets from damage, and maintain instruments installed. Calibrate equipment to negate the movements due to thermal effects. Make no change or relocation of instruments without the prior written approval of the Engineer. Report to the Engineer whenever any reference point is lost, destroyed, malfunctioning, worn-out, or requires relocation because of necessary changes in grades or locations. Replace and accurately relocate all reference points so lost, destroyed, malfunctioning, worn-out, or moved.
 - e. Provide the Engineer access to collected data from movement monitoring systems via a website at all times throughout construction and until Substantial Completion. Ensure the website is automatically updated following each automatic reading taken.
 - f. Implement response actions if the movement or vibration measurements are over the Response Values for Selected Instrumentation as shown on Table 1.
 - g. Install all instrumentation (seismographs and optical survey targets), meter cabinets for instrumentation wiring, and data communication equipment such that they do not interfere with subsequent construction operations.
 - h. Take optical survey readings on a twice daily basis throughout the aforementioned vibration causing construction activities and at least once per day for a period of 3 months after completion of pile construction activities.
 - i. Notify the Engineer at least 24 hours before starting a new vibration-producing construction task.
 - j. Ensure marine traffic passing in the navigable channel is not affected throughout all construction operations.
2. Implementation
- a. The Engineer will have the right to interpret vibration and movement data collected and provided by the Contractor. However, the Contractor's Vibration Specialist will have the primary responsibility for interpretation. Interpretation includes making correlations between instrumentation data and specific construction operations within the Monitoring Zone. Movement survey data to be evaluated by Professional Land Surveyor licensed in the State of Delaware.

Evaluate instrumentation data to determine whether the response actions are reasonable and propose modifications to construction operations to mitigate the possibility of potential damage.

- b. Limit the peak particle velocity and vertical and horizontal deformations to the Response Values indicated in Table 1. If the Contractor's findings and the recommendations by the qualified Vibration Specialist during the pre-construction inspection survey warrant Threshold Values less than the tabulated values, then include these Threshold Values in the report and limit vibrations and movement to these more restrictive values.
- c. The Threshold and Limiting Values indicated in Table 1 are defined collectively as Response Values. The actions associated with these Response Values are defined below. The Engineer may adjust Response Values based on prevailing conditions or circumstances.
- d. Ensure the Contractor, Vibration Specialist, and Engineer receive an automatic email alert upon exceedance of Threshold Action Values.

Table 1 – Response Values for Selected Instrumentation

Instrument	Threshold Action	Limiting Allowable
<u>Seismograph:</u> Existing Building(s), facilities, and utilities	0.35 in./sec.	0.5 in./sec.
<u>Seismograph:</u> Sensitive Structures, Structures Presenting Deficiencies	0.1 in./sec.	0.2 in./sec.
<u>Seismograph:</u> Noncritical Structures & Existing Bulkheads	1.5 in./sec.	2.0 in./sec.
<u>Survey:</u> Any Structures, Buildings, Facilities, and Utilities within Monitoring Zone	0.1 in.	0.125 in.
Note: Response Values for seismograph are peak particle velocity (PPV).		

e. Response Actions

If the Threshold Action Value is reached, comply with the following:

- i. Meet with the Engineer to discuss all necessary steps to ensure that the Limiting Value is not exceeded.
- ii. If directed by the Engineer, implement the reviewed plan of action within 24 hours so that the Limiting Allowable Value is not exceeded.
- iii. Install additional instrumentation as directed by the Engineer.
- iv. Take all necessary steps to avoid exceeding the Limiting Value. If the Limiting Allowable Value is exceeded, the Engineer may direct the Contractor to suspend all related construction activities immediately. Vibration causing activities may not resume until a reviewed plan of action is received proving, to the satisfaction of the Engineer, that the vibration levels will remain below the Limiting Allowable Value upon resumption of vibration causing activities. All costs resulting from, and associated with, stoppage of work due to high vibration levels are the responsibility of the Contractor.

METHOD OF MEASUREMENT:

- A. The Department will not measure a quantity for vibration monitoring.

BASIS OF PAYMENT:

- A. The Department will pay for vibration monitoring as a lump sum item. Price and payment will constitute full compensation for all work described in this section including:
 - 1. Providing and placing all equipment;
 - 2. surveying;
 - 3. inspection;
 - 4. preparation and submission of all reports;
 - 5. equipment monitoring and preservation;
 - 6. responsive action; and
 - 7. all incidentals required to complete the Work.
- B. Contractor shall repair any damage caused to any structures by the Contractor's activities at no additional cost to the Department.
- C. Payment will be made as follows:
 - 1. 25% payment will be made upon submission and acceptance of pre-construction report.
 - 2. 50% upon completion of all foundation construction operations, such as installation of sheet piles, cofferdams, piles, casings, or any other vibration-causing construction activities within the Monitoring Zone.
 - 3. 25% upon submission and acceptance of post-construction inspection report.

11/06/2023

610500 – ULTRA HIGH-PERFORMANCE CONCRETE**Description:**

This work consists of providing, mixing, transporting, placing, finishing, curing, and grinding Ultra High Performance Concrete (UHPC).

Materials.

Use only materials from the same batch or lot.

- A. Fine Aggregate: Crushed Quartz with 100% passing the No. 30 sieve and a maximum of 3% passing the No. 200 sieve.
- B. Cementitious Material Section 1022.
- C. Steel Fibers: ASTM A 820, Type 1 Cold drawn high-carbon steel with a minimum tensile strength of 300 ksi. Minimum steel fiber content will be 2% of the mix's dry volume.
- D. Water Section 1021
- E. Admixtures: Only as directed by the manufacturer's representative
- F. The UHPC will meet the conditions listed in Table 1: UHPC Material Properties after 28-days, unless otherwise noted in the Contract or as directed by the engineer. Material properties listed below will be verified by the manufacturer and submitted for approval in the Placement Plan.

Table 1: UHPC Material Properties

Description	Test Method	Acceptance Criteria
Compressive Strength Ends of cylinders must be ground flush prior to testing. Saw cutting, capping, and use of neoprene pads are not permitted.	AASHTO T 22 (3"x6" cylinders) (150 psi/sec loading rate)	≥ 22 ksi after 28 days
Shrinkage	AASHTO T 160 / ASTM C 157	≤ 800 micro-strain
Rapid Chloride Ion Penetrability or Surface Resistivity Testing	AASHTO T 277 / ASTM C 1202 or AASHTO TP 95	≤ 350 coulombs
Chloride Ion Penetrability	AASHTO T 259 ($\frac{1}{2}$ " depth)	< 0.1183 lbs/yd ³
Scaling Resistance	ASTM C 672	$Y < 3$
Freeze-Thaw Resistance	AASHTO T 161 / ASTM C 666A (300 cycles)	Relative Dynamic Modulus of Elasticity $> 95\%$
Alkali-Silica Reaction	ASTM C 1567 (Modified)	$\leq 0.08\%$ at 28 days
Slump Flow and Visual Stability	ASTM C1437 / ASTM C 1611	7 inches (Minimum) 10 inches (Maximum) No bleed water Consistent fiber distribution

Construction.

A. Submittals

1. Material Batch. At least 60-days prior to the placement of UHPC, submit a prepackaged batch of dry ingredients and admixtures sufficient for the Department to make a 1-cubic-foot trial batch of UHPC. Any testing for alkali-silica reaction or permeability will be performed on specimens without steel reinforcement. Batch proportions will otherwise remain the same per the prepackaged blend and water to cementitious materials ratio (w/cm).
2. Placement Plan. Submit a Placement Plan in accordance with Section 610.3.1 and the manufacturer's recommendations with a detailed construction work schedule to the engineer for review at least 10-days prior to the scheduled UHPC placement pour. The Placement Plan will address at a minimum:

The following list is intended as a guide and may not address all the means and methods the Contractor may elect to use. The Contractor is expected to assemble a comprehensive list of all necessary items for executing the placement of UHPC.

1. Responsible personnel and hierarchy.
2. Equipment – including but not limited to pumps, hoses, mixers, holding tanks, wheelbarrows, scales, meters, thermometers, floats, screeds, burlap, plastic, heaters, blankets, etc.
3. Quality Control of batch proportions - including dry ingredients, steel fibers, water, and admixtures.
4. Quality Control of mixing time and batch times.
5. Batch procedure sequence.
6. Form work – including materials and removal.
7. Placement procedure – including but not limited to surface preparation (comprising of exposed aggregate surface finish along precast elements and pre-wetting the precast concrete interface to a saturated-surface-dry (SSD) condition before the placement of UHPC), spreading, finishing, and curing protection. Include provisions for acceptable ambient conditions and batch temperatures and corrective measures as appropriate. Include means and methods to ensure all air is displaced by the UHPC and the void is completely filled.
8. Threshold limits for ambient temperature, ambient relative humidity, batch consistency, batch temperature, batch times and related corrective actions.
9. Construction joints, if needed, within the UHPC should be detailed and approved by the engineer.
10. Means and methods for water containment and clean up, for pre-wetting and for watertight integrity testing.

Arrange for a meeting between the UHPC manufacturer's representative, the Contractor's staff, and representatives from DelDOT Bridge Design, Construction, and Materials and Research to review the Contractor's Placement Plan. No UHPC pour will be permitted until the Placement Plan has been submitted by the Contractor and approved by the engineer.

Pumping of UHPC is not allowed.

Submit calculations and detailed drawings of the formwork, signed and sealed by a Professional Engineer registered in the State of Delaware. The design and fabrication of forms will be consistent with the installation drawings and follow the recommendations of the UHPC manufacturer.

Construction loads applied to the bridge during UHPC placement and curing are the responsibility

of the Contractor. Submit the weight and placement of concrete buggies, grinding equipment or other significant construction loads for review as part of the proposed Placement Plan.

3. Temperature Control Plan. When temperature ranges fall outside of the manufacturer's recommended placement temperatures, submit a Temperature Control Plan in accordance with Section 610.3.1, ACI 306R as applicable, and the manufacturer's recommendations. No UHPC pour will be permitted until the Temperature Control Plan has been submitted by the Contractor and approved by the engineer.

B. Storage.

1. Ensure proper storage of all materials including but not limited to cement, aggregate, steel reinforcement and additives, as required by the supplier's recommendation in order to protect the integrity of the materials against the loss of physical and mechanical properties.

C. Forming, Mixing, Transporting, Placing and Curing.

1. The Contractor will arrange for an on-site meeting with the UHPC manufacturer's representative one day before the start of the actual UHPC placement. The Contractor's staff and representatives from DelDOT Bridge Design, Construction, and Materials and Research, will attend the meeting. The objective of the meeting will be to clearly outline the procedures for mixing, transporting, finishing and curing of the UHPC.
2. Design and fabricate formwork to adhere to Section 604.03.2 and the recommendations of the UHPC manufacturer. Construct forms from a nonabsorbent homogeneous material that is properly sealed and capable of resisting the hydrostatic pressures from UHPC in the unhardened state. Do not remove formwork until a compressive strength of 10 ksi is achieved. Internal vibration of the UHPC is not acceptable. However, rodding may be satisfactory to achieve a suitable blended connection where two successive pours meet.
3. Cover all UHPC joints with a top form with a moisture barrier. Supplemental heat can be provided to the UHPC and surrounding prefabricated elements to reduce initial set times and accelerate strength gain. Include the proposed method of artificial heating the precast concrete element in the installation drawings. Follow the UHPC manufacturer's recommendations for curing to attain the required strength to meet the project schedule.
4. When applicable, due to weather constraints, place UHPC in accordance with the approved Temperature Control Plan.
5. Once the UHPC reaches a compressive strength of 10-ksi, the top forms of the joint may be removed to facilitate grinding of the joint to be even with the top surface of precast concrete element.
6. Form, batch, place, and cure in accordance with the UHPC manufacturer's recommendations and as submitted and accepted by the Engineer.
7. Representatives of the UHPC manufacturer knowledgeable in supplying, mixing, transporting, placing, finishing and curing of the UHPC material must be present during mixing, transporting and placing of the UHPC. The Contractor will arrange for two manufacturer's representatives to be on site for the duration of the UHPC construction; one representative will remain with the mixing operations and the second representative will remain with the placement operations. Do not start mixing or placing UHPC until the manufacturer's representatives are on-site. Place UHPC in accordance with the approved Placement Plan using one continuous pour unless otherwise detailed in the Contract Documents or as approved per the Placement Plan. Do not allow the UHPC to freeze before attaining a compressive

strength of 10-ksi.

8. Provide a minimum of two portable batching units for mixing of the UHPC. Mixing equipment which is not supplied by the UHPC manufacturer must be reviewed by the UHPC manufacturer for adequacy. During batching keep the temperature of the UHPC below 90-degrees F; ice may be added to the mix as recommended by the UHPC manufacturer's representative.

D. Acceptance Testing.

1. DelDOT Materials and Research will be on site during the placement of UHPC. To schedule a representative, contact DelDOT Materials and Research a minimum of 48-hours prior to the anticipated UHPC placement. A representative from the Materials and Research section will perform a slump flow test according to ASTM C 1437 / ASTM C 1611 on each batch of UHPC. DelDOT Materials and Research will cast 3-inch x 6-inch cylinders according to AASHTO T 23 at a minimum of once per day. Cast the cylinders in a single lift. Compressive strength testing will be performed at 1, 2, 3, 4 and 28 day cure times. Final acceptance will be based upon 4-day and 28-day strengths. Field coring of UHPC for dispute resolution will not be allowed.
2. Additional specimens will be cast for permeability testing. A minimum of two lots will be selected at random from the permeability specimens and tested in accordance with AASHTO T 277 / ASTM C 1202 and AASHTO TP 95. In the event of a discrepancy between the two methods, results from ASTM C 1202 will supersede. If one specimen from either lot exceeds the maximum permeability, two additional specimens will be selected and tested in accordance with AASHTO T 277 / ASTM C 1202, the average of which will replace the failed specimen result.
3. The Contractor is responsible for providing an adequate location to place acceptance specimens for initial curing prior to transport to the lab. Curing boxes will be equipped with supplemental heat or cooling as necessary to cure specimens in accordance with ASTM C 31. Testing performed by the DelDOT Materials and Research has been summarized in Table 2: DelDOT M&R UHPC Acceptance Testing. Performance frequencies of each test listed in Table 2 are a minimum value. Tests may be performed at more frequent intervals than described in Table 2, at the discretion of the engineer or DelDOT Materials and Research.

Table 2: DelDOT M&R UHPC Acceptance Testing

Description	Test Method	Acceptance Criteria	Frequency
Compressive Strength	AASHTO T 22	≥ 22 ksi after 28 days ≥ 14 ksi after 4 days (3"x6" cylinders) (150 psi/sec loading rate)	At least once per 25 CY or once per 12 hour shift
Rapid Chloride Ion Penetrability or Surface Resistivity Testing	AASHTO T 277 / ASTM C 1202 or AASHTO TP 95	≤ 350 coulombs after 28 days	1 per job (Performed prior to field placement)
Slump Flow and Visual Stability	ASTM C1437 / ASTM C 1611	7 inches (Min.) 10 inches (Max.) No bleed water Consistent fiber distribution	1 per batch

- E. Surface Preparation. Create an exposed aggregate finish on all surfaces of the precast concrete element in contact with UHPC to facilitate bond. The exposed aggregate finish must have a 0.25-inch amplitude. In addition, immediately before concrete placement, wet the clean surface with water to a saturated surface dry (SSD) condition. Saturated surface dry (SSD) is a state where the concrete has absorbed as much water it can possibly absorb without ponding or puddles forming on the surface. Achieve SSD condition by placing wet burlap on the surface for a minimum of 24-hours or by other means submitted for approval by the Engineer. Use compressed air, free of oil, to blow out any standing water in areas of concrete removal.
- F. Surface Profile.
1. The finished surface of the UHPC field joints must be flush with adjacent precast elements to within a tolerance of plus $\frac{1}{4}$ inch and minus 0 inches. After curing, grind the UHPC surface smooth with adjacent concrete elements in order to match the profile of the structural elements that are being connected within the acceptable surface tolerance. Grinding of the UHPC surface can be performed when a minimum strength of 10 ksi is achieved. During grinding operations, if steel fiber pullout is observed, suspend the grinding and do not resume until approved by the engineer.
 2. If deemed as necessary by the engineer, perform a watertight integrity test on 10-percent of the joints after grinding has been completed. The test will consist of continuously applying running water at an approximate rate of 300-gallons per hour along the length of the joints to be tested, for a duration of 30-minutes. Inspect the underside of the joint for water leakage at 30-minutes and at 1-hour. The joint is considered watertight if no dripping water or water droplets are visible underneath precast concrete element areas along the full length of the joint. If the results of the watertight integrity test are not satisfactory, the engineer will determine the required corrective action.
- G. Traffic is not permitted on the bridge until the UHPC has achieved a minimum compressive strength of 14-ksi or unless otherwise approved by the engineer.

Method of Measurement

- A. The quantity of Ultra High Performance Concrete will be measured as the number of cubic feet of UHPC placed and accepted. The volume will be computed using the dimensions shown on the plans.
- B. The Department will not measure surface grinding.

Basis of Payment

- A. The Department will pay for UHPC at the contract unit price per cubic foot. Price and payment constitute full compensation for:
 1. Preparing and submitting all required submittals to the Department;
 2. mixing, transporting, placing, finishing, curing, and grinding;
 3. and for all incidentals required to complete the Work.
- B. Additional quantity of material used in the determination of material properties and for acceptance testing will be provided at no additional cost to the Department.
- C. The Department will make no additional payments for any additional Work relating to the placement of UHPC in accordance with the Temperature Control Plan.
- D. The Department will make no additional payments for remediation if the UHPC does not meet the minimal material properties of the contract. Remove and replace or remediate the UHPC to the satisfaction of the engineer.
- E. The Department will make no additional payments for:

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1. Watertight integrity tests are required by the engineer;
2. joint surface preparation or grinding procedures; or
3. remedial solutions to insufficient bonding of joints.

12/14/2023

612500 - PRECAST CONCRETE PIER CAP

DESCRIPTION:

This work consists of fabrication, storage, transportation, erection, and temporary support of the bascule pier, rest pier and fender system precast footing caps, tub beams, and maintenance platforms, as described herein and shown in the Plans. Precast elements are used to facilitate concrete construction in the water and accelerate bridge construction. This work also consists of surface preparation, supplemental forming, placement, finishing and curing of the cast-in-place closure concrete, used to make solid the precast footing caps and tub beams, to connect the precast footing caps to the piles and to the precast tub beams. This work also consists of supplemental forming, placement of non-shrink grout, fabrication and placement of welded stud connectors, to level, align and anchor precast maintenance slabs to the precast footing caps.

MATERIALS:

- A. Bar Reinforcement Section 1037
 - 1. Epoxy coated, AASHTO M31 (ASTM A615), Grade 60 for both precast concrete elements and cast-in-place closure concrete.
- B. Portland Cement Concrete (PCC) Section 1022
 - 1. Class A PCC with 28-day compressive strength of 4,500 psi for precast concrete elements.
 - 2. Class A PCC with 28-day compressive strength of 4,500 psi and shrinkage reducing/compensating admixture that expands at a rate that closely compensates for shrinkage, with dosage recommended by manufacturer, for cast-in-place closure concrete.
- C. Non-shrink Grout Section 1047.2
 - 1. ASTM C1107 Grade C for precast maintenance platform blockouts and haunches.
- D. Welded Shear Connectors Section 1039.5
 - 1. Automatic end-welded stud connectors for anchorage of precast maintenance platforms to precast footing caps.

CONSTRUCTION METHODS:

- A. Perform general concrete and reinforcement work in accordance with Sections 610 and 611, respectively, and precast work in accordance with Section 612, along with corresponding referenced Sections, as clarified and supplemented herein or in the Plans.
- B. Shop Drawings and Working Drawings.
 - 1. Prepare and submit to the Engineer, shop drawings and working drawings of the precast concrete footing caps, tub beams and maintenance platforms, signed and sealed by a registered Professional Engineer in the State of Delaware. Do not order materials or begin fabrication until approval by the Engineer. Coordinate precast details with cast-in-place concrete closures; piles and pile reinforcing; anchor bolts for the bascule span A-frame towers, centering device, span locks, handrails, and fender system; approach span superstructure precast, prestressed slabs; welded shear connectors and connection plates. Account for as-built pile placement and bascule span structural steel as-built

dimensions and tolerances. In addition to the items listed in Section 612.3.1, include the following with the shop drawings and working drawings:

- a. Means and methods for temporary support and alignment of the precast elements until the cast-in-place closure concrete has cured and achieved required strength for self-support.
 - b. Supplemental formwork, means and methods for sealing interfaces at joints between pile and precast footing caps and between precast tub beams and footing caps during placement of cast-in-place concrete and non-shrink grout.
 - c. Thermal Control Plan, in accordance with Sections 610.3.1.A.2, 610.3.4.D.3 and 610.3.6.B, for cast-in-place mass closure concrete placed within the precast footing caps and tub beams.
 - d. Means, methods and sequence of lifting, handling and erection. Include details of all equipment to be used including crane and barge locations at the site relative to the bridge, crane operating radii, precast unit weights and centers-of-gravity, lifting points, details, and devices, crane and barge capacity.
 - e. Means, methods, materials and procedures for removing lifting devices and other surface inserts, and patching holes and blockouts.
2. Alternate pier cap designs may be proposed with Department approval. Submit alternate designs with supporting details and calculations, signed and sealed by a registered Professional Engineer in the State of Delaware, demonstrating that the alternate design meets the project design specifications. The alternate design shall be of equal or greater quality and value as the design shown in the Plans. A fully cast-in-place concrete solution and a fully cast-in-place concrete cap with precast concrete access platforms will be considered.

C. Precast Concrete Elements.

1. Fabrication.

- a. Manufacture precast concrete elements in accordance with the general requirements of Section 612.3.2.
- b. Fabricate precast concrete elements to the dimensional tolerances of the *Precast Concrete Institute Tolerance Manual for Precast and Prestressed Concrete Construction* (PCI MNL 135-00), Category B1 (Bridge Products, Not Prestressed).
- c. Unless approved by the Engineer, delay fabrication of the precast concrete units until pile installation and bascule span structural steel fabrication and shop assembly has advanced to the level at which as-built dimensions for these components are established. Modify shop drawings and working drawings as required to accommodate the as-built dimensions.
- d. Provide formwork that will produce a Class One ordinary surface finish to exposed exterior surfaces. When a Class One finish does not produce an acceptable concrete surface, as determined by the Engineer, apply a Class 2 finish to that surface. Roughen surfaces in contact with cast-in-place closure concrete to expose coarse aggregate with a minimum 1/4-inch amplitude. Finish tops of precast maintenance platform surfaces similar to pedestrian walkways.
Form shear keys at interface locations per the details in the Plans. Prepare shear key surfaces with an in-form retarder to create an exposed aggregate surface.
- e. Precast footing caps and tub beams include optional threaded bar couplers and dowels, at locations where reinforcing bars cross interior surfaces, to facilitate form removal.
- f. Form blockouts in the precast footing caps, tub beams and maintenance platforms for bascule span A-frame tower, centering device, span lock, fender system, and hand rail anchor bolt assemblies.

2. Storage, Shipment and Erection.

- a. Erect precast concrete elements to the dimensional tolerances of the *Precast Concrete Institute Tolerance Manual for Precast and Prestressed Concrete Construction* (PCI MNL 135-00), Category B1 (Bridge Products, Not Prestressed). Achieve and maintain alignment of adjacent precast concrete elements at the joints between elements during erection and placement of cast-in-place closure concrete. Alignment shall achieve uniform surfaces, free of steps or irregularities, on all sides. Temporary supports shall be designed with adequate strength and stiffness to achieve these requirements.
- b. Lift and handle precast concrete elements at the approved designated points, using approved engineered lifting devices properly anchored to the precast concrete elements, utilizing proper hoisting procedures. Design the lifting devices and all necessary modifications to the precast concrete elements to accommodate lifting and handling stresses.
- c. Support precast concrete elements during storage and transportation on approved engineered dunnage at the approved designated points. Stacking of precast maintenance platforms is permitted provided that adequate dunnage is provided between slabs. Stacking of precast footing caps and tub beams is not permitted. Secure and stabilize precast concrete elements from shifting or tipping during storage and transportation.
- d. The centers-of-gravity of the precast footing caps are not coincident with the piles. Account for offset centers-of-gravity in lifting, handling and support.
- e. Erect the precast footing caps after the cast-in-place concrete fill in the steel pipe piles has been placed to the top of the pile, cured, and achieved the required 28-day compressive strength.
- f. Erect the precast tub beams between the precast footing caps after the cast-in-place closure concrete in the voids in the precast footing caps, over the piles, has been placed to the top, cured and achieved the minimum 28-day compressive strength.
- g. Erect the precast maintenance platforms on top of the precast footing caps after the cast-in-place closure concrete in the precast footing caps and tub beams has been placed to the top, cured and achieved the minimum 28-day compressive strength. Provide means and methods to level and align the slabs including leveling bolts, non-metallic shims or other approved devices. Elastomeric pads shall have adequate compression resistance for the loads and a minimum thickness of 1/8-inch and maximum of 1/4-inch. Approved leveling devices may remain embedded within the concrete.
- h. Set the precast footing caps, tub beams and maintenance platforms such that all top surfaces are level and at the specified plan elevations to an accuracy of (+/-) 1/4-inch. Survey the top elevations and adjust as required prior to placement of closure concrete.
- i. Remove portions of embedded lifting devices and other embedments that protrude above the concrete surface and fill pockets with an approved epoxy mortar.

3. Cast-in-place Concrete and Non-Shrink Grout

- a. Place cast-in-place closure concrete only after the precast elements have been erected, surveyed, adjusted, and aligned within specified tolerances; verified as stable; blockouts for anchor bolts formed; welded shear connectors installed, supported and aligned; joints between components formed and sealed; surfaces prepared and saturated; and recesses dewatered.
- b. Install, align, temporarily support, and stabilize anchor bolts for the bascule span A-frame towers within the precast interior voids. Accurately survey, locate and plumb the anchor bolts to the required alignment and tolerances. Use templates as required. Coordinate anchor bolt locations with as-built pier cap and bascule span dimensions.

- c. Install, align, temporarily support, and stabilize welded stud connector assemblies for anchorage of the maintenance platforms. Coordinate locations with the as-built maintenance platform blockouts.
- d. Place and cure cast-in-place closure concrete in lifts as shown in the Plans. Allow the concrete of each lift to achieve the minimum 28-day compressive strength prior to placement of subsequent lifts.
- e. Install reinforcing steel and form, place, finish and cure cast-in-place concrete for the approach span beam seat pedestals.
- f. Before placement of the cast-in-place closure concrete and non-shrink grout, clean the precast surfaces of all loose and inadherent material, dirt, dust, debris, laitance and other foreign matter that may adversely affect the bond. Immediately prior to placement of the cast-in-place concrete, saturate the precast concrete surfaces with clean water. Remove standing water.
- g. Remove supplemental formwork and patch form holes with an approved epoxy mortar.

METHOD OF MEASUREMENT:

- A. The Department will measure the quantity of precast concrete footing caps, tub beams and maintenance platforms in cubic yards, computed based on dimensions shown in the Plans, excluding voids to be filled with cast-in-place closure concrete.

BASIS OF PAYMENT:

- A. The Department will pay for the precast footing caps, tub beams and maintenance platforms at the contract unit price per cubic yard. Price and payment will constitute full compensation for labor, equipment and materials required for fabrication and erection of the complete precast concrete pier cap assembly including:
 - 1. concrete,
 - 2. steel reinforcing,
 - 3. welded shear connector and connection plate assemblies,
 - 4. non-shrink grout,
 - 5. lifting devices,
 - 6. formwork,
 - 7. temporary supports,
 - 8. surface preparation,
 - 9. engineering,
 - 10. storage,
 - 11. transportation,
 - 12. survey measurements,
 - 13. other incidental work materials.

The Department will consider anything not measured separately as incidental to the respective item. The Price and payment will be at the Contract unit price per cubic yard of precast components.

- B. The Department will pay for the cast-in-place closure concrete within the precast footing caps and tub beams and for the beam seat pedestals in accordance with Section 610.

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- C. The Department will not pay for:
1. Rejected precast pier footing caps, tub beams and/or maintenance platforms due to defective workmanship or damage from improper storage, handling, transportation, or erection.
 2. Work associated with development, design and detailing of alternate designs from those in the Contract documents.

08/23/2023

615503 – BRIDGE MECHANICAL SYSTEM

DESCRIPTION:

This section applies to the detailed work to be performed on the bridge machinery. The bridge mechanical system includes the following systems: Bridge Machinery, Hydraulic Machinery, and Span Lock Machinery. The requirements of this section also apply to the installation of electric motors, instrumentation, and limit switches to be mounted with the machinery, but supplied under separate items. Provide all required materials, equipment, and labor to complete the work indicated in the Contract Drawings and as specified herein.

MATERIALS:

Bridge Machinery

A. Submittals

1. Submit manufacturer's data and/or shop drawing data for all manufactured and purchased items of bridge machinery in accordance with the Standard Specification. Include for each manufactured item: the manufacturer's descriptive literature, drawings, diagrams, performance and characteristic curves, and catalog cuts; the manufacturer's name, trade name, catalog model or number, nameplate data, size, certified layout dimensions, capacity, specification reference, and applicable Federal and Military Specification references; and all other information necessary to establish Contract compliance.

B. Shop Drawings

1. Provide shop drawings conforming to the Standard Specifications, as supplemented and amended elsewhere and to the special requirements specified hereinafter. Show all parts completely detailed and dimensioned on the shop drawings. State the grade and amount of finish machining, with all tolerances and allowances, and identify each part requiring a specific fit. Finished surfaces are defined by the ANSI/ASME B46.1, Surface Texture, and fits are defined by the ANSI/ASME B4.1, Preferred Limits and Fits for Cylindrical Parts, unless otherwise noted on the plans or stated herein. The ANSI/ASME B4.1 standard also applies to fits for non-cylindrical parts.
2. Show proprietary items in outline form on the drawings. Indicate the method and sequence to be employed during assembly of bridge machinery and installation of necessary utilities support and service facilities. Show all external dimensions and clearances necessary for installation and operation of each item or furnish complete assembly diagrams showing each part contained within an assembly and the manufacturer's part number assigned to each part. Provide a diagram sufficient to enable complete disassembly and reassembly of the item covered. In the event that any part is modified in any manner from the way it is described or delivered by its original manufacturer, deliver a drawing that details each modification and assign a unique part number to preclude the supply of replacement parts not modified in similar fashion. Provide assembly drawings of each item in addition to identifying and describing each internal part to contain: dimensions of all principal elements within the item; certified external dimensions affecting interfaces or installations; gross weight capacity and normal operating ratings; method and recommended type of lubrication, including location and type of fittings and provisions for adding, draining, and checking the level of each lubricant employed; inspection openings, seals, and vents; and details of all fasteners used to mount the equipment to its foundation.
3. Make a complete shop bill of materials for all machinery parts.
4. State the material and material specifications for each part. Give the designated numbers of specifications where American Society for Testing and Materials Specifications or any other standard specifications are used. Use abbreviations on the drawings to designate standard specifications for materials and workmanship as listed in Section C.3, Codes and Standards, of these Detailed Requirements.

5. These abbreviations are used on the plans and within these Detailed Requirements.
6. Furnish complete assembly and erection drawings. Include identifying marks and essential dimensions for locating each part or assembled unit with respect to the bridge structure or foundation. Use of mirror image or opposite hand erection drawings is prohibited.
7. Give a suitable title to each shop drawing to describe the parts detailed thereon and state by whom the internal quality control shop inspection will be performed.
8. Standard Compliance: Submit proof of conformance for applicable organizations such as, American Society for Mechanical Engineers (ASME), Underwriters Laboratories (UL), American Gas Association (AGA), and American Refrigeration Institute (ARI), for all equipment or materials. The label or listing of the specified organization will be acceptable evidence. In lieu of the label or listing, submit a certificate from an independent testing organization, adequately equipped and competent to perform those services, and reviewed by the Engineer. Provide a certificate which states that the item has been tested in accordance with the specified organization's test methods, and that the item conforms to the specified organization's standard or code.
9. Certified Test Reports: As used herein, certified test reports refer to reports of tests conducted on previously manufactured materials or equipment identical to that proposed for use.
10. Factory Tests: Factory tests refer to tests required to be performed on the actual materials or equipment proposed for use. Submit the results of all tests in accordance with the provisions of this Contract for laboratory test results.
11. Submit the required shop drawings for machinery items to the Engineer for review within 60 days after the first day of contract time.
12. Submit all shop drawings to the Engineer for his acceptance. In case of correction or rejection, resubmit until drawings are accepted. All costs for damages, which may result from the ordering of any materials prior to the acceptance of the shop drawings will be the responsibility of the Contractor; no work shall be done until the shop drawings have been accepted. After acceptance of the shop drawings, supply the Engineer with copies of the accepted shop drawings.

C. Quality Assurance

1. Standard Products
 - a. Provide materials and equipment that are essentially the standard catalogued product of manufacturers regularly engaged in production of those materials or equipment and are manufacturer's latest standard design that complies with these Detailed Requirements. Provide materials and equipment that are essentially duplicate items that have been in satisfactory commercial or industrial use at least two years prior to bid opening. Where two units of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the system need not be the products of the same manufacturer. Provide the manufacturer's name and address and the model and serial number on a nameplate, securely affixed in a conspicuous place for each major component. The nameplate of the distributing agent will not be acceptable.
2. Manufacturer's Recommendations
 - a. Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations are to be furnished to the Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material. Provide as part of the work, all special machining and installation required by the component manufacturer.
3. Codes and Standards
 - a. All work must comply with all applicable requirements of the latest edition of codes and standards issued by, but not limited to, the Standard Specifications as well as the following

organizations and publications, whose abbreviations used in these Special Provisions are as shown:

i. AASHTO	American Association of State Highway and Transportation Officials
ii. ABMA	American Bearing Manufacturers Association
iii. AGMA	American Gear Manufacturers Association
iv. AISI	American Iron and Steel Institute
v. ANSI	American National Standards Institute
vi. ASTM	American Society for Testing and Materials
vii. ASME	American Society of Mechanical Engineers
viii. AWS	American Welding Society
ix. NLGI	National Lubricating Grease Institute
x. SAE	Society of Automotive Engineers
xi. NFPA	National Fluid Power Association
xii. ISO	International Organization for Standardization

- b. Meet the work requirements of all other codes and standards as specified elsewhere in these Special Provisions. Where codes and standards are mentioned for any pay item, it is intended to call particular attention to them; it is not intended that any other codes and standards be omitted if not mentioned.
4. Qualifications, Personnel and Facilities
 - a. For the fabrication, installation, aligning, cleaning, lubricating, testing, and all other work required by bridge machinery pay items, use adequate numbers of skilled, trained, and experienced mechanics, millwrights, and service personnel who are thoroughly familiar with the requirements and methods specified for the proper execution of work.
 - b. For the installation, aligning, and fastening of bridge machinery, use adequate numbers of skilled, trained, and experienced millwrights with at least two (2) prior movable bridge jobs as past experience. Submit the millwrights' resumes showing the applicable experience for acceptance by the Engineer.
 - c. Equip mechanics, millwrights, and service personnel with all necessary instruments to assure that related components have been provided within acceptable tolerances, and to make all necessary adjustments for attaining the specified ratings.
 - d. Hydraulic system fabrication, installation and startup shall be performed by a qualified Contractor with at least ten years of experience in the design, fabrication, and installation of hydraulic systems of this size and type.
 - e. Piping and flushing shall be done under the direction of a certified fluid power technician with proper experience on similar systems.
 - f. At least one member of the installation crew shall be a certified fluid power technician unless otherwise accepted by the Engineer. Their certification number and experience demonstrating skill in this type of work shall be submitted for review and acceptance.
5. Rules, Regulations and Ordinances
 - a. Assure that work complies with all applicable Federal, State, and Local rules, regulations, and ordinances.
 - b. In the event of a conflict between these Specifications and the above-mentioned codes, standards, rules, regulations and ordinances, the most stringent requirement shall apply.
6. Substitutions
 - a. The terms "approved equal," "of equal quality," and "or equal" which appear on the plans and in these Special Provisions, are intended to allow the Contractor to substitute other manufacturers and model numbers of products of equal quality and rating for those specified.

- b. Prior to the ordering of any substitute product, obtain in writing the Engineer's acceptance of the equivalence of the substitute product. The acceptance of the substitute product is at the sole discretion of the Engineer who will establish the basis for equivalence and will review the quality of the materials and products described in detail on the submitted shop drawings and product data.
- c. The Engineer will return submissions for substitute material marked "Reviewed for General Conformity with the Plans and Specifications" (RGC), Reviewed for General Conformity with the Plans and Specifications As Noted" (RGCAN), or "Returned for Resubmission" (RFR). Upon return of a submission marked "Returned for Resubmission," return the submission showing the specified product. Rejection or acceptance of a proposed substitute will not in any way result in additional cost to the Department, or in additional contract time.
- d. Acceptance by the Engineer of any substitute product submitted by the Contractor does not relieve the Contractor of responsibility for the proper operation, performance, or functioning of that product.
- e. A manufacturer's name and catalog part number specifying a particular product, whether in these Special Provisions or on the plans, is so specified to establish quality, configuration, and arrangement of parts. An equivalent product made by another manufacturer may be substituted for the specified product subject to the acceptance by the Engineer; however, make all necessary changes required by the substitution in related machinery and structural, architectural, and electrical parts, at no additional cost to the Department.
- f. If any departures from the plans or these Special Provisions are deemed necessary by the Contractor, submit details of those departures and the reasons therefore, as soon as practicable for acceptance. Make no such departures without acceptance by the Engineer.

D. Operating and Maintenance Manuals

1. General Requirements for Manuals

- a. Furnish manuals containing descriptive material, catalog cuts with non-pertinent data blocked out, reduced shop drawings, and all information necessary for successful operation and maintenance of the bridge machinery systems. Any revisions required after the start-up period should be addressed by errata or addenda to the manuals.
- b. Clearly print all submittals, data, drawings, diagrams, etc. so that all printed matter is accurate, distinct, and clearly legible. Illustrations are to be clear and printed matter, including dimensions and lettering on drawings, are to be legible. If reduced drawings are incorporated within the manuals, darken the original lines and letters as necessary to retain legibility of the drawings after reduction. Fold larger drawings to page size and insert in manuals.
- c. Produce all printed matter, data, drawings, diagrams, etc., by methods that shall offer permanence and durability. Use paper that is water resistant. No materials are to be used that will adversely affect this permanence and durability.

2. Contents of Manuals

- a. Inscribe the following identification on the manual cover: the words "Operating and Maintenance Manual," the name and location of the bridge, the contract number, the date, and the names of the Consultant and Contractor.
- b. Include the names, addresses, and telephone numbers of each subcontractor installing the equipment and systems, as well as the local representatives for each item of equipment and system to be installed.
- c. Provide a table of contents and assemble to conform to the table of contents with the tab sheets placed before instructions covering the subject.
- d. Include the following in the manual as a minimum: a system layout showing all machinery/hydraulic components and equipment with data to explain detailed operation and

control of each component; a control sequence describing the operation; a detailed description of the function of each principal component of the system; the procedure for operation; installation instructions; maintenance and overhaul instructions; lubrication schedule to include type, grade, temperature range, and frequency; safety precautions, diagrams, and illustrations; test procedures; performance data; and parts lists. The parts lists for equipment shall indicate the sources of supply, recommended spare parts, and the service organization that is reasonably convenient to the bridge site.

- e. Include table of installation measurements for all alignment sensitive machinery items including but not limited to the heel trunnion shafts, the counterweight trunnion shafts, all bearings, the cylinders, the link arms, the span lock bar, and all couplings.
- f. Include manufacturer's standard publications provided that particular literature covers information and data specific to the equipment actually furnished.
- g. Include information for trouble-shooting the bridge machinery. List behavioral warning signs, possible problems, and potential solutions; incorporate each into the manual for each principal piece of equipment.
- h. Include detailed steps for cursory and in-depth inspections that should be performed annually and biennially, respectively.
- i. Complete the manuals in all respects for all equipment, controls, accessories, and associated appurtenances provided.

3. Materials for Manuals

- a. Bind the operating and maintenance manuals in heavy-duty, nickel-plated three-hole binders with three trigger positions: lock, unlock and open. Use binders that have metal hinges. Use a locking mechanism that allows sheets to lie flat (i.e., channel lock). Use covers made of stiff, heavy-duty plastic or other similar material. Binder type shall be either elliptical ring, round ring, screw post, or post with channel lock, as directed by the Engineer.
- b. Bind the printed material into each book between rigid covers. Use instruction books containing drawings that measure 8.5 x 11 inches to minimize excessive folding and to allow for ease of use. Neatly title the books with a descriptive title, the name of the project, the location, the year of installation, the name of the manufacturer, the engineering firm, and the Contractor. Provide legible copies of drawings in black on white background. Submit the arrangements of the books, the method of binding, and the material to be included to the Engineer for acceptance.
- c. Use 8.5 x 11-inch, 20 lb., copy paper, acid-free punched paper that is a quality suitable for archival use. The punched holes, each with a minimum diameter of 5/16-inch, are to be reinforced with plastic or cloth to the standard three (3) hole spacing.
- d. For foldout diagrams and illustrations, reinforce all holes (5/16-inch minimum diameter) with plastic or cloth to standard three (3) hole spacing.

4. Sequence of Submittals for Manuals

- a. Submit two copies of sample formats and outlines of contents in draft form ninety (90) days prior to the earliest: of final inspection, acceptance tests, or return of the span operation to the Department. Show proposed methods of binding, methods of printing, and reproduction.
- b. Submit two copies of complete manual in final form thirty (30) days prior to final inspection, acceptance tests, or return of the span operation to the Department.
- c. Submit five (5) hard copies and three (3) electronic copies, in .pdf format, of accepted manual ten (10) days after final inspection and acceptance tests. One of the five hard copies and one of the three electronic copies shall become the property of the Consultant; the remaining copies shall become the property of the Department.

5. Posted Operating Instructions

- a. Provide operating instructions (accepted by the Engineer) for each system and each principal piece of equipment for the use of operation and maintenance personnel. Include diagrams showing the complete layout of the entire system framed under acrylic plastic or in laminated plastic and posted where directed by the Engineer. Post printed operating instructions for each principal piece of equipment including proper adjustment, operation, lubrication, safety precautions, procedures in the event of equipment failure, and any other necessary items of instruction as recommended by the manufacturer of the unit. Attach to or post adjacent to the piece of equipment. Use weather-resistant materials when producing operating instructions, or suitably enclose the instructions for protection from the weather. Do not mount operating instructions in direct sunlight. Secure operating instructions to prevent easy removal or peeling.

E. Castings and Forgings

1. Before any work is started, the manufacturer shall communicate with the Engineer to arrange for inspections and tests. The Engineer shall be notified not less than two weeks prior to the start of work so that a representative of the Engineer may be present.
2. All necessary precautions shall be taken to fabricate the castings true to pattern in form and dimensions, free of pouring faults, cracks, cold shuts, blow holes and other defects in positions affecting their strength and value for the service intended.
3. All castings shall be cleaned free of loose scale and sand; all fins, seams, gates, risers, and other irregularities shall be removed. All unfinished edges of castings shall be neatly cast with rounded corners and all inside angles shall have ample fillets.
4. All castings shall be visually examined in accordance with ASTM A802, meeting visual inspection acceptance criteria Level II. Castings that do not pass this test may be rejected. Test results, whether positive or negative, shall be submitted to the Engineer. Test records meeting Level III may be considered for weld repair, provided the manufacturer submits a procedure to the Engineer for review and acceptance.
5. All castings that have solid sections 2 inches (50.8 mm) thick or greater and all fracture critical members shall be ultrasonically tested in accordance with ASTM A609, Method A, meeting Quality Level 2. Castings that do not pass this test may be rejected. Test results, whether positive or negative, shall be submitted to the Engineer. Test records meeting Quality Level 3 may be considered for weld repair, provided the manufacturer submits a procedure to the Engineer for review and acceptance.
6. All casting surfaces shall be magnetic particle examined in accordance with ASTM E125, meeting the following acceptable levels of discontinuities:

a. Type I	Cracks/Hot Tears	1/4-inch (6.35 mm) max
b. Type II	Shrinkage	Degree 3
c. Type III	Inclusions	Degree 3
d. Type IV	Chaplets	Degree 2
e. Type V	Porosity	Degree 1
7. Test results, whether positive or negative, shall be submitted to the Engineer. All surface discontinuities may be considered for weld repair, provided the manufacturer submits a procedure to the Engineer for review and acceptance.
8. All repair procedures shall include details of the areas to be repaired and a means to qualify the repair method. Repair procedures shall be performed prior to final heat treatment, so that no weld repairs will be needed after final machining. In addition, all surface defects removed by machining shall be performed prior to final heat treatment.
9. All castings that fail to meet the established acceptance criteria and considered rejected shall be replaced, at the Contractors expense, with new castings.

10. All carbon and alloy steel forgings shall meet the requirements of AASHTO Specification M102 (ASTM A668) unless otherwise indicated or accepted by the Engineer.
11. ASTM A668 forgings that are welded for fabrication of the completed machinery part shall have carbon content limited in accordance with Supplementary Requirement S4.
12. No tack welding on forged materials is permitted for lugs to aid with handling materials.
13. All forgings shall be reduced to size from a single bloom or ingot until homogeneity is secured. The blooms or ingots, from which shafts or pins are to be made, shall have a cross-sectional area at least three times that required after finishing. No forging shall be done at less than a red heat.

F. Bronze Castings

1. All bronze castings shall meet the requirements of AASHTO Specification M107 (ASTM B22) and be Copper Alloy UNS No. C91100 unless otherwise indicated or accepted by the Engineer.

G. Shafting and Pins

1. Fabricate all shafts in conformance to tolerances in ASTM A29 unless otherwise indicated. Turned, ground, and polished shafting straightness tolerances are to be up to 0.002 inch per foot (0.16 mm per meter) for shafts up to and including 1-1/2 inches (38 mm) in diameter, and up to 0.003 inch per foot (0.25 mm per meter) for shafts over 1-1/2 inches (38 mm) in diameter.
2. Accurately finish all shafts and pins round, smooth, and straight and when turned to different diameters, round fillets at the shoulders. Bore lengthwise through the center (to a diameter approximately 1/5 the smallest body diameter) for each shaft or pin having a uniform diameter of more than 8 inches (203 mm) and each shaft or pin having several diameters, of which the smallest is more than 8 inches (203 mm).
3. As required lengths are reached, fabricate each end of all shafts with a 60-degree lathe center, with a clearance hole at the exact center of the shaft. Prepare the ends of the shafts that have a hole bored lengthwise through the center for the attachment of a centering device equivalent to the lathe center. All such devices are furnished as part of the work. All such devices are to fit within the shaft ends such that the bore and lathe center are concentric to within 0.002 inch.
4. Where it is required on the plans that stepped shafts have fillets blended in smoothly to adjacent surfaces without tool marks or scratches, machine the surfaces to an ANSI maximum roughness of 63 micro-inches (1.6 micro-meters), unless otherwise required herein or on the plans to have a finer finish.
5. Fabricate all cold-finished shafting that is the type and grade of the steel shown on the plans, test for its mechanical properties, and submit a test certificate to the Engineer. Fabricate each cold-finished shaft free from camber. Test each to ensure rotation and that each runs without vibration, noise, or chatter at all speeds up to and including the maximum rated speed.
6. Use turned, ground, and polished commercial shafting of the grade specified where shown on the plans.

H. Fasteners

1. All bolts, either for connecting machinery parts to each other or to supporting members are categorized as one of the following types:
 - a. Finished body, high-strength bolts
 - b. Turned bolts, cap screws, and studs
 - c. High-strength turned bolts, cap screws, and studs
2. All high-strength bolts shown on the plans shall be finished body, high-strength bolts unless otherwise noted.
3. Finished body high-strength bolts are to meet the requirements of ASTM A449. High-strength bolts shall have finished bodies and regular hexagonal heads. Holes for high-strength bolts are to be individually reamed for a clearance of not more than 0.010 inch (0.25 mm) larger than the actual diameter of individual bolts for that hole.
4. Turned bolts, cap screws, and studs are to be provided with turned shanks, cut threads, and finished washer-faced hexagonal heads. For the finished shank of all turned bolts, cap screws and studs, use 1/16 inch (1.6mm) larger in diameter than the diameter of the thread. Determine the head and nut

dimensions based on the thread diameter. For the shanks of all turned fasteners, use a Class LC6 fit in the finished holes in accordance with ANSI B4.1. The material for the turned fasteners shall meet the requirements of ASTM A307, Grade A.

5. High-strength turned bolts, cap screws, and studs are to meet the requirements above, except that the material shall meet the requirements of ASTM A449.
6. Dimensions of all bolt heads, nuts, and hexagonal head cap screws are to conform to ANSI/ASME B18.2.1, Square and Hex Bolts and Screws, and ANSI/ASME B18.2.2, Square and Hex Nuts.
7. Provide heavy series heads and nuts for turned bolts, turned cap screws, and turned studs.
8. Dimensions of socket-head cap screws, socket flat-head cap screw, and socket-set screws are to conform to ANSI B18.3, Socket Cap, Shoulder, and Set Screws. Unless otherwise called for on the plans or specified herein, make the screws of heat-treated alloy steel, cadmium-plated, and furnish with a self-locking nylon pellet embedded in the threaded section. Set screws are to be of the headless, safety type with threads of the coarse thread series and having cup points. Do not use set screws to transmit torsion nor as the fastening or stop for any equipment that contributes to the stability or operation of the bridge.
9. Fabricate all threads for bolts, nuts, and cap screws to conform to the coarse thread series having a Class 2 tolerance for bolts and nuts or Class 2A tolerance for bolts and Class 2B tolerance for nuts in accordance with the ANSI/ASME B1.1, Unified Inch Screw Threads.
10. Spot face all bolt holes through unfinished surfaces for the head and nut, square with the axis of the hole.
11. Unless otherwise called for, sub drill all bolt holes in the machinery parts for connecting these parts to the supporting steel work at least 1/32 inch (0.8 mm) smaller in diameter than the bolt diameter and ream assembled for the proper fit at assembly or at erection with the steel work after the parts are correctly assembled and aligned.
12. Furnish positive locks for all nuts, except those on ASTM A449 bolts. Provide tempered steel and conform to the SAE regular dimensions for lock washers, where applicable. Use materials that meet the SAE tests for temper and toughness.
13. Furnish a hardened plain washer at each end of high-strength bolts meeting the requirements of ASTM F436.
14. Provide cotters conforming to the SAE standard dimensions and made of half-round stainless-steel wire, ASTM A276, Type 316.

Use only fasteners manufactured in the United States with the property class and source identification appearing on the top of head.

I. Keys and Keyways

1. Furnish keys and keyways conforming to the dimensions and tolerances for square and rectangular keys of the ANSI B17.1, Keys and Keyseats, meeting the requirements of Class 2 fits, unless otherwise specified. Furnish keys with chamfers on the outside corners and keyways with fillet radii on the inside corners as suggested by the ANSI Standard.
2. Effectively hold all keys in place, preferably by setting them into closed-end keyways milled into the shaft. Round the ends of all such keys to a half circle equal to the width of the key. If two keys are used in a hub, locate the keys 120 degrees apart and in line with wheel arms where practicable.
3. Furnish keys that are machined from alloy steel forgings, ASTM A668, Class K unless otherwise specified herein or on the plans. Orient the key lengths parallel to the metal flow during the hot working operation.

J. Sleeve Bearings and Bushings.

1. Fit all bearings as shown on the plans. Accurately machine the surface between the bushing and base.
2. Provide spiral grease grooves for each bushing. Round the corners of all grooves to a radius of not more than half the width of the groove.

K. Roller Bearings

1. Size anti-friction bearings for a B-10 life of 40,000 hours as defined by ABMA for the ratings shown on the plans.
2. Provide pillow block bearings, adapter mounted, self-aligning expansion and non-expansion types, as called for on the plans. Provide cast steel housings capable of withstanding the design radial load in any direction, including uplift. Cast bases without mounting holes. Sub-drill mounting holes from the solid and final ream with supporting steel work. Provide seals that retain the lubricant and exclude water and debris. Provide high-strength steel cap bolts for pillow blocks. Use cap and cap bolts capable of resisting the rated bearing load as an uplift force.

L. Shaft and Pin Journals

1. Accurately turn all journal bearing areas on shafts and pins. Grind and polish the journal surface and adjoining shoulder fillets to an ANSI maximum roughness of 8 micro-inches (0.2 micro-meters), leaving no trace of tool marks or scratches. Burnishing of the shaft journal area and adjoining shoulder fillets will be acceptable in lieu of grinding and polishing, provided the burnishing is done with a Stellite roller or equal, finished to a mirror surface. Finish journal diameters to the limits of an ANSI Class RC6 running fit.

M. Hubs and Bores

1. Finish the hubs of all gears, wheels, and couplings on both faces; polish the area where the hub face performs the function of a collar to prevent shaft movement. Bore the hubs concentric with the rims of gears and wheels or with the outside of the couplings. Furnish all hubs to have an ANSI Class FN2 medium shrink fit on the shafts, unless otherwise specified.

N. Shims

1. Where shown on the plans, all machinery shims required for leveling and alignment of equipment shall be brass, neatly trimmed to the dimensions of the assembled parts and drill for all bolts that pass through the shims. Shims shall be half-hard tempered Brass Alloy 260 conforming to ASTM B19 or ASTM B36 and furnished with certification and test reports. Shims shall be provided without bolt holes and shall be reamed after final alignment of equipment to the same fit as the other connected components. For shims greater than 1/2 inch (12.7 mm), include one solid plate of thickness equal to 1/2 inch (12.7 mm) less than total shim thickness.
2. Provide fully dimensioned shims as shown and detailed on the shop drawings. Shims with open side or U-shaped holes for bolts will not be permitted. Shims will have a minimum of two holes for bolts. To prevent distortion of shims, bolt holes shall not be punched at machine shop.
3. In general, provide sufficient thickness to secure 1/64-inch (0.4 mm) variations of the shim allowance plus one shim equal to the full allowance. Comprise the 1/2-inch (12.7 mm) nominal shim pack of the following thickness variations: one 1/2-inch (12.7 mm), one 1/4-inch (6.4 mm), one 1/8-inch (3.2 mm), one 1/16-inch (1.6 mm), one 1/32-inch (0.8 mm), and two 1/64-inch (0.4 mm).

O. Welding

1. Perform welding required for machinery in accordance with the requirements of the AASHTO/AWS D1.5, Bridge Welding Code. Stress relieving will be required prior to machining.
2. Provide welding joint sizes and details as shown on the shop drawings. For required multi-pass welds, submit welding procedures with shop drawings.
3. Distortion during fabrication must be kept to a minimum with the use of welding fixtures and proper welding procedures.
4. For all welds used to fabricate machinery, completely test by ultrasonic inspection per AWS D1.5 for compression welds unless otherwise noted. Perform all machining after welding and stress relieving.

P. Flexible Couplings

1. Provide couplings of the type as shown on the plans, which includes grid type, gear type, and others as needed.

2. In general, furnish couplings that are finish-bored and have keyways cut by the coupling manufacturer to dimensions and tolerances established on the shop drawings then ship to the manufacturers of the various components for shop installation on the shafts.
3. Provide grid-type, self-aligning, fully flexible, torsionally flexible couplings to connect electric motors to machinery components. Provide grid-type couplings with steel hubs, alloy steel grids, and steel or aluminum covers. Furnish all couplings with shrouded bolts.
4. Provide gear-type, self-aligning, full-flexible or semi-flexible couplings with floating shafts to connect all machinery components, except where other types of couplings are called for on the plans. Furnish all couplings with shrouded bolts. Make the gear-type couplings of forged steel having curved face teeth and providing for at least a plus and minus 3/4-degree misalignment per gear mesh.
5. Provide special couplings as shown on the plans.
6. Provide couplings that are standard products of an established manufacturer.

Q. Machinery Guards

1. Provide machinery guards for all moving parts as called for on the Contract Drawings.
2. Construct machinery guards to comply with the applicable requirements of ANSI B15.1, Safety Standard for Mechanical Power Transmission Apparatus.
3. Unless otherwise indicated or specified, construct all machinery guards with stainless steel with minimum thickness of No. 12 Gauge (2.6 mm). Furnish guards that require no disassembly of any machinery component.
4. Provide machinery guards with removable hinged or bolted covers for access to lubrication fittings enclosed by the guard. Provide phenolic nameplates on these covers with lubrication instructions.

R. Lubrication

1. Lubrication Fittings

- a. Use NPS 1/4 giant button head fittings, unless otherwise indicated on the plans. Where required, provide stainless steel seamless pipe to connect fittings to housings, allowing grease to discharge directly through the housing, shims, bushing, and into the grease grooves for distribution. Locate all grease fittings for convenient greasing, and if necessary, connect the points requiring lubrication from convenient lubrication stations by NPS 1/4 stainless steel seamless pipe – schedule 80 with stainless steel threaded pipe fittings – 3000 psi. Meet ASTM A312 and ASTM A182 for all stainless-steel pipe and fittings, respectively. Keep all pipe extensions as short as practical; securely support the pipe extensions at fittings and at intermediate points and locate so that they are protected from injury. Install only lubricating equipment that is in perfect condition.
- b. Do not use more than two (2) sizes of fittings. Use the larger size wherever possible; use the smaller size for motor bearings and other small devices. Use pressure fittings rated at a minimum of 3,000 psi (21 mPa). Furnish fittings that contain a steel check valve that will receive grease and close against back pressure.
- c. Immediately after the completion of fabrication, plug all fitting locations until components are installed and regular lubrication is started. At that time, replace the plugs with proper grease fittings. During installation, lubricate all rotating and sliding parts of the machinery and fill all gear reducers, bearing housings, and flexible couplings with lubricants indicated on accepted lubrication charts.

2. Lubrication Chart

- a. Furnish one (1) copy (on mylar) of lubrication charts showing the location of all lubricating fittings and other points of the mechanical and electrical equipment which require lubrication of any kind; show the kind of lubricant to be used at each point; and document the frequency of lubrication. Frame the chart under acrylic in a neat wooden frame, and place as directed by the Engineer.

- b. For each machinery component, store all related maintenance and lubrication literature in a heavy-bound binder, which is to be kept in the control house.

S. Hydraulic Charts

1. Furnish one (1) copy (on mylar) of hydraulic schematic. Frame the chart under acrylic in neat wooden frame and place on the wall adjacent to the hydraulic power unit.

Hydraulic Machinery

A. The requirements from Bridge Machinery specified herein apply to Hydraulic Operating Machinery.

B. Hydraulic Power Unit (HPU)

1. The HPU shall conform to ISO 4413.
2. All HPU components shall be arranged to be readily accessible for adjustment and maintenance.
3. The reservoir shall be a JIC configuration or equal as accepted by the Engineer. The reservoir shall be of heavy-duty welded ASTM A276 Type 316L stainless steel construction. Painting of interior surfaces is not permitted. The reservoir shall be structurally rigid to resist warpage and damage from the mounting of equipment on the reservoir top, handling during shipping, and erection at the bridge site. The reservoir shall have drains which allow a complete fluid change without disconnecting any hydraulic components. The reservoir shall have a fill port with a filter. The reservoir shall have an additional 2" NPS port with isolation valve and plug to allow for accessories to be added at a later date.
4. The reservoir shall contain a fluid conditioning magnet. The magnet shall extend from the top of the fluid level to 1" from the bottom of the reservoir and shall be removable without draining the reservoir.
5. The level indicator with integral thermometer shall be compatible with the hydraulic fluid. Permanent markings shall be provided showing the acceptable range of fluid levels and temperatures.
6. The reservoir shall contain means to separate return fluid from pump intake points by baffles or other means accepted by the Engineer; if baffles are used, they shall not prevent thorough cleaning of the reservoir.
7. The reservoir shall include a 316 stainless steel drip pan to contain minor fluid spills.
8. All fasteners, fittings, valves, equipment mounts, etc. shall be of a similar material to the reservoir, i.e., type 316 stainless steel, unless otherwise accepted by the Engineer.

C. Hydraulic Cylinders

1. Hydraulic cylinders shall be as specified on the plans, or approved equal.
2. Hydraulic cylinders shall conform to ISO 4413, Section 5.4.2.
3. Hydraulic cylinders shall be rated for 3,000 psi and shall have a minimum factor of safety of 3.00 against static pressure failure and buckling.
4. The hydraulic cylinder shall be manufactured by one of the following:
 - a. Bosch Rexroth
 - b. Eaton Hydraulics
 - c. Parker Hannifin

D. Hydraulic Pumps

1. Hydraulic pumps shall be as specified on the plans, or approved equal.
2. Hydraulic pumps shall be axial piston pumps with electronic displacement control.
3. Hydraulic pumps shall be manufactured by one of the following:
 - a. Bosch Rexroth
 - b. Eaton Hydraulics
 - c. Parker Hannifin

E. Hydraulic Piping and Tubing

1. All hydraulic piping material shall be seamless, low carbon stainless steel conforming to ASTM A312, type 316L. All hydraulic tubing material shall be seamless, annealed, low carbon stainless steel conforming to ASTM A269, type 316L, ISO 10763, and ANSI B31.1 standards. Maximum tubing size shall be 1.5 in nominal unless otherwise specified.

2. Pipe and tubing shall be designed such that the allowable working stresses established in ASME B31.1 are not exceeded at the maximum working pressure.
3. Unless otherwise specified or accepted by the Engineer, all piping shall be installed parallel or perpendicular to walls, floors and ceilings and shall be installed plumb, level and square. The installed location of the new piping shall not interfere with access to any equipment for maintenance (disassembly or in-kind replacement), lubrication, or cleaning. Piping shall be installed such that all NEC workspace clearances are met for new and existing equipment.

F. Pipe and Tube Supports

1. Hydraulic pipe and tube supports shall be of the cushion clamp type.
2. All clamps, fasteners, channels, unistrut, or adhesive anchors used for support shall be 316 stainless steel.
3. Support spacing and locations shall be in accordance with ISO 4413, Section 5.4.6 and ASME B31.1.
4. Hydraulic pipe and tube supports shall be manufactured by one of the following, or approved equal:
 - a. Hydac
 - b. Hydra-Zorb Company
 - c. Stauff

G. Pipe and Tube Fittings

1. All pipe and tube fittings shall be similar materials to the pipes/tubes in which they are fitted, i.e., 304 or 316 stainless steel.
2. Acceptable welded pipe fittings shall be 37° flare type or SAE straight thread for sizes up to and including 1.5-inch NPS. Mating 37° surface shall have an O-ring and O-ring boss for a leak-free connection. For connections greater than 1.5-inch NPS, butt welded or welded four-bolt flanges utilizing a captive O-ring pressure seal system shall be used. Flange fittings materials shall be similar to the flange materials. Flange bolts shall be provided with locking washers. Pipe threads shall not be used on any portion of the system where pressures exceed 200 psi. Where pipe threads are permitted (200 psi and below), pipe sealant is not permitted.
3. Tube connections shall use 37° flared fittings. The mating 37° surface shall use an O-ring and O-ring boss to provide a leak-free connection. The maximum allowable tubing size shall be 1.5-inch OD (outside diameter) unless otherwise specified.
4. The following standards apply for pipe and tube fittings:
 - a. SAE J514 for JIC 37° fittings
 - b. SAE J514 for O-Ring Boss (ORB) fittings
 - c. SAE J1453 for O-Ring Face Seal (ORFS) fittings
 - d. SAE J518 for Flanges
5. For pipe/tube located in any areas that are not readily accessible and/or located outdoors, only welded pipe/fittings are permitted.

H. Hydraulic Pipe Welding

1. Hydraulic pipe welding and testing shall be in accordance with ASME B31.1
2. Welding joint sizes and details shall be shown on shop/working drawings. Weld procedures shall be submitted with the shop/working drawing.

I. Flexible Hose

1. Flexible hose material shall be hydraulic duty. SAE J517 shall be used to determine the maximum allowable operating pressure for the hose. Hoses shall be designed for an operating pressure of 3000psi. Hose assemblies shall be shop assembled by the hose supplier. Hose lengths shall be kept consistent, where practical.
2. Hose end connections shall be Type 304 stainless steel for 37° female JIC swivel connections or Type 316 stainless steel for four-bolt, O-ring flange connections. Flange dimensions shall be in accordance

with SAE J518. Flange bolts shall be provided with locking washers. Hose fittings shall conform to SAE J516 standards.

3. Flexible hoses shall be restrained or confined in all cases where a hose failure would constitute a hazard.
4. Hoses shall only be used where specified on the plans, unless otherwise accepted by the Engineer.

J. Valves

1. Valves shall conform to ISO 4413, Section 5.4.4. All valves required for span movement shall be provided with a manual override.
2. Adjustable valves shall be equipped with protective caps or locking nuts on the adjusting screws to prevent unintentional maladjustments. Set points shall be clearly identified on the valves.
3. Directional control valves and blocking valves shall be provided with adjustable pilot control chokes to increase valve opening and closing time for shock and surge pressure control.
4. All valves and valve housings shall be similar materials to the pipes/tubes in which they are fitted, i.e., 304 or 316 stainless steel, unless otherwise accepted by the Engineer.

K. Filtration and Fluid Conditioning

1. Filtration and fluid conditioning shall be in accordance with ISO 4413. All filters and strainers shall be equipped with an indicator to show when the filter requires servicing.
2. Provide the degree and quality of filtration to meet the cleanliness requirements provided herein. Filter Bypass valves shall be provided as required by the Plans. Filter flow capacity ratings shall be as recommended by the pump manufacturer.

L. Pressure Indicators

1. Gages shall be of durable construction. Dial faces shall be clearly calibrated for pressure ranges 50% beyond the maximum design operating pressures of the hydraulic system. Gages shall be accurate and shall permit continuous monitoring. Gages shall have a minimum diameter of 3 inches, and preferably 4 inches. Shutoff valves shall be provided at each gage.
2. Portable gages shall be provided for maintenance and adjustment of the hydraulic system. The pressure ranges shall cover all possible values that will be needed for the system. One gage shall be provided for each pressure range such that the test pressure will be within the mid-half of the total pressure range of the gage. Connections for portable gages shall be of the quick-disconnect type. Test ports shall be equipped with removable, protective caps, secured by chains to the component. Test ports shall be provided for all locations that can be pressurized without a permanent pressure gage indicating the pressure.

M. Nameplates

1. Hydraulic cylinders shall have engraved permanent stainless-steel nameplates which are securely attached to the head of the cylinder. The nameplate shall clearly indicate the manufacturer, model number, cylinder bore, rod diameter, stroke length, pressure rating, and a list of nonstandard features.
2. Nameplates shall be provided for each control valve indicating the name and function of the valve. The manufacturer part number shall be shown on the nameplate. Nameplates shall either be engraved stainless steel or a lamicoid nameplate showing white characters on a black background or black characters on a white background.
3. Nameplates shall be provided for each adjustable hydraulic component. The nameplate shall provide the name, function, set point, and manufacturer part number for the component.
4. Nameplates shall additionally meet the requirements of ISO 4413 Section 7.4 Marking and Identification.
5. A unique identifier for each component shall be shown on each nameplate to allow the item to be cross-referenced on the hydraulic schematic.

N. Hydraulic Fluid

1. Provide all hydraulic fluid required to test, store, flush, and install the hydraulic systems in working order.
2. The hydraulic fluid must be a premium non-toxic, anti-wear hydraulic oil suitable for the environmental conditions. The fluid must be non-harmful to the environment and readily biodegradable.
3. The hydraulic fluid must have a minimum viscosity index of 200 with an ISO Viscosity Grade of 32 to 46 at a temperature of 100°F unless otherwise approved by the Engineer. The hydraulic fluid selection shall be coordinated with the Department.
4. The minimum fluid cleanliness level shall be as stated in the plans, or the cleanliness level required by the most contaminant-sensitive component in the system, whichever is cleaner.

O. Quick Disconnects

1. Quick disconnects shall not be used except where otherwise specified herein.

P. Bends

1. 5D bends or greater shall be utilized where practicable to eliminate pipe joints. Bends of any lesser radius are not permitted.

Q. Spare Parts

1. Spare parts shall be packaged and lubricated for long term storage.
2. Spare parts shall be labeled with a unique identifier to allow the part to be cross-referenced on the hydraulic schematic.
3. In addition to the spare parts described under other items, the following spare parts shall be provided:
 - a. Two lubrication fittings of each different type and size used.
 - b. One desiccant breather for the reservoir.
 - c. Two spare solenoids for each different solenoid used.
 - d. One spare filter element for each filter.
 - e. Two spare seals/o-rings for each different type/size used.
 - f. Two spare hoses for each different size/length. Consistent hose sizes shall be used to the maximum extent practical.
 - g. One spare ball valve for each size used.
 - h. One spare pressure gage for each type/range.
 - i. One spare pressure relief valve for each unique valve.
 - j. One spare for each different pipe fitting (tee, union, etc.)
 - k. Four 5-gallon buckets of hydraulic oil
 - l. One spare card for each proportional control valve

Span Lock Machinery

A. The requirements from Bridge Machinery listed herein apply to Span Lock Machinery.

B. Lock Bar Actuator

1. The lock bar actuator must be of the acme screw type, ball screw type, or roller screw type, meet the requirements of the plans, these specifications and the electrical specifications, and contain the following features:
 - a. Integrated limit switches
 - b. Solenoid brake
 - c. Marine environment rating, materials and coatings
 - d. Manual drive hand crank with safety interlocks
 - e. Designed for motor stall loads and/or provided with a means to prevent a mechanical failure in the event of actuator binding.

2. The lock bar actuator shall be equipped with a disengaging manual hand crank and disengaging mechanism with an electrical interlock safety switch that prevents the actuator from powered operation when the hand crank is engaged.
3. Anti-friction bearings shall be sized for a B-10 life of 10,000 hours as defined by ABMA for the normal operating thrust loads shown above.
4. The actuator shall be rated for outdoor use in a marine environment.

C. Spare Parts

1. Provide the following spare parts for the Span Lock Machinery:
 - a. One (1) spare shim pack per wear plate

Span Balance

A. General

1. All materials for Span Balance shall meet the requirements of Bridge Machinery and the Plans.

B. Submittals

1. Shop drawings shall meet the requirements of Bridge Machinery.
2. Submit shop drawings showing the final dimensional configuration of counterweight pockets and counterweight blocks.
3. Submit detailed counterweight computations for the final leaf configuration and balance state.
4. Counterweight computations shall include all calculations required to determine the balance condition, including the final span weight and the location of the center of gravity as specified herein.
5. Span Balancing Procedure: Submit description of proposed equipment to be utilized, parameters for equating pressure/torque to imbalance moment, proposed balancing procedures and proposed reporting forms for review and acceptance.
6. Span Balancing Report: Submit the aforementioned Span Balancing Procedure along with the pressure/torque measurements with associated leaf positions, accompanying weather, wind, and temperature measurements, quantification of the location of the center of gravity of the leaf, summary, and conclusions, and Signed and Sealed by a Professional Engineer registered in the State of Delaware.
7. Provide all counterweight shop drawings and counterweight computations signed and sealed by a Professional Engineer registered in the State of Delaware.

C. Counterweight

1. The Counterweight design was based on an assumed concrete unit weight of 369 pcf.
2. Any variation to the Contract Drawings or Special Provisions must be submitted to the Engineer for review and approval.

D. Counterweight Unit Weight Testing

1. A minimum of 60 days prior to completion of the final balance calculations and final detailing of the Counterweight, perform concrete unit weight testing for the purpose of determining the actual unit weights of the Counterweight concrete and concrete to be used in the Bascule Leaf deck, slabs, and curbs. Utilize the same concrete mixing procedures proposed for use in the completed structure. Submit the procedure(s) for review and approval prior to unit weight testing. Include in the mix design submittals the theoretical (computed) wet unit weights and the estimated equilibrium unit weights of the concrete.
2. Suggested Unit Weight Testing procedure is as follows:
 - a. Following approval of the mix designs, perform unit weight tests of wet concrete in accordance with ASTM C138, *Standard Test Method for Unit Weight, Yield and Air Content (Gravimetric) of Concrete* (i.e., use of a calibrated unit weight test bucket) for the purpose of accurately verifying the computed wet unit weights. Perform unit weight verification tests for each concrete mix design.
 - b. Make test cylinders (or blocks) for each mix design to establish the change (reduction) in concrete unit weight from the wet condition to the equilibrium condition for purpose of

verifying the estimated equilibrium concrete unit weights. Make a minimum of five test samples for each mix design. Prepare samples from the same batch of concrete that the wet unit weight tests were performed. Use only plastic or metal forms. Weigh the forms for the test samples prior to making the samples and immediately after making the samples (i.e., while the concrete is wet.) Determine the approximate unit weight by dividing the net weight of the concrete (weight of concrete less weight of form) by the computed volume of the sample. Leave the concrete in the form for a period equal to the wet curing period for the actual Counterweight. Following this period, remove the concrete from the forms to permit normal water evaporation. Store the samples under shelter in the open air and do not apply water to them for purpose of curing. Weigh the samples immediately following removal from the forms and at subsequent intervals not to exceed seven days until the unit weight has achieved an equilibrium unit weight within ± 0.5 pcf.

- c. Perform additional unit weight testing of the concrete of each truck delivered to the site for placement into the counterweight or bascule span deck in accordance with ASTM C138. Do not place concrete into the structure unless the wet unit weight is found to be within ± 2.0 pcf of the previously verified wet unit weight. Maintain a running total of concrete weight and make adjustments in air content as required to achieve the target average.
3. Following the unit weight testing, submit all test data to the Engineer for review. Once approved, use the verified unit weights for all balance calculations and counterweight details.

E. Counterweight Balance Blocks

1. Materials shall be as per the plans.

CONSTRUCTION METHODS:

Bridge Machinery

A. General

1. Demolition and disposal of the existing bridge machinery components mounted on the piers, abutments, and superstructure shall be paid under Item 211505 – REMOVAL OF EXISTING BRIDGE.
2. Comply with all City, State and Federal rules and regulations concerning the legal disposal of any contaminated waste materials from the execution of this work.

B. Shop Fabrication

1. To permit inspection, give two weeks' notice to the Engineer before the beginning of work at foundries, forge, and machine shops. Notify the Engineer of the location(s) where the order(s) have been placed prior to casting, forging, or machining any materials.
2. Furnish all facilities for the inspection of material and workmanship in the foundries, forge, and machine shops. Allow free access to necessary parts of the premises to the Inspector designated by the Engineer. Work done while the Inspector has been refused access or presented in a manner that prevents adequate inspection will automatically be rejected.
3. The Inspector shall have the authority to reject materials or workmanship, which do not fulfill the requirements of these Special Provisions.
4. Inspection at the foundries, forge, and machine shops is intended as a means of facilitating the work and avoiding errors. It is expressly understood that inspection will not relieve the Contractor from any responsibility in regard to imperfect material or workmanship and the necessity for replacing defective materials or workmanship, which are delivered to the job site.
5. Furnish the Engineer with a copy of all orders covering work performed by subcontractors or suppliers.

6. Unless otherwise provided, furnish without additional cost to the Department test specimens as required, and all labor, testing machines, tools, and equipment necessary to prepare the specimens and to make the physical tests and chemical analyses required by material specifications. Furnish a copy of all test reports and chemical analyses to the Engineer.
7. The acceptance of any material or finished parts by the Engineer are to be a bar to their subsequent rejection if found defective. Rejected material and workmanship shall be replaced or made acceptable by the Contractor at no additional cost to the Department.

C. Shop Installation and Testing

1. Assemble machinery components to verify their correct fit prior to shipment. Measurements required for each assembly shall be as shown on the plans and/or described in the individual pay items.

D. Defective Material and Workmanship

1. All machinery rejected during inspection and testing, that is not made acceptable, is to be removed from the work site and replaced at Contractor's expense.
2. Delays resulting from the rejection of material, equipment or work is not to be the basis of any claim.
3. Correct, at Contractor's expense, all defects found during the guarantee period resulting from faulty material, components, workmanship, or installation.

E. Delivery and Storage

1. Protection for Shipment

- a. Clean machinery parts of dirt, chips, grit, and all other injurious materials and coat all unpainted surfaces with a corrosion-inhibiting preservative prior to shipping.
- b. Finished metal surfaces and unpainted metal surfaces that would be damaged by corrosion are to be coated as soon, as practicable, after finishing with a rust-inhibiting preservative. With the exception of unfinished metal surfaces inside of gear reducers, remove this coating prior to operation and from all surfaces prior to painting after erection.
- c. Any interface between stainless steel or aluminum and structural steel is to receive an Engineer-accepted coat of zinc-rich primer prior to assembly.
- d. Completely protect machinery parts from weather, dirt, and all other injurious conditions during manufacture, shipment, and storage.
- e. Protect shaft journals that are shipped disassembled from their bearings during shipment and before erection by a packing of oil-soaked rags secured in place by burlap and covered with heavy metal thimbles or heavy timber lagging securely attached. Take every precaution to ensure that the bearing surfaces are not damaged and that all parts arrive at their destination in satisfactory condition.
- f. Mount assembled units on skids or otherwise crate for protection during handling and shipment.

2. Package and Delivery of Spare Parts

- a. Protect spare parts for shipment and prolonged storage by coating, wrapping, and boxing.
- b. Durably tag or mark all spare parts with clear identification showing the designation used on the accepted shop drawing.
- c. Clearly mark on the outside of the boxes for spare parts showing their contents. Deliver spare parts to a location designated by the Department.

3. Guarantee and Warranties

- a. Manufacturers' warranties or guarantees on equipment, materials, or products purchased for use on the Contract are to be consistent with those provided as customary trade practice, obtained by the Contractor, and upon acceptance of the Contract. Assign to the Department all manufacturers' warranties or guarantees on all such equipment, material, or products furnished for or installed as part of the Contract.

- b. Warrant the satisfactory in-service operation of the mechanical equipment, material, products, and related components. This warranty extends for a period of one year following the date of final acceptance of the Project.

F. Erection

1. Submit calculations for each stage of construction, and drawings and procedures detailing the intended scheme for installing all machinery. Machinery installation is done in a coordinated manner to ensure all the machinery components fit the adjacent material furnished under other items.
2. Alignment and Bolting
 - a. The order of assembly and alignment of bridge machinery shall be as per an Engineer accepted installation procedure. To achieve proper alignment of mating components prior to final reaming and fastening, limit the finality of some staged machinery installations.
 - b. Match-mark all parts of the machinery for proper assembly and correct orientation. Before final drilling or reaming, adjust all parts to exact alignment by means of shims. If required, provide tapered shims at Contractor's expense. Include installation, alignment, and shimming of the electric motors and devices such as limit switches and encoders, with the machinery for such erection. After final alignment and bolting, all parts are to operate smoothly.
 - c. Do not operate the span via the hydraulic cylinders until all machinery components are installed and bolted, in final alignment, as accepted by the Engineer.
 - d. In general, after final alignment of machinery, drill bolt holes into the structural steel from the solid for connecting machinery. For erection and alignment of machinery, use sufficient erection holes, sub-drilled 1/4-inch (6.35 mm) undersize for undersized temporary bolts. As the machinery is aligned in its final position, drill full-size holes for the remaining bolts, or sub-drill and ream; install the full-size bolts; and remove the temporary bolts. Ream full-size the undersized holes (used for temporary bolts) and install full-size bolts.
 - e. Drill and ream assembled bolt holes in structural steel and machinery components (with shims in place) to assure accurate alignment of the hole and accurate clearance over the entire length of the bolt within the specified limit. Check the clearance with 0.011-inch (0.28 mm) wire. The hole is considered too large if the wire can be inserted in the hole together with the bolt. Connect machinery components to structural elements or to other machinery components comprised of different thickness using high-strength bolts. Wherever possible, install the bolts such that the head is adjacent to the connected element with the least thickness.
 - f. Handheld reamers are not considered accurate enough; use a reaming jig to keep the bolt hole cylindrical. Use a jig made of structural steel, fixed to the drill, and secured to the work preventing the reamer shaft from deviating. Check holes with a bolt hole micrometer to assure uniform diameter.
 - g. Torque finished body high-strength bolts meeting the requirements of ASTM A449 to the same tension required for ASTM A325 bolts.
 - h. Indicate torque values for other classes of bolts on the erection drawings proportioned to their strength.
3. Coatings
 - a. Coat threads for turned bolts with anti-seize compound before assembly with nuts to prevent corrosion or galling, and to facilitate future removal, if necessary.
4. Edges and Corners
 - a. Round or chamfer all edges and corners of machinery parts, sheet metal work, bed plates, and fabricated supports that are exposed in the finished work. Remove all burrs or other surface defects that could be injurious to workers erecting or maintaining the bridge machinery.
5. Personnel and Facilities

- a. Use competent millwrights that are skilled in the type of work involved to erect and adjust the machinery. Provide them with all necessary measuring and leveling instruments, as required.

G. Painting

1. Clean and paint any and all unfinished surfaces of machinery, as specified in Standard Painting Specifications. Along with the shop drawings, submit an outline of painting materials and methods for review.
2. Shop Painting
 - a. During final preparation, blast clean all external surfaces of unfinished machinery prior to painting. Blast cleaning must comply with the requirements of SSPC-SP6, Commercial Blast Cleaning, with the following exceptions:
 - i. Bearings with bushings in place
 - ii. Electric motors
 - iii. Limit switches
 - iv. Hydraulic cylinders
 - v. All equipment with shaft and/or hydraulic seals
 - vi. Other equipment as accepted by the Engineer
 - b. For the items above, clean the machinery or equipment with solvent and hand tools to meet the requirements of SSPC-SP2, Hand Tool Cleaning as depicted in SSPC VIS 1.
 - c. After proper surface preparation, give one shop coat of primer by hand brushing to all unfinished machinery surfaces. Protect cylinder rods.
3. Field Painting
 - a. Apply touch-up per the requirements of structural steel.
 - b. Take special care to avoid painting machinery surfaces, which are in normal rubbing contact. Mask, for protection from paint, all nameplates, legend plates, and escutcheons mounted on machinery. Lubrication fittings shall be kept clog-free.

H. Contractor's Inspection

1. After erection is complete, make a thorough inspection to ensure that mating surfaces are clean and free of obstruction, that all parts are properly aligned and adjusted as closely as practicable without actual operation; that all bolts are properly tightened; and that the span is properly balanced.
2. Inspect tightened fasteners in accordance with the Structural Steel Standard Specification. Verify that field painting has been performed as specified herein. Perform touch-up painting to correct all painting defects found during this inspection.
3. Verify that all components are properly lubricated as recommended by the manufacturers of the units.
4. Verify that the hydraulic oil meets the required cleanliness level.
5. Prior to machinery testing, the Engineer will accompany the Contractor during his final inspection. On the basis of the results of this inspection, the Engineer will determine whether the bridge is ready for field testing.

I. Field Testing

1. When the mechanical components and electrical equipment are ready for final testing, inform the Engineer not less than fifteen (15) calendar days prior to the scheduling of tests. During all tests, keep available a complete crew of mechanics and hydraulic technicians in order to provide operation of the span and to make all adjustments and corrections, which is required to complete the tests.
2. Prepare a field-testing procedure and submit to the Engineer for review and acceptance. Coordinate the testing procedure with tests required for the electrical equipment and include measurements of power and current drawn by the motors when operating under load as required hereinafter. Record hydraulic pressures and flow rates.
3. The testing procedure shall include but not be limited to the verification of proper installation, alignment, fastening, operation, and/or final adjustment of the following:

- a. Hydraulic Operating System
 - b. Trunnion and Counterweight Bearings
 - c. Span Lock Machinery
 - d. Span Link Arms and Bearings
 - e. Machinery Instrument Drives and Limit Switches
4. When the machinery and hydraulic system is ready for field testing, drive the machinery assemblies under normal, auxiliary, and manual operations. During normal operation, use the main electric power to cycle the operating machinery and bridge seats in the proper sequence to raise/lower the lift span ten (10) times. During normal operation, use both electric motors to cycle the operating machinery. During auxiliary operation, use the backup service and both motors to perform the same.
 5. During manual operation, demonstrate the use of manual features used to seat the bridge in case of emergency five (5) times.
 6. During the test runs, inspect each machinery assembly in its entirety to determine whether everything is in proper working order and fully meets the requirements of these Special Provisions, plans, and manufacturers' recommended tolerances. Perform all test runs in the presence of the machinery manufacturer's representative, the electrical control equipment manufacturer's representative, and the Engineer. The temperature rise of all electrical/hydraulic components shall not exceed design ratings. If any test shows that the components are defective, inadequate, or functioning improperly, make all corrections and adjustments, or provide the replacements required before final acceptance, at Contractor's expense.
 7. Coordinate this work with the field testing requirements for the hydraulic system.

J. Training

1. Provide two (2), 8-hour days of instruction to the Department's Operation and Maintenance personnel. The instruction shall include but not be limited to the following with respect to all bridge machinery components:
 - a. Function, Purpose
 - b. Normal Operation
 - c. Auxiliary Operation
 - d. Manual Operation
 - e. Maintenance
 - f. Adjustment
 - g. Trouble Shooting
 - h. Repair and Replacement
 - i. Checking and adding lubricants and hydraulic fluid
 - j. Venting of the hydraulic system
 - k. Adjustment of all adjustable components
2. During the training period, use the completed operating and maintenance manuals, in final form, for the purpose of familiarizing the Department personnel with its contents and usefulness. Provide an opportunity for Department personnel to offer final review comments on the content of the manuals both during and after the training period.

Trunnion Assemblies

A. General

1. Furnish, install, and adjust two heel trunnion assemblies and two counterweight trunnion assemblies. Trunnion assemblies must be as specified and as shown in the plans and include, but are not limited to, trunnion shafts, trunnion bearing assemblies, trunnion hub with backing ring, trunnion bore cover plates, liners, dowels, fasteners, shims, and lubrication fittings.
2. The requirements for trunnion assemblies apply to both the heel trunnion and the counterweight trunnion.

B. Work Included

1. There are two heel trunnion assemblies and two counterweight trunnion assemblies. The work includes shop drawing preparation, detailing, fabrication, erection. Alignment, testing, and adjustment as required to place the movable span trunnions into working condition.
2. Vertical and horizontal position, and angular orientation of the trunnions and trunnion bearings are to be determined relative the Trunnion Reference Centerline.
3. Determine orientation of the trunnion relative to the Trunnion Reference Centerline with the leaf in both the open and closed positions. In addition, take a minimum of two evenly spaced positions between fully open and fully closed.

C. Submittals

1. Submit complete fully detailed Shop Drawings of the trunnion assemblies and all parts and sub-assemblies. Indicate fits, finishes, sizes, connection attachments, size and type of fasteners, and accessories. Provide sub-assembly drawings for the machine shop and steel fabrication shop in addition to the final assembly drawings.
2. Submit shop erection drawings indicating the shop alignment tolerances for the counterweight trunnion shafts, hubs and backing rings, upon installation into the assembled structural steel. Submit shop erection drawings indicating the shop alignment tolerances for the heel trunnion bearing assembly upon installation into the assembled structural steel. Provide plan and elevation drawings of the trunnion assemblies indicating reference datums established on the structural steel. Indicate temporary supports, falsework, alignment jigs, etc., to be used to install the trunnion assemblies/bearings and adjust alignment. Indicate fastener installation (permanent and temporary) and tensioning or torque values.
3. Prepare and submit to the Engineer for review a detailed step-by-step procedure for machining the bascule girders to receive the trunnion assemblies. Include complete details and description of the equipment and tools used to establish the alignment of the machining equipment relative to the bascule girders (e.g., precision surveying, optical tooling, alignment wires, dial indicators, etc.). Include complete details and description of the equipment used to machine the bascule girder web faces and bores to receive the trunnion hubs. Provide sample data tables to be used in recording measured alignment, runout of the bascule girder webs and the bores. Submit the completed data tables with the measured values for each location prior to performing the machining operations.
4. Prepare and submit to the Engineer for review a detailed step-by-step procedure for installation of the trunnion hubs and backing ring into the bascule girders and trunnions into the hubs. Include methods for shrink fitting operations including cooling and/or heating of components, target temperatures and clearances. Provide complete details and description of the methods for lifting the components and inserting them (e.g., direct vertical insertion, horizontal sliding, etc.) Lifting and insertion devices shall be designed with appropriate factors of safety for the anticipated loads. Include a list of equipment and tools used to measure component dimensions and temperatures. Include sample data tables to be used in recording as-built girder web bores, trunnion, hub bores and outside diameters, and backing ring bore dimensions prior to performing the work and submit completed data tables with measured values for each assembly to the Engineer for review prior to performing the shrink fitting operations. Provide details of the equipment used during the installation including temporary supports, lifting devices, slides, stops, insulation, etc.
5. Prepare and submit to the Engineer for review a detailed step-by-step procedure for establishing and verifying the heel trunnion alignment during shop assembly of the bascule leaf steel framing to the specified tolerances. Include complete details of the equipment and tools to be used to establish the Bascule Leaf Shop Axis relative to the bascule leaf steel framing and to measure the alignment (e.g., alignment wires, lasers, precision surveying, optical tooling, etc.) Provide sample data tables to be used in recording the alignment of the trunnions relative to the Bascule Leaf Shop Axis and submit to the Engineer for review prior to performing the bascule leaf shop assembly. Submit the completed data

tables with the measured values prior to drilling bolt holes for the bascule leaf steel framing connections. Include calculations of alignment wire catenary sag where used.

6. Submit field erection drawings indicating field alignment tolerances for the trunnion assemblies. Provide plan and elevation drawings of trunnion assembly indicating reference datums established on the bascule pier and structural steel. Include plan for installing trunnion bearings on trunnion columns. Indicate temporary supports, falsework, alignment jigs, etc., to be used to install the trunnion assemblies, adjustment and alignment. Indicate fastener installation (permanent and temporary) and tensioning or torque values.
7. Prepare and submit to the Engineer for review a detailed step-by-step procedure for establishing and verifying the counterweight trunnion alignment during field erection of the balance frame structure to the specified tolerances. Include complete details of the equipment and tools to be used to set the Established Axis of Rotation and to measure the alignment (e.g., alignment wires, lasers, precision surveying, optical tooling, feeler gages, machinist level, etc.) Provide sample data tables to be used in recording the alignment of the trunnions relative to the Established Axis of Rotation and submit to the Engineer for review prior to balance frame field erection. Submit the completed data tables with the measured trunnion alignment values for final acceptance. Include calculations of alignment wire catenary sag where used.
8. Prepare and submit to the Engineer for review a detailed step-by-step procedure for establishing and verifying the location and alignment of the heel trunnion bearings. Refer to structural details and specifications and coordinate with the alignment and positioning of the trunnion towers. Include complete details of the equipment and tools to be used to position these components and to measure the alignment relative the Established Axis of Rotation (e.g., alignment wires, lasers, precision surveying, optical tooling, machinist level, etc.).
9. Prepare and submit to the Engineer for review a detailed step-by-step procedure for establishing and verifying the location and alignment of the counterweight trunnion bearing bases. Include complete details of the equipment and tools to be used to position these components and to measure the alignment relative the Established Axis of Rotation (e.g., alignment wires, lasers, precision surveying, optical tooling, machinist level, etc.).
10. Prepare and submit to the Engineer for review a detailed step-by-step procedure establishing and verifying the location and alignment of the link arm pins.
11. Submit As-Built measurements of each bearing clearance and bearing/hub clearance. Prepare and submit to the Engineer for review and approval fully detailed shop drawings of the trunnion assembly and all parts and subassemblies. Include all required materials, dimensions, fits, finishes, welds including associated weld procedure specifications, sizes and type of fasteners and associated installation tensioning values, coatings, and detailed information for all associated components and accessories. Provide sub-assembly drawings for the machine shop and steel fabrication shop in addition to the final assembly drawing(s).

D. Trunnion Tools, Materials, and Testing

1. Provide two (2) spherical bearings for the heel trunnion assemblies as shown on the plans.
 - a. Each heel trunnion spherical bearing must have a capacity of 225 kips static loading, 100 kips operational loading, 35 kips thrust loading and must not exceed a pressure of 1500 psi while in motion and 2000 psi while at rest.
 - b. Bearing grease groove design and locations to be coordinated with the minimum number of lubrication fittings as shown on the plans.
2. Provide two (2) spherical bearings for the counterweight trunnion assemblies as shown on the plans.
 - a. Each counterweight trunnion spherical bearing must have a capacity of 400 kips static loading, 375 kips operational loading, 60 kips thrust loading and must not exceed a pressure of 1500 psi while in motion and 2000 psi while at rest.

- b. Bearing grease groove design and locations to be coordinated with the minimum number of lubrication fittings as shown on the plans.
3. Provide materials for the remaining components of the trunnion assemblies as shown in the Plans. Provide all tools required for proper installation and alignment of the trunnion assemblies, including precision machinist levels. Utilize precision machinist level(s) for trunnion bearing setting and alignment accurate to the nearest 0.005-inch or less per foot. Provide required testing of all trunnion forgings per these Technical Special Provisions.

E. Trunnion and Hub Installation:

1. Conduct the entire trunnion/hub assembly procedure in the presence of the Engineer.
2. Submit as-built trunnion and hub dimensions to the Engineer prior to trunnion/hub assembly.
3. Assemble the trunnion to the hub to the fit shown in the Plans, by immersion of the trunnion shaft in a bath of dry ice and alcohol. Do not use liquid nitrogen or any other super-cooled gas. Provide an immersion time as directed by the fabricator, but not be less than 12-hours. This may be combined with heating the hub.
4. Prior to insertion of the trunnion into the hub, verify the diameters of the trunnion and hub bore using a micrometer accurate to the nearest 0.001-inch. Measure and record temperatures for trunnion and hub to the nearest 5-degree Fahrenheit.
5. Refer to the plans for the assembly steps required for both the heel trunnion and the counterweight trunnion.
6. Do not damage the trunnion shaft journals or hub during the assembly process. Inspect the hub for defects prior to and following assembly. Do not repair hub defects resulting from the assembly process without written approval of the Engineer.
7. Notify the Engineer of the trunnion/hub assembly procedure.

F. Initial Counterweight Trunnion Bearing Setting and Alignment Procedure:

1. Submit Alignment Procedure for Engineer review and approval. Refer to the Erection and Alignment Special Provision and the Plans for the alignment requirements.

G. Setting of Trunnion Shafts and Bearings

1. Submit Alignment Procedure for Engineer review and approval. Refer to the Erection and Alignment Special Provision and the Plans for the alignment requirements. Refer to the plans for the proposed installation steps.
2. After bascule leaf erection is complete, re-verify the alignment prior to drilling holes for permanent bolts. Drill and ream the holes and install the permanent bolts, one bolt at a time, to preserve alignment.

Hydraulic Machinery

A. Shop Assembly and Operation

1. The hydraulic power unit shall be shop assembled to verify proper operation prior to shipment. Components not mounted in a common base shall then be disassembled for shipment. Any components requiring selective assembly shall be match marked for future assembly. Notify the Engineer a minimum of two weeks prior to the shop operation. All tests listed in this section shall be witnessed and accepted by the Engineer. If any malfunctions are observed, they shall be corrected, and such units shall pass all shop tests before release from the manufacturer or assembler's shop.
2. Shop test procedures shall be submitted for review and acceptance by the Engineer. Test procedures shall have sufficient detail to show that all of the requirements from the contract documents are being met.
3. Custom manifolds shall be pressure tested to three times the maximum working pressure. This requirement does not apply to commercial manifolds that are rated for the maximum working pressure.

4. The assembled HPU and control valve stand shall be shop tested to 1.5 times the maximum working pressure for proper operation per the latest AASHTO Movable Bridge Design Specifications with interims section 7.8.4.2.2. Certified test data shall be submitted to the Engineer for review prior to shipment to the bridge site.
5. The HPU shall be shop tested a minimum of five (5) operating cycles for each mode of operation. Valves or other means shall be used to simulate the cylinder loads and piping pressure losses. The modes of operation to be tested include:
 - a. Bridge idle
 - b. Bridge raise/lower, normal operating pressure
 - c. Bridge raise/lower, peak operating pressure
 - d. Bridge raise/lower, 3-cylinder operation
 - e. Bridge raise/lower, 2-cylinder operation
6. During all tests, the HPU shall be checked for fluid leaks, fluid temperature, and proper relief valve operation.
7. The settings for all adjustable hydraulic components shall be verified and recorded during shop testing.
8. Pumps shall be checked during testing for external leakage, charge pump pressure and flow (when applicable), and main pump pressure and flow. Pump relief valves shall be checked for proper operation.
9. Hydraulic cylinders shall be tested by the manufacturer before shipment to the site. Testing shall include a 30-minute static pressure test in both the extended and retracted position at 1.5 times the maximum working pressure per the latest AASHTO Movable Bridge Design Specifications with interims section 7.8.4.2.2. The catalog rating certification shall be provided to the engineer.

B. Installation Sequence

1. Installation of the hydraulic equipment will include installing, aligning, and testing the complete hydraulic systems.
2. Prior to the start of any installation work, submit a procedure to the Engineer for review and acceptance.
3. It is the contractor's responsibility to verify and maintain the required cleanliness level at all time the equipment may be operated and verifying the level through resampling in the event of a deficient report from the first sample. The procedure of further cleaning the fluid, collecting, and processing additional samples shall be at the expense of the contractor.

C. Field Testing

1. When the mechanical machinery and electrical equipment are ready for final testing, submit to the Engineer a testing procedure and schedule in accordance with the requirements specified in the herein and Bridge Electrical Work. The bridge shall not be operated by the hydraulic equipment until all other machinery is in final alignment and bolted as accepted by the Engineer.
2. Prior to field testing the hydraulic system, flush the system (all field piping, etc.) as specified herein.
3. Reservoirs shall be filled with fluid to the correct level. Hydraulic fluid shall be filtered during filling to maintain the required cleanliness level.
4. During these tests, equipment shall be inspected for external fluid leakage, and to determine whether all features are in proper working order and adjustment, and whether they meet the requirements of the drawings and specifications. Portable pressure gages shall be used at all test stations of the hydraulic system, including the power unit. Leaks of any kind are not permitted and shall be corrected.
5. During all tests, the level of the hydraulic fluid in the reservoir shall be closely monitored. Proper fluid level shall be maintained at all times to prevent pump cavitation or drawing air. Air shall be bled from the hydraulic system and make-up fluid added to the reservoir as required. Hydraulic fluid shall be filtered during filling to maintain the required cleanliness level. In the event tests show that any

features are defective or inadequate, or function improperly, make all necessary corrections, adjustments, or replacements.

6. When all the components are in proper working order and adjustment, the pressure readings taken at each test station shall be recorded and provided to the Engineer.
7. After completion of final tests hydraulic fluid shall be removed, properly discarded, replaced with new fluid, and air bled from the entire hydraulic system. New fluid shall be added and shall be filtered during filling to maintain the required cleanliness level. In lieu of fluid replacement, the Contractor may take fluid samples from each reservoir for analysis by the fluid supplier. The fluid shall be changed if sample contamination levels are greater than the requirements for new fluid. New fluid, where required, shall be added and shall be filtered during filling to maintain the required cleanliness level.
8. After completion of final hydraulic testing, and either fluid replacement or the continued use of fluid which has passed contamination level testing, filter elements shall be replaced, magnets cleaned, and strainers shall be checked to confirm cleanliness.

D. Submittals

1. A hydraulic schematic shall be provided for review and acceptance by the Engineer. The schematic shall conform to the requirements of ISO 4413. The hydraulic schematic shall contain, at a minimum:
 - a. An item name and description for all components.
 - b. Design set points for all adjustable components
 - c. Item numbers and call outs for all components
2. A hydraulic power unit assembly drawing shall be provided for review and acceptance by the Engineer. The drawing shall conform to the requirements of ISO 4413. The hydraulic power unit assembly drawing shall contain, at a minimum:
 - a. Outside envelope dimensions of the hydraulic power unit assembly.
 - b. Maintenance envelope dimensions.
 - c. A complete bill of materials for all components including item number, item name/description, and original equipment manufacturer part number shall be provided. The description shall have sufficient detail so that all items can be replaced without having the original stock number of the item.
 - d. Call out bubbles shall be provided for all items.
 - e. Final set points shall be provided for all adjustable components.
3. A fill procedure shall be provided for review and acceptance by the Engineer. The fill procedure shall include materials and quantities.
4. Piping diagrams shall be provided for review and acceptance by the Engineer. The drawing shall conform to the requirements of ISO 4413. The drawing shall contain a complete pipe and fitting schedule. The descriptions in the pipe and fitting schedules shall have sufficient detail such that all items can be replaced without the original stock numbers.
5. Piping layouts and assembly drawings shall be provided for the hydraulic system. The drawings shall conform to the requirements of ISO 4413. These drawings shall clearly indicate the type and spacing of piping supports. The drawings shall be submitted and accepted by the Engineer before field erection will be permitted.
6. A Theory of operation shall be provided explaining how the control system works, including any PLC adjustments.
7. A flushing procedure shall be provided for review and acceptance by the Engineer. The flushing procedure shall describe the flushing loop(s), flushing flow rates, durations, and required cleanliness level.
8. Complete power calculations for the actual components used including pressure drop calculations for the system during normal operation.

9. Assembly and detail drawings shall be provided for all machinery components. These drawings shall be sufficiently complete that the machinery parts may be duplicated without reference to patterns, other drawings, or individual shop practice. These drawings shall be reviewed and accepted by the Engineer prior to purchasing any materials. This requirement shall include any custom hydraulic components.
10. Cutsheets shall be provided for all commercial components. The cutsheet shall indicate the full part number of the component. All of the catalog sheets for the component shall be included with the cutsheet submittal. Cutsheets shall be reviewed and accepted by the Engineer prior to purchasing any materials.
11. Certified test data shall be submitted to the Engineer for acceptance before shipment to the bridge site. Testing requirements are provided herein.
12. Certified dimension prints of the apparatus shall state in the certification the name of the job, the application of the apparatus, assembly/part designation, number required, right-hand or left-hand assembly, material, finish, and any other pertinent data to show that the apparatus meets the specified requirements.
13. Equipment shall not be shipped to the job site until the submittals are accepted by the Engineer.
14. Upon completion of the work, correct all shop or working drawings to show the work as constructed and provide As-Built copies to the Owner. As-built drawings shall include dimensioned assembly views and all dimensions, tolerances, fit, and finishes of all parts manufactured and installed on the bridge by the Contractor.
15. Operations and maintenance manuals per the requirements of Bridge Mechanical System – General shall be furnished to Owner. Note that all manuals shall be organized such that all operations, maintenance procedures, lubrication charts, and drawings shall be located in the front of the manual. Backup data such as cut sheets and standard equipment data shall be organized in an appendix.
16. Lubrication charts shall be provided for review and acceptance by the Engineer. The charts shall include all bearings, electrical equipment, and all elements of the bridge which require lubrication. The chart shall provide the recommended lubricant and the frequency of lubrication. The chart shall detail any purge plugs that need to be removed prior to lubrication. In addition, 24"x36" large format lubrication charts framed and covered with plexi-glass shall be provided for the bridge and mounted at a location chosen by the Owner.
17. Submit to the Engineer for acceptance all of the aforementioned submittals. In case of correction or rejection, resubmit until they are accepted. Bear all costs for damages, which may result from the ordering of any materials prior to any required approval; and no work shall be done until the design drawings therefore have been accepted by the Engineer.

Span Lock Machinery

A. General

1. All construction methods shall meet the requirements of the Bridge Machinery specified herein.

B. Work Included

1. There are two span lock assemblies. The work includes shop drawing preparation, detailing, fabrication, erection. Alignment, testing, and adjustment as required to place the movable span trunnions into working condition.
2. Vertical and horizontal position, and angular orientation of the span lock front guides and actuators shall be from the bascule girder centerlines at fully closed.

C. Submittals

1. Submit complete fully detailed Shop Drawings of the span lock assemblies and all parts and sub-assemblies. Indicate fits, finishes, sizes, connection attachments, size and type of fasteners, and accessories. Provide sub-assembly drawings for the machine shop and steel fabrication shop in addition to the final assembly drawings.

2. Prepare and submit to the Engineer for review a detailed step-by-step procedure for machining the bascule girders to receive the span lock receiver weldments. Include complete details and description of the equipment and tools used to establish the alignment of the machining equipment relative to the bascule girders (e.g., precision surveying, optical tooling, alignment wires, dial indicators, etc.). Include complete details and description of the equipment used to machine the bascule girder web and stiffener faces. Provide sample data tables to be used in recording measured alignment, runout of the bascule girder webs and stiffeners. Submit the completed data tables with the measured values for each location prior to performing the machining operations.
3. Submit field erection drawings indicating field alignment tolerances for the span lock assemblies. Provide plan and elevation drawings of span lock assembly indicating reference datums established on the approach and structural steel. Include plan for installing front guides and actuators on the approach slabs. Indicate fastener installation and tensioning or torque values.

D. Span Lock Machinery Anchors and Alignment

1. Coordinate the positioning and embedment of the anchors for the front guides and span lock actuators with the new concrete slabs.
2. Anchors for the front guide are to be 1" nominal diameter and shall meet the requirements of H.S. bolts for the Bridge Machinery.
3. Nominal diameter for the span lock actuator anchors will be as specified by the manufacturer.
4. Utilize jacking screws in the base plates of the front guides and actuators for alignment and leveling.
5. After final alignment is approved, grout the front guides and actuators in place with non-shrink grout as specified in DelDOT Standard Specifications. Fill all annular areas.

Span Balance

A. General

1. Notify the Engineer a minimum of 28 days prior to the date that is anticipated that the Balance Verification Testing will be performed.
2. Coordinate the work of this section to ensure proper alignment of the live load shoe assemblies, proper alignment and installation of span lock wear plates, proper alignment of span lock bars, and proper adjustment of the bascule link arms.
3. Prepare and submit for review and approval complete balance calculations and Counterweight Shop Drawings as described within the Special Provisions, as well as the Contract Plans. Do not proceed with construction of the Counterweight (i.e., placement of the Counterweight concrete) until balance calculations, drawings and final details have been reviewed and approved by the Engineer. The Contractor's Specialty Engineer shall certify that the calculations have been fully checked prior to submission.
4. Prepare and submit for review and approval complete weight and center of gravity calculations from approved shop details of the Bascule Leaf, balance frame, and all components attached thereto. Compute balance calculations for the Initial Balance state and Final Balance state as described within the Special Provisions and Contract Drawings.
 - a. Compute weights of individual components to the nearest 0.1 lb accuracy. Summarize weights of assemblies to the nearest 1.0 lb accuracy. Summarize Bascule Leaf weight to the nearest 0.1 kip accuracy.
 - b. Locate the Center of Gravity (C.G.) of each component or assembly of components both horizontally and vertically.
 - i. The C.G.'s shall be referenced longitudinally to the center line of the heel trunnion:
 - (1.) Positive (+) distances are recorded for elements forward of the trunnion (i.e., toward the channel).
 - (2.) Negative (-) distances are recorded for elements behind the trunnion.
 - ii. The C.G.'s shall be referenced vertically to the center line of the heel trunnion:

(1.) Positive (+) distances are recorded for elements above the trunnion.

(2.) Negative (-) distances are recorded for elements below the trunnion.

c. Record distances to components or assemblies to the nearest 0.01 foot of accuracy.

5. Throughout the construction and testing phases, the bascule span must be verified to be within the following tolerance and approved by the Engineer for temporary operation:

a. Toe Reaction: 1000 lbs. to 5000 lbs.

B. Counterweight Adjusting Blocks

1. Fabricate counterweight adjusting blocks only after acceptance by the Engineer of the appropriate counterweight computations as specified elsewhere in this Technical Special Provision.
2. Place and arrange blocks throughout the course of the Work as required for achieving or maintaining acceptable balance states.

C. Span Balancing - General

1. For the initial and final balance states, obtain, as a minimum, pressure/torque measurements as follows: At leaf angular positions of every 10 degrees from Fully Closed to Fully Open. For a minimum of three cycles of the leaf; the intent is to obtain three measurements at each angular position, the second and third measurement being made after the leaf is cycled back to the closed position.
2. Given the numerous variables that may have an effect on the values of the pressure/torque measurements, schedule testing generally as follows in order that measurements taken on one day may be better correlated with measurements taken on another day:
 - a. In the morning at sunrise so as to minimize the differential in ambient temperature.
 - b. At a time with no wind; if wind exists, preferably the wind should not be in a direction along centerline of the bridge (perpendicular to the bridge deck surface).
 - c. At a time where the main hydraulic system has remained idle for a period of time and the hydraulic oil is being maintained by the system at its lowest temperature.
3. For each torque measurement, obtain and record the following data: Ambient temperature, weather conditions, wind speed and direction at the roadway surface, and oil temperature in power unit reservoirs and surface temperature of blind end cylinder piping.

D. Initial Balance State

1. Establish the initial balance state of each leaf at the time that tie-downs are disengaged, and the leaf is moved for the first time utilizing the main drive system.
2. If appropriate, revise Leaf Balancing and Stability Plan and submit for the record.

E. Final Balancing

1. Complete all work on the leaf, including application of protective coatings, except for the installation of the live load shoe assemblies and the adjustment of the span lock assemblies, prior to initiation of the final balancing program.
2. Perform the final balancing of the leaf; achieve an acceptable final balance state as specified on the Contract Drawings and as follows:
 - a. Toe Reaction: 3750 lbs. to 4250 lbs.
3. Achieve an acceptable final balance state prior to the Department conducting Balance Verification Tests.
4. Submit Balance Report and arrangement of adjusting blocks; submit Balance Report a minimum of seven days prior to date that the project is ready for the Department to begin Balance Verification Testing.
5. The reports will be bound in between heavy plastic covers. Include in the report an introductory section incorporating the name of the bridge, the shafts tested, the date of the test, weather conditions during testing, and any other information requested by the Engineer.
6. Record changes for submittal of final adjusting block configuration.

METHOD OF MEASUREMENT:

A. The Department will not measure the work included under this item.

BASIS OF PAYMENT:

The work will be paid for at the contract bid price for lump sum for Item 615503-Bridge Mechanical System. This price shall include all labor, tools, equipment, material and incidentals necessary to satisfactorily complete the work in accordance with the Contract Plans and Special Provisions.

The lump sum bid for Item 615503 shall be the sum of the costs associated with the work performed. The completed Breakout Sheets must be submitted with Bid Proposal.

12/14/2023

615504 – BRIDGE ELECTRICAL SYSTEM

DESCRIPTION:

The work under this Section shall consist of furnishing all labor, materials, plant and equipment, and performing all work necessary to furnish and install electrical equipment and controls for operation of the bascule span and its auxiliaries, all as specified herein and indicated on the Contract Drawings.

Any incidental apparatus, appliance, material, or labor not specifically mentioned or included in the Contract Documents that may be found necessary to comply with the requirements of the related documents and referenced standards or codes shall be furnished by the Contractor at no additional cost to the Delaware Department of Transportation (DelDOT).

The contractor shall refer to the specific testing requirements herein which require stage 2 testing to be completed before the roadway detour expires and the bridge is opened back up to traffic.

Materials:

A. Standards

1. All electrical equipment and its installation shall conform to the requirements of the most current revision of the following specific codes and standards or the most current revision of the various standards produced by the agency listed, except as may be otherwise provided herein:
 - a. American Association of State Highway and Transportation Officials (AASHTO)
 - b. National Electrical Code (NEC)
 - c. American Society for Testing and Materials (ASTM)
 - d. American National Standards Institute (ANSI)
 - e. National Electrical Manufacturers Association (NEMA)
 - f. National Electrical Contractors Association (NECA)
 - g. InterNational Electrical Testing Association (NETA)
 - h. Underwriters Laboratories, Inc. (UL)
 - i. National Fire Protection Association (NFPA)
 - j. Institute of Electrical and Electronic Engineers (IEEE)
 - k. Occupational Safety and Health Administration (OSHA).
 - l. Insulated cable Engineers Association (ICEA).

B. General Requirements

1. All equipment and materials to be furnished shall be new unless otherwise specified elsewhere. All equipment, materials, and workmanship shall be manufactured and erected to the satisfaction of the

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Engineer. Any piece of equipment which is found to be defective or damaged in any way must be replaced at no additional cost to DelDOT.

2. The work shall include a warrantee for the in-service working of the electrical installations for one year or the manufacturer's warranty period, whichever is greater, following project acceptance by DelDOT. If the Contractor has any objection to any feature of the electrical equipment as designed or arranged, he must state his objection in writing to the Engineer prior to submittal of shop drawings, otherwise his objection will not be accepted if offered as an excuse for malfunctioning of the equipment or for defective or broken apparatus. Changes shall be made at the discretion of the Engineer.
3. Prior to installation, electrical equipment shall be stored in a temperature and humidity controlled environment. Damage to electrical equipment caused by moisture and/or weather conditions will require replacement. Once the equipment is installed but prior to acceptance of the bridge by DelDOT the Contractor will be responsible for maintaining the equipment in like-new condition and follow all manufacturer maintenance requirements. Equipment which is damaged in any way at the Engineers discretion shall require replacement at no additional cost to DelDOT.
4. Each piece of electrical equipment and apparatus shall have a corrosion-resistant nameplate screwed in place on which is stamped the name of the manufacturer, rating or capacity of the equipment or apparatus, catalog number, serial number, etc.
5. All metal parts of the installation, except structural steel, shall be of corrosion-resisting material, such as bronze or stainless steel. Cast-iron, malleable iron or steel with a hot-dip galvanized finish shall be used where specified herein.
6. In general, all mounting hardware and all wire and cable terminals shall be vibration resistant. If any departures from the Contract Plans or Specifications are deemed necessary by the Contractor, details of such departures, and the reasons for such departures shall be submitted for approval as soon as practicable. No such departures shall be made nor work started without the written approval of the DelDOT or authorized representative.

C. Sole Source Equipment

1. The Contractors attention is directed to the various sole source items for PLC equipment (Allen Bradley Control Logix), Traffic Gate Equipment (B&B Roadway) and general control equipment (Square D). Information regarding sole source products are specified elsewhere. No substitutions shall be granted for these items other than alternate part and model numbers that may be required due to obsolescence of equipment or to adjust the specified equipment for proper operation.

D. Substitutions

1. The terms "approved equal," "of equal quality," and "or equal" which appear on the plans and in these Special Provisions, are intended to allow the Contractor to substitute other manufacturers and model numbers of products of equal quality and rating for those specified unless specifically designated as a sole source item.
2. Prior to the ordering of any substitute product, the Contractor shall obtain in writing the Engineer's acceptance of the equivalence of the substitute product. Where materials are specified as Engineer approved equal, either DelDOT, or their authorized representative shall establish the basis for equivalence. The acceptance of the substitute product is at the sole discretion of this designated representative who will review the quality of the materials and products described in detail on the submitted shop drawings and product data.
3. The Engineer will return submissions for substitute material marked "Reviewed for General Conformity with the Plans and Specifications" (RGC), Reviewed for General Conformity with the Plans and Specifications As Noted" (RGCAN), or "Returned for Resubmission" (RFR). Upon return of a submission marked "Returned for Resubmission," return the submission showing the specified

product. Rejection or acceptance of a proposed substitute will not in any way result in additional cost to the Department, or in additional contract time.

4. Acceptance by the Engineer of any substitute product submitted by the Contractor does not relieve the Contractor of responsibility for the proper operation, performance, or functioning of that product.
5. A manufacturer's name and catalog part number specifying a particular product, whether in these Special Provisions or on the plans, is so specified to establish quality, configuration, and arrangement of parts. An equivalent product made by another manufacturer may be substituted for the specified product subject to the acceptance by the Engineer; however, make all necessary changes required by the substitution in related machinery and structural, architectural, and electrical parts, at no additional cost to DelDOT.
6. If any departures from the plans or these Special Provisions are deemed necessary by the Contractor, submit details of those departures and the reasons therefore, as soon as practicable for acceptance. Make no such departures without acceptance by the Engineer.

E. Bridge Control System Vendor.

1. All apparatus and equipment comprising the bridge control system, including, but not limited to motors, motor encoders, speed switches, limit switches, inclinometers, proximity sensors, back panels, terminal boxes, cabinets, control desk, resolvers, PLC equipment, ATS, relays, contactors, starters, circuit breakers, fuses, transformers and other apparatus required to provide a complete functioning system, shall be manufactured and/or furnished, assembled and integrated by a single qualified control system vendor. The vendor shall assemble all panels and cabinets at an Underwriters Laboratory approved facility in accordance with UL 508.
2. The control system vendor shall have experience in providing electrical control systems for movable highway bridges of various types, including bascule with PLC control systems, HMI touchscreen-controlled systems and hydraulically operated equipment. Such experience shall be demonstrated by identifying a minimum of five (5) movable bridges for which the system vendor has provided and fabricated similar systems. Pre-approved vendors are listed below who are known to meet these requirements.
 - a. Panatrol Corporation (630-655-4700)
 - b. EHM (954-981-0023)
 - c. Faith Technologies (631-793-4019)
3. The control system vendor shall assume complete system responsibility for the integrated functioning of all components to provide a satisfactory assembled system operating in accordance with specified requirements. The control system vendor shall be responsible for the detailed schematics and fabrication of the total control and power distribution system to ensure compatibility of equipment and suitability for the intended system functionality. The vendor shall provide supervisory assistance in the installation of equipment at the bridge site to ensure correct field wiring, maximum reliability, and ease of maintenance.
4. The vendor shall work closely with the hydraulic vendor for connection and control of the pump motors, hydraulic cylinders, valves, and amplifiers.
5. The system vendor shall provide a field service staff having the capability of providing services for field coordination of construction and final adjustments to the bridge control systems. Upon final acceptance of the bridge by DelDOT, the system vendors shall provide on-call warranty service for a period of one year.
6. Written certification shall be provided for compliance with specified requirements for his control system vendor who are not listed on the pre-approved vendor list above. Include documentation of conformance with these requirements. Provide references as needed to allow the Engineer to verify conformance with these requirements. This certification shall be submitted immediately after award of the contract and shall

be subject to approval by the Engineer. No payments shall be made prior to submission and approval of the certification of compliance for the control system vendor.

F. Control Apparatus and Miscellaneous Equipment

1. **Circuit Breakers:** All branch circuits from the buses shall be protected by molded-case circuit breakers and meet the requirements of UL 489. All breakers shall be compact and have quick-make, quick-break contacts and the mechanism shall be trip-free and trip indicating. Frame sizes shall be not less than 100 amperes. The breakers shall be equipped with thermal-magnetic trips or adjustable instantaneous magnetic trip units. Circuit breakers shall have a minimum interrupting capacity rating of 35 kAIC. The circuit breakers shall be Powerpact model manufactured by Square D.
2. **Miniature Circuit Breakers:** Circuit breakers for control circuits shall be single pole miniature type and meet the requirements of UL 489. The miniature circuit breakers shall be din railed mounted in the control panels and shall have a trip curve of D.
3. **Motor Starters and Magnetic Contactors:** The continuous current rating of contactors and starters shall be adequate for the connected inductive loads, and no starter shall be smaller than the size specified. Motor protective circuit breakers shall be provided for motor protection. The motor protective circuit breakers shall function as an overload and circuit breaker as one combined unit with plug in trip block modules. The motor protective units shall be of the manual reset type unless otherwise specified. Contactors and circuit breakers, overload modules shall be provided with the required auxiliary contacts as shown on the Contract Plans. Reversing contactors shall be electrically and mechanically interlocked. All motor starters and circuits breakers shall be connectable to a bus bar system, both manufactured by a single manufacturer. All contactors shall be provided with surge suppressors. Motor starter/protective circuit breakers and contactors shall be type GV2P, GV3P, and LC1/LC2 as manufactured by Schneider Electric.
4. **Industrial Control Relays** shall be multi-contact magnetic relays with contacts rated at 10 amperes, 600 volts on a continuous basis. All relays shall be provided with surge suppressors. Time-delay relays shall be provided through a delay attachment to the specified control relays. The time delays shall be electronic type providing time delay intervals as required with a linear timing range in the ratio of 1:10. The number and type of poles shall be as shown on the Contract Plans. Relays shall be CAD series as manufactured by Square D.
5. **Safety Control Relays:** Industrial control safety relays shall be multi-contact magnetic machine tool relays with contacts rated at 10 amperes, 600 volts on a continuous basis. Relays shall feature mechanically linked double break contacts on each pole and shall be specifically designed for safety applications. Tamper resistant covers shall be provided on each relay. Each safety control relay shall be equipped with surge suppression. Safety relays shall be type 700S as manufactured by Allen Bradley or approved equal.
6. **Control Cabinet Terminal Blocks:** Terminal blocks for conductors of Size No. 8 AWG and smaller for control cabinet and control desk connections shall be push-in type din rail mountable terminals rated for a maximum voltage of 1000 VAC/57 Amperes. Each terminal requiring a splice or jumper shall be provided with pin jumper connectors which are mountable to the terminal block. The terminal blocks assembly shall be provided with ground terminals, screw terminals, din rail, end plates, separators, pin connectors and any other required accessory. Where ground terminals are installed the enclosure back panel paint shall be removed exposing the steel for the ground connection. The terminal blocks shall be connected to wiring using insulated wire ferrule connectors. Factory printable corrosion resistant marking strips shall be provided for conductor identification. At least twenty percent spare terminals shall be provided. Terminal blocks shall be Phoenix Contact PT6 or approved equal.
7. **Field Mounted Terminal Blocks:** Terminal blocks for conductors of Size No. 8 AWG and smaller for terminal boxes shall be lug type din rail mountable terminals rated for a maximum voltage of 1000 VAC/125 Amperes. Each terminal requiring a splice or jumper shall be provided with pin jumper

connectors which are mountable to the terminal block. The terminal blocks assembly shall be provided with ground terminals, screw terminals, din rail, end plates, separators, pin connectors and any other required accessory. Where ground terminals are installed the enclosure back panel paint shall be removed exposing the steel for the ground connection. The terminal blocks shall be connected to wiring using insulated flanged fork connectors. Factory printable corrosion resistant marking strips shall be provided for conductor identification. At least ten percent spare terminals shall be provided. Terminal blocks shall be Phoenix Contact RTO 8 or approved equal.

8. Power Distribution Terminal Blocks: Power distribution blocks shall be used for conductor sizes No. 6 and larger and shall be UL listed. Terminal blocks shall be suitable for use with copper wire and shall provide a withstand voltage rating of 750 volts per IEEE switchgear standards. Corrosion resistant marking strips shall be provided for conductor identification. At least ten percent spare terminals shall be provided. Terminal blocks shall be Gould Shawmut Power Distribution Blocks – Heavy Duty Series 68000 or approved equal.
9. Terminal Connectors: Connectors shall be seamless, heavy-duty insulated wire ferrules or flanged fork terminal lugs where specified. Terminal lugs shall be installed per lug manufacturer recommendations using the proper tools approved by the manufacturer. Under no circumstance will splicing of wires be permitted without the use of a terminal block.
10. Nameplates: Nameplates, where required, shall be made of laminated phenolic plastic with white front and back and black core and shall be not less than 0.094 inches thick. The lettering shall be etched through the front layer to show black engraved letters on a white background. Lettering shall be not less than ¼ inch high, unless otherwise detailed on the Contract Plans. Nameplates shall be securely fastened to the equipment with stainless steel screws.
11. Key Operated Selector Switches, Selector Switches, Indicating lights and Push-buttons: Control switches, key operated switches, selector switches, indicating lights and push-buttons shall be heavy-duty NEMA type, 1.2 inch diameter base (30mm), oil-tight contact blocks operated by glove handle (pistol grip) selector knobs or push-buttons as indicated in the Plans. All switches, indicating lights and pushbuttons shall be equipped with escutcheon plates as shown on the plans. All lenses shall be glass, with color as shown on the plans. Lamps for indicating lights shall be LED type. Contacts shall be fine silver, capable of interrupting 6 amperes at 120 volts AC and of continuously carrying 10 amperes. Key operated switches shall be wired and configured such that the key can only be removed in the off position. Pilot devices for the control desk shall be Square D 9001 series. Cluster lights for the control cabinet doors shall be Allen Bradley 800T series Cluster Lights or Engineer approved equal.
12. Emergency Stop Push-button: Emergency stop push-buttons shall be heavy-duty, 1.2 inch diameter base, 2.25 inch diameter mushroom head, oil-tight contact blocks operated by pushing in and pulling out the button mushroom head as indicated in the Plans. The Emergency Stop button shall illuminate when the button mushroom head is pulled out to clearly indicate the emergency stop button has been de-activated. Pulling out the button mushroom head shall deactivate the emergency stop condition. The pushbutton shall be equipped with an escutcheon plate as shown on the plans. Contacts shall be fine silver, capable of interrupting 6 amperes at 120 volts AC and of continuously carrying 10 amperes. The quantity of contacts shall be as shown on the plans. The push-button shall be equipped with surge suppression. Emergency Stop push-buttons shall be Square D 9001 series.
13. Safety Relays and Modules: All emergency stop shall be connected to a single safety module as shown on the spans. The safety module shall be rated for 120V control power and specifically designed for emergency stop safety circuits (Category 0). A minimum number of two N.C. output safety contacts shall be provided with a minimum number of two input channels. The safety module shall be arranged to connect the output contacts to safety relays to immediately disable control power to the motor starter circuits when an emergency stop is detected. Safety modules shall be type XPS as manufactured by Square D. Safety relays shall be manufactured with tamper resistant covers and have mechanically linked

contacts and shall be marked for safety applications. Safety relays shall be Allen Bradley 700S or Engineer approved equal.

14. 24VDC Power Supplies: All 24V DC power supplies shall be rated for 120VAC input at 60 hertz, and 10A, 24V DC output. The power supplies shall be single output, regulated linear DC power supply. The power supply shall be convection cooled, constant voltage, short circuit proof, current limiting (automatic reset) unit with an output voltage adjustment of +/- 5%, and input/output isolation of 1,000 mega-ohms DC. The power unit shall operate over a temperature range of 0° Celsius through 55° Celsius. Units shall be DIN rail mountable and finger safe. Power supplies shall be Square D Phaseo power supplies.
15. Control Transformers: Control transformers shall be 2-KVA, 480-volt primary, 120-volt secondary, low impedance with copper windings and high voltage regulation. The control transformer shall be located as shown on the plans in the ATS enclosure. The transformer shall be Square D Type T, 60 HZ, 2 KVA Class 9070 Industrial Control Transformer.
16. Hydraulic Amplifiers: Control of the proportional valves shall be achieved through a hydraulic interface amplifier. Each amplifier shall be from the same manufacturer as the associated hydraulics equipment and rated for 24VDC, 2A. The amplifier shall be connected to an analog out to provide feedback position information. The amplifier shall be capable of controlling the proportional valve based on output voltage provided to the solenoid. There are 3 proportional valves. One for each hydraulic pump and one proportional relief valve. During normal operation (two, three, and four cylinder), the proportional relief valve is set to provide the maximum relief setting shown on the plans. During creep speed, the proportional signal reduces the relief valve setting to the value shown on the plans.
17. Power Monitor: A multifunctional power monitor shall be located in the motor control enclosure and display three phase power measurements on a self-contained meter for 480/227 Volt AC power systems. The meter shall accept universal voltage input and be user programmable for voltage range to any PT ratio. The metering system shall have an accuracy of +/- 0.1% or better for voltage and current, and 0.2% for power functions and provide RMS measurements of voltage, - phase to neutral and phase-to-phase; and current, per phase and neutral. Ethernet communication port shall be located on the back of the meter to communicate directly with the PLC and display data on each HMI screen. The metering system shall be Electro Industries/GaugeTech, Model: Shark 200 or approved equal.

G. Enclosed Control Cabinet

1. Freestanding Control Cabinets and back panels shall be furnished and installed in the control house where shown on the Plans. Circuit breakers, switches, contactors, starters, relays, buss bar system, PLC system, touchscreen, UPS and other apparatus as shown on the Plans shall be mounted and enclosed in free standing cabinets. The arrangement and line-up of the individual control cabinets shall be as shown on the Plans.
2. All equipment in each control cabinet shall be mounted on sheet-steel bases, and each device shall be front-connected, front-wired, and removable from the front. The equipment in all cabinets shall be arranged for ease of access and for safety and convenience of operation. Special care shall be taken to obtain a systematic and neat arrangement of the equipment. Each device shall be suitably named and plainly marked by a laminated nameplate mounted near the device on the panel. Each nameplate shall show an approved descriptive title for the apparatus, together with the device designation appearing on the schematic wiring diagrams. Nameplates shall meet the requirements as specified under Control Apparatus and Miscellaneous Equipment. Each relay shall be identified with letter designations shown on the plans and numerically as installed in the cabinet from left to right starting at the upper left corner of the cabinet. The vendor shall provide a typewritten, laminated directory with relay number associated alphanumeric designation and descriptive function listed in alphabetical order such that relays can be located by numerical position.
3. Each new control cabinet shall be a NEMA Type 12 enclosure where installed indoors and NEMA 4X stainless steel when installed outside the control house. Enclosures shall be constructed of No. 12 gauge

sheet-steel or stainless steel and shall be reinforced with steel angles or channels so as to provide a rigid, freestanding structure. The control cabinets shall be provided with continuous stainless steel door hinges on the front of each panel section. Each door cabinets shall be gasketed and shall be provided with three-point, vault-type latches. Ventilating louvers shall be provided at the top of each enclosure. All hardware shall be corrosion resistant. Thermostatically controlled strip heaters shall be provided in each cabinet to prevent build-up of excess moisture. Each panel shall be provided with suitable interior light fixtures and a duplex receptacle.

4. Each Cabinet enclosure and back panel shall be as shown on the plans. Modifications of the dimensions shown on the plans may be required to accommodate the required equipment at no additional cost to DelDOT. The dimensions of each cabinet and back panel shall be such as to permit mounting in the available space along the walls of the control house as shown on the Plans. If the final cabinet dimensions, as established by the manufacturer, should necessitate rearrangement or modification of the equipment in order to fit in the available space, such rearrangement or modifications shall be made at no additional cost. The final arrangement of all equipment in the Control House shall be subject to the approval of the Engineer.
5. The cabinet enclosures (for NEMA 12 enclosures) and all metal reinforcing shall be painted inside with two coats and outside with three coats, consisting of one coat of primer followed by one coat of gray or white enamel on the inside surfaces and two coats of gray enamel outside. The finish exterior coat shall be ANSI 61 light gray enamel.
6. All contactors, relays, and other devices shall be of required current carrying and interrupting capacity. All wiring installed within each cabinet shall be flame-retardant, ethylene-propylene insulated, switchboard wire, Type SIS. Conductors shall be stranded copper not smaller than No. 14 American Wire Gauge.
7. For each assembled control cabinet and back panel, all outgoing wire, No. 8 AWG or smaller, shall be connected to terminal blocks installed at the sides of the cabinet and mounted in channels. The terminal block channels shall be orientated on an angle to permit easy access for field terminal points which shall be directed towards the front of the enclosure. Ground mounted terminal blocks shall be provided, one for each device, and shall be installed such that the grounding point is in direct contact with the enclosure steel. The control cabinets and back panels shall also provide sufficient extra terminals to allow connection of all wires coming from limit switches and other devices that go on to the bridge control desk and other locations as required, even though these wires do not connect to apparatus on the control cabinet. Spare terminals totaling at least 20 percent of those actually used shall be provided. Each terminal shall be identified per wire number shown on the Contractor's schematic wiring diagrams.
8. All cabinet and back panel wiring shall be arranged systematically so that circuits can be readily traced. The wiring shall be installed in a network of troughs consisting of horizontal and vertical sections securely bolted to the cabinets and back panels. The troughs shall be fabricated from heavy-duty Noryl plastic shaped into a channel cross-section. After installation of the wiring, an insulated, flanged cover shall be fitted over the open side of each trough section.

H. PLC Equipment

1. Bridge control logic functions shall be performed by a programmable logic controller system, which shall provide for operation of the bridge and its auxiliaries in accordance with the system functioning specified herein and the control logic shown on the Plans.
2. The programmable logic controller (PLC) shall be an Allen Bradley (AB) ControlLogix brand PLC with components, hardware and remote input/output drops. No substitutions shall be accepted. The PLC shall be of modular construction, provide high-speed peer-to-peer networking, and be programmable with ladder logic.
3. The PLC system will consist of two redundant 1756-L72 CPU's. Only one CPU will be in use at a time, and the other CPU will be offline and de-energized. The remote PLC equipment furnished inside the

control desk shall be of the same make and manufacturer as that provided for the PLC Cabinet. A selector switch mounted on the control desk, specified elsewhere will select the CPU in use.

4. HMI (Touchscreens) shall be furnished and installed as shown on the plans and meet the minimum requirements specified below. Each touchscreens shall be a 15" display with solid state hard drive and be compatible with Allen Bradley PLC systems. Each touchscreen shall be identical make/model and used to display alarms, equipment status and be capable of operating the bridge via password. The HMI panel PC display shall have an Ethernet interface and the following minimum features:
 - a. Windows 10 IoT with Intel® 6th Gen. Core i3 CPU processor SoC system chipset.
 - b. 4GB RAM, 1x 260 Pin SO-DIMM DDR4, 128GB SSD.
 - c. I/O ports: 2 USB 3.0 Type A, 2 serial DB9 RS-232/422/485, 1 Audio Line Out, 2 GbE LAN RJ-45.
 - d. Operate at 120VAC or 9~36VDC (provide with external power supply).
 - e. 15" TFT LCD
 - f. Maximum resolution of 1280 x 1024, 16.7M maximum colors, a luminance of 350 cd/m², a 170 degree viewing angle and a contrast ration of 1000:1.
 - g. Resistive touchscreen. with aluminum or stainless-steel bezel and shall be rated IP 67 or NEMA 4X.
5. HMI displays known to meet these requirements include the Panelview Plus (Bulletin 2711) as manufactured by Allen Bradley, G15 Graphite Modular Display a manufactured by Redlion or PHM flat panel as manufactured by Parker.
6. For each control desk, the lower touchscreen shall be the primary control for the bridge and shall include buttons to operate each component as specified. The PLC system shall be capable of operating the bridge should either or both touchscreens fail using hardwired push-buttons and selector switches located as shown on the plans.
7. All PLC equipment for the control desk including power supplies, I/O cards, modules, switches and all accessories shall be mounted inside the control desk base on a back panel
8. The PLC shall be provided with the following features:
 - a. 1.5M of battery backed static RAM.
 - b. 1.5M of Nonvolatile RAM.
 - c. Ethernet communication
9. Each PLC remote input/output rack will be connected to both CPUs by means of a communication bus that will use Ethernet as the method of communication.
10. Each PLC rack shall be supplied with a ControlLogix chassis as shown on the plans.
11. Each input and output card shall be equipped with cage clamp removable terminal blocks wiring arms, oversized housings, and covers. Terminal blocks shall be provided as needed.
12. Each PLC chassis shall be provided with an Allen Bradley power supply.
13. All parts shall be as shown on the plans.
14. Furnish and install active line filters as shown on the plans to protect the PLC equipment and controls. The noise filter shall be a series connected high frequency noise filter with transient protection. It shall offer hard wired connection to all critical loads and be rated for use in an industrial environment. It shall reduce mode transients to +/- 2 volts, have a surge capacity of 45,000 amps, provide transient protection in all modes (line to neutral, line to ground, and neutral to ground), have an LED power indication, and be UL approved. The 120VAC MCOV shall be rated 150 VRMS. The line frequency response time shall

be less than 0.5 nanoseconds. The operating temperature shall be –40°C to 45°C at full load. The unit shall be capable of protecting against a peak surge current of 15,000 amps in all modes.

15. Furnish and install managed ethernet switches as required in the control enclosures for local and remote communication. The local communication switches shall be Rockwell Automation Allen Bradley Stratix Switch, Redlion N-Tron, Phoenix Contact FL Switch, or Engineer approved equal. The remote network switch shall be Redlion DSPGT firewall networks witch or Engineer approved equal. The network switches shall include fiber optic connections and a minimum of 10 Ethernet ports. Each switch shall have an option to save and load configuration via an SD Card.
16. Furnish and install a touchscreen as part of the PLC equipment to be mounted in the control house. The touchscreen shall be a 15” display with solid state hard drive and be of the same manufacturer as the PLC system. The switchboard room touchscreen shall be used to display alarms, equipment status and be capable of operating the bridge as a back-up to the control desk equipment.

I. Computer and Software

1. Provide a laptop computer with specified software suitable for programming the PLC, PanelView, and variable frequency drive systems. The computer shall be the latest commercially available unit and contain, as a minimum requirement, an IBM compatible Intel Core i5 processor operating at 3 GHz or better. The random access memory (RAM) shall contain a minimum capacity of 8 GByte and be expandable to 16 GByte. The hard disk drive shall have a storage capacity of 512 GBytes or more. The DVD/CD drive shall be a 40x CD/DVD +/-R/+/-RW dual layer combo drive. The unit shall have 15 inch class color display, 2 USB ports, and programming cables for the PLC, Panel View, and drive. The unit shall serve as an intelligent terminal, functioning both as a PLC/vector drive programming and data monitoring terminal. It shall permit PLC programming, including loading, editing, and monitoring ladder diagram programs in memory by entering through the keyboard and track pad and monitoring on the display. PLC program instructions shall be in ladder logic. All PLC programs shall become the sole property of DelDOT and should not be password protected.
2. Two licenses for each software application shall be provided. The following software applications shall be loaded onto the computer and made fully operational by the Contractor:
3. The latest version Windows compatible operating system supported by the PLC, PanelView, and drive programming software. All software shall operate properly on the operating system and coordinate with the software vendors and the operating platform requirements to select the proper software version.
4. Studio 5000 Logix Designer – Latest programming software for Allen Bradley ControlLogix Processors. Software shall be compatible with the Contractor supplied version of Microsoft Windows.
5. RSNetworks for Ethernet/IP – 32-bit graphical network management configuration tool for the Ethernet/IP networks. Configures network-wide parameters such as network update time (NUT), schedules I/O data transfers and peer-to-peer messaging for PLC processors. Software shall be compatible with the Contractor supplied version of Microsoft Windows.
6. FactoryTalk View – Panel View programming software. Software shall be compatible with the Contractor supplied version of Microsoft Windows.
7. Power Monitor software to program the Automatic Transfer Switch and monitor the incoming power at the Automatic Transfer Switch. Software shall be compatible with the Contractor supplied version of Microsoft Windows.
8. As part of personnel training a demonstration shall be performed on the operation and use of the software.

J. Control Desk

1. Each control desk shall be of neat, substantial construction. The desk shall be fabricated from No. 11 gauge sheet-steel, properly formed and suitably reinforced to provide adequate strength. The desktop shall be fabricated of No. 10 gauge, Type 304, stainless steel sheet with a non-glare, satin finish.

Removable doors shall be provided in the front and side panels of the desk, pivoted on 90-degree hinges, and secured with flush type, three-point latches. The desk shall be neatly fitted up with close joints, all rough edges or corners shall be ground off smooth, and all projecting edges rounded off. All metal hardware shall be of substantial construction and shall have a satin-chrome plate finish. All equipment mounting screws and bolts shall be stainless steel.

2. The sheet-steel portions of the desk and all metal reinforcing shall be painted inside with two coats and outside with three coats of paint, consisting of one coat of primer followed by two coats of enamel on the outside surfaces and one coat of white enamel inside. The finish coat shall be of a color to match the house interior. Color samples shall be submitted for approval to the Engineer. The stainless steel desktop shall not be painted.
3. The control desk interior shall be suitably lighted and controlled by a switch mounted near the front doors. One duplex receptacle shall be mounted in the desk's interior and one combination duplex receptacle and ethernet port shall be flush mounted exterior to the desk. The light and receptacles shall be powered from the lighting panel board as shown on the drawings.
4. The control desk shall be provided with selector switches, push-buttons, indicating lights and touchscreens as shown on the plans. The primary control method shall be performed through the lower touchscreen which shall include buttons to operate the equipment. The upper touchscreen shall be for monitoring purposes only and shall match the function and operation of the switchboard touchscreen as specified herein.
5. All contact blocks for control switches, pushbuttons, and other control devices shall be mounted within the body of the desk. The operators for these devices shall protrude through the desktop. The indicating lights for each operation shall be mounted as shown on the plans.

K. Automatic Transfer Switch

1. An automatic transfer switch shall be furnished and installed in the ATS and Power Cabinet. All work required for the fabrication of the ATS and enclosure shall be performed by the control system vendor.
2. Each automatic transfer switch shall consist of an inherently double throw power transfer switch unit and a microprocessor controller, interconnected to provide complete automatic operation. The entire transfer switch assembly shall be the product of the same manufacturer.
3. Each unit shall be electrically operated and mechanically locked without the use of hooks, latches, magnets or springs. The electrical operator shall be a single-solenoid mechanism, momentarily energized. Main operators which include overcurrent disconnect devices will not be accepted. The switch shall be mechanically interlocked to ensure only one of two possible positions, normal or emergency.
4. The switch shall be positively locked and unaffected by momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life.
5. All main contacts shall be of silver composition. Switches shall have segmented, blow-on construction for high withstand current capability and be protected by separate arcing contacts.
6. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to manually stop the contacts at any point throughout their entire travel to inspect and service the contacts when required.
7. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

8. Where neutral conductors are to be solidly connected, a neutral terminal plate with fully-rated AL-CU pressure connectors shall be provided.
9. Each ATS shall be provided with a controller, which shall direct the operation of the transfer switch. The controller's sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance, and inherent serial communications capability. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance.
10. The controller shall be enclosed with a protective cover and be mounted separate from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers.
11. Voltage and Frequency Sensing shall be provided on each ATS as follows:
 - a. Single-phase voltage and frequency sensing of the emergency or alternate source shall be provided.
 - b. The voltage of each phase of the normal source shall be monitored, with pickup adjustable to 95% of nominal and dropout adjustable from 70% to 90% of pickup setting.
12. Each ATS shall have time delays as follows:
 - a. An adjustable time delay shall be provided to override momentary normal source outages and delay all transfer and engine starting signals.
 - b. An adjustable time delay shall be provided on transfer to emergency, adjustable from 0 to 5 minutes for controlled timing of transfer of loads to emergency.
 - c. A generator stabilization time delay shall be provided after transfer to emergency.
 - d. An adjustable time delay and interlocking feature shall be provided on retransfer to normal. The time delay shall be adjustable from 0 to 30 minutes. Time delay shall be automatically bypassed if emergency source fails and normal source is acceptable.
 - e. A 5-minute cooldown time delay shall be provided on shutdown of engine generator.
 - f. All adjustable time delays shall be field adjustable without the use of special tools.
13. Each ATS shall have the following additional features:
 - a. A set of contacts rated 5 amps, 32 VDC shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.
 - b. A push-button type test switch located on the front of the enclosure door shall be provided to simulate a normal source failure. This function shall be able to be locked out.
 - c. A push-button type switch located on the enclosure door shall be provided to bypass the time delay on transfer to emergency, the engine exerciser period on the retransfer to normal time delay whichever delay is active at the time the push-button is activated. This function shall be able to be locked out.
 - d. Terminals shall be provided for a remote contact as follows
 - i. Remote contacts which opens to signal the ATS to transfer to the emergency source.
 - ii. Remote contacts which open to inhibit transfer to emergency and/or retransfer to normal.
 - e. Auxiliary contacts shall be provided on the transfer mechanism and connected to the PLC. The auxiliary contacts shall be rated 10 amps, 250 VAC and provided two contacts, closed when the ATS is connected to the normal source and two contacts, closed, when the ATS is connected to the emergency source.

- f. Indicating lights shall be provided, one to indicate when the ATS is connected to the normal sources (green) and one to indicate when the ATS is connected to the emergency sources (red).
 - g. Auxiliary contacts shall be provided for signal availability from the 11BG accessory module (Normal Available, Normal Failure, Generator Available and Generator Failure). The terminals from the module shall be connected to the source as shown on the plans.
 - h. The ATS shall have the ability to inhibit retransfer.
14. Upon retransfer of the ATS back to normal power the system shall automatically reconnect the power bus from emergency to normal power and allows the main line contactor to re-energize. Any accessories such as timers, relays, contactors etc. shall be furnished and installed to permit operation in this manner.
15. The ATS shall be furnished and installed in the ATS enclosure as shown on the plans. Each Controller shall be a flush-mounted display with LED indicators for switch position and source availability mounted to the front of the enclosure door. Each Automatic Transfer Switch shall be a four-pole, 200-ampere, 480-volt switch and approved equal to Automatic Transfer Switch Co., Model 300.

L. Surge Suppression Device (SSD)

1. Furnish and install the Transient Voltage Surge Suppression Device (SSD) equipment having the electrical characteristics, ratings and modifications as specified herein and as shown on the contract drawings. The SSD shall be sized as a service entrance application and located on the load side of the nearest disconnect switch. To maximize performance and reliability, the AC surge protection shall be integrated into the ATS enclosure as shown on the plans. All surge suppression shall meet the latest requirements and UL standards.
2. Electrical Requirements for the system are as follows:
 - a. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
 - b. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall be greater than 115% of the nominal system operating voltage.
 - c. The suppression system shall incorporate a hybrid designed Metal-Oxide Varistors (MOV) surge suppressor for the service entrance and other distribution level. The system shall not utilize silicon avalanche diodes, selenium cell, air gaps or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.
 - d. Protection Modes – For a wye configured system, the device must have directly connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G). For a delta-configured system, the device must have suppression elements between line to line (L-L) and line to ground (L-G).
 - e. UL 1449 Suppressed Voltage Rating (SVR) – The maximum UL 1449 SVR for the device must not exceed 800V for L-N, L-G, N-G modes and 1800V for L-L mode.
3. SSD Design for the system shall be as follows:
 - a. Balanced Suppression Platform – The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating TVSS modules shall not be acceptable.
 - b. Electrical Noise Filter – Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be 50 dB at 100 kHz using the MIL-STD-220A insertion loss test method. Products not able to demonstrate noise attenuation of 50 dB @ 100 kHz shall be rejected.

- c. Extended Range Filter –The Surge Protective Device shall have a High Frequency Extended Range Tracking Filter in each Line to Neutral mode with compliance to UL 1283 and NEMA LS1. The filter shall have published high frequency attenuation rating in the attenuation frequencies.
- d. Internal Connections – No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be hardwired with connections utilizing low impedance conductors and compression fittings.
- e. Standard Monitoring Diagnostics – Each SSD shall provide integral monitoring options:
 - i. Each unit shall provide a green / red solid state indicator light shall be provided on each phase. The absence of a green light and the presence of a red light, shall indicate which phase(s) have been damaged.
 - ii. Remote Status Monitor – The TVSS device must include form C dry contacts (one NO and one NC) for remote annunciation of unit status. The remote alarm shall change state if any of the three phases detect a fault condition.
 - iii. Audible Alarm – The TVSS shall provide an audible alarm with a reset pushbutton that will be activated under any fault condition.
 - iv. Event Counter – The TVSS shall be equipped with an LCD display system designed to indicate to the user how many surges, sags, swells and outages have occurred at the location. The event counter triggers each time under each respective category after significant event occurs. A reset pushbutton shall also be standard allowing all counters to be zeroed.
 - v. Push to Test – The TVSS shall be equipped with push-to-test feature, designed to provide users with real time testing of the suppressor's monitoring and diagnostic system. By depressing the test button, the diagnostic system initiates a self test procedure. If the system is fully operational, the self test will activate all indicator lights.
 - vi. Voltage Monitoring – The TVSS shall display true Root Mean Square (RMS) on three L-N voltage protection mode on Wye configuration and three L-L voltage on delta configuration.

M. Manual Operation Limit Switch

- 1. Emergency operation limit switches for the span lock motors and gates motors shall be furnished and installed as shown in the Plans. The switches shall trip when the mechanical hand crank is activated.
- 2. Each limit switch shall meet the following requirements:
 - a. Track-type, lever-actuated, spring-return, two-circuit limit switch
 - b. 1 NC safety contact and 1 NO ancillary contact
 - c. Rated 600V, 10A
 - d. NEMA 4/6P watertight enclosure
 - e. Meet requirements of EN 954-1, ISO 13849-1, NFPA 79, ANSI B11.19
- 3. The length of the arm on each switch shall be to allow for the limit switch to be activated with the system.
- 4. Each limit switch shall be installed in such a way to permit field adjustment of the trip point in order to optimally sense when the motor is being manually operated. Manual operation limit switches shall be the Allen Bradley 802T Direct Opening Safety Limit Switch or approved equal.

N. Position Absolute Cylinder Position Transducer

- 1. Two cylinder position transducer assemblies shall be furnished and installed on the bascule span and operate with the hydraulic cylinders. Each unit shall send a signal to the PLC and touchscreens as specified herein to indicate absolute leaf angular position and speed.

2. The absolute encoder shall be mounted to a wire spool as a combined product. Separately manufactured systems are not acceptable. Each encoder shall rotate and provide the PLC with feedback information through an analog connection. Each encoder shall be capable of travel up to 164 feet (50 meters) where the wire shall extend from the assembly to a fix position.
3. Each unit shall be rated NEMA 4X (IP64), intended for outdoor use and designed for high vibration/shock environments. Each resolver shall be scaled to equate resolver shaft rotation to actual span travel in angular degrees and speed in RPM's.
4. Each wire draw absolute encoder shall be the Highline Wire Draw Absolute Encoder with integral cable and connectors as manufactured by SICK or approved equal.

O. Position Inclinometers

1. Two position inclinometers shall be furnished and installed on the bascule span within the movable droop cable terminal boxes as shown on the plans and will send a signal to the PLC and touchscreens as specified herein to indicate absolute leaf angular position.
2. Each inclinometer will be provided with highly accurate tilt sensing in a rugged shock and vibration resistant metal IP68 rated unit with operating temperature from -40° C to 85° C and capable of underwater submersion. The output parameters can be modified at the factory as required.
3. Each unit shall be dual axis and have an 11 to 36 VDC input fed from an independent power supply located in the PLC cabinet and have a 4-20mA output (RS-485) connected directly to the PLC. All cables shall be provided by the manufacturer and installed in conduit. Cord sets shall be connected internal to the junction box.
4. Each inclinometer shall be Flex Series H6 and connectors as manufactured by Rieker or approved equal.

P. Proximity Limit Switch

1. Unless otherwise shown and detailed on the plans, proximity limit switches shall be furnished and installed for the fully closed and span over travel.
2. The proximity limit switches shall be inductive type, barrel type, stainless steel and rated NEMA 4X. Each limit switch shall be provided with mounting brackets, hardware and supports as shown on the plans and required for proper operation. The sensing range shall be a minimum of 40mm unless otherwise noted.
3. The switch shall include a conduit NPT hub and adapter for connection to 3/4" conduit. Each unit shall include a LED indicating light and shall be 120VAC and connected as a PLC input. Proximity limit switches shall be the Turk NI40-G47SR or approved equal.

Q. Span Motors/Cooling Motor

1. Each span pump motor shall be AC induction type, squirrel cage and will not start under load. Each motor shall be built in strict accordance with NEMA publication MG-1. Each span motor shall be 3-phase 60-Hertz, NEMA Design B with moisture resistance insulation, 40° C temperature rise, and capable of instant reversing. Motor frame shall be constructed of cast iron. Ratings for the pump motors shall be as follows:

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Horsepower	25HP (Pump)/3HP (Cooling)
Nominal Voltage	480 VAC, 3 Phase
Duty	30 minute
Speed	1800 RPM
Frame Size	284TC*(Pump)/182TC*(Cooling)
Insulation	HHH
Service Factor	1.15
* Frame size shall be coordinated with the motor manufacturer for accuracy.	

2. The motors shall be totally enclosed non-ventilated (TENV) construction, with re-greaseable ball bearings, moisture resistant insulation and internal space heater sized by the manufacturer. The space heater shall operate at 120-VAC. The motor shafts shall be fabricated from corrosion resistant materials. A drain hole of not less than ½ inch diameter shall be provided at the bottom of the motor, fitted with a suitable drain plug.
3. All windings shall be copper. The motor shall be capable of having a minimum breakdown torque of 300% of full load torque. A normally closed temperature sensor shall be embedded in the windings.
4. Each motor junction box mounted to the motor shall be liberally sized and located to avoid interference with the machinery. The conduit boxes shall be sized in accordance with the requirements of the NEMA MG 1-2003 PART 11. The junction box shall be provided with terminal blocks, sized by the manufacturer to terminate all cables routed to the motor. A suitable ground lug shall also be provided.
5. Each motor shall be provided with an output shaft as shown on the drawings.
6. The motors shall be designed and manufactured in the United States of America.
7. All motors shall be manufactured to the following standards:
 - a. IEEE Marine Standards No. 45.
 - b. American Bureau of Shipping (A.B.S.).
 - c. U.S. Coast Guard Inspection Service
 - d. NEMA MG-1
8. Pump motors shall also be provided with the following features in order to meet the requirements of these Specifications.
 - a. Cast iron frame and box.
 - b. Corrosion resistant shaft and hardware.
 - c. Double Sealed ball bearings.
 - d. Seal all joints and eye bolt holes.
 - e. Sealed leads in terminal box.
 - f. Shaft seals.
 - g. Removable drain plugs.
 - h. Final coat of epoxy paint.
 - i. Corrosion resistant coating - rotor and stator laminations.
 - j. Stainless steel nameplate.
 - k. Super 'H' insulation including protection against fungus growth.

9. The motor frame shall be finished with a corrosion-resistant paint or coating. Exposed unpainted metal surfaces shall be of a corrosion-resistant material.
10. An in-sight disconnect switch shall be provided within view of each motor as specified under "Disconnect Switches." The 120-volt strip heater in each motor frame shall be wired to the normally open auxiliary contact in the corresponding motor disconnect switch.
11. Motors shall be manufactured by Reuland Electric Company or approved equal.

R. Lock Motors

1. Each motor for the span lock shall be fabricated per NEMA publication MG-1 and designed for high-slip, high-starting torque, NEMA Design D, weatherproof, totally-enclosed, non-ventilated (TENV), ball-bearing, squirrel-cage motor, capable of withstanding instant reversal when running at full speed. It shall be rated on a basis of 30 minutes at 40 degrees Celsius ambient. Each motor shall be provided with a single-phase, 120-volt, space heater installed in the lower frame beneath the windings. The wattage of the heater shall be determined by the manufacturer. Ratings shall be as follows:

Horsepower	1 ½ HP
Nominal Voltage	480 VAC, 3 Phase
Duty	30 minute
Speed	1800 RPM
Frame Size	145TC*
Insulation	HHH
Service Factor	1.15
* Frame size shall be coordinated with the motor manufacturer for accuracy.	

2. Each lock motor junction box mounted to the motor shall be sized in accordance with the requirements of the NEMA MG 1-2003 PART 11. The junction box shall be provided with terminal blocks, sized by the manufacturer to terminate all cables routed to the motor. A suitable ground lug shall also be provided.
3. Each lock motor shall be provided with a motor-mounted, totally enclosed, spring-set, 480-volt, magnetically released disc brake with rated torque approximately equal to, but not less than, motor full-load torque.
4. Each brake shall be of dust-tight, self-adjusting, weatherproof, cast-iron construction, except modified for marine duty to comply with IEEE Standard 45, "Recommended Practice for Electrical Installations on Shipboard". The marine duty modification includes the use of brass internal parts.
5. Each brake shall be provided with a 120-volt, 15-watt internal strip heater and a single-voltage operating coil. Each brake shall be approved equal to the Stearns 87,000 Series brake with M-Mod for marine duty, equivalent as manufactured by Harnischfeger or Dings, or approved equal. Each lock motor shall be controlled by magnetic reversing contactors, electrically and mechanically interlocked.
6. Manual operation lever mechanism and limit switches shall be furnished and installed under this item and assembled with the lock motors. The manual operation limit switches shall meet the requirements specified under "Manual Operation Limit Switch." The manual operation limit switches shall be as shown on the plans and include a custom fabricated lever to cover the shaft on each motor.
7. The locks shall be operated from selector switches and touchscreens located on the control console. The switches shall have spring-return to center drive and pull positions, with circuitry arranged such that the lock will stop immediately when the lock rod is fully driven or pulled.
8. Each span lock shall be provided with new limit switches as part of the actuator assembly. The limit switches shall be as specified and shall provide contacts to control the limit of travel in each direction and for indication and sequence interlocking.

9. New span lock linear actuator assembly shall be specified under the item “615503 – Bridge Mechanical System.”
10. Adjustment of center lock crank arms, supports, strike plates and limit switches for proper operation shall be done under the item “615503 – Bridge Mechanical System.”
11. Motors shall be manufactured by Reuland Electric Company, Baldor or Engineer approved equal with all required modifications performed in the factory.

S. General Requirements for Warning and Barrier Gates

1. It is the intent of this specification to sole source B&B Roadway Warning Gate (VW-5) and Barrier Gates (VR-6) with accessories as specified herein or shown on the drawings. No substitutions are permitted.
2. Operating mechanism and main control components for each gate shall be contained in a weatherproof housing. The housing shall be constructed of 3/8” carbon steel, hot dip galvanized after fabrication. Exterior surfaces shall be painted aluminum. All fasteners shall be corrosion resistant. Arm shaft openings shall incorporate O-ring seals.
3. The front and rear access doors shall be mounted on full cross bronze straps. Hinges shall be of the slip-off type and shall have stainless steel pins. Door handles, two per door, shall use a vise action to compress a neoprene bulb-type gasket to seal the door openings. Each warning and barrier gate shall be built for routine maintenance access from the back of each gate, with the barrier gate having rear access only.
4. Each gate shall be fixed to new foundations, using new anchor bolts. The gate housing base shall be provided with four holes on a square pattern. The mounting holes in standard base shall be slotted to allow for adjustment.
5. Each gate shall pivot in the vertical plane via a mechanical 4-bar linkage. The linkage shall utilize cranks keyed to the main arm shaft and transmission shaft and an adjustable connecting rod between a pair of self-aligning spherical rod ends. The linkage shall be driven by a fully enclosed, double reduction, worm gear speed reducer. Gear ratio used shall produce an operation time of 13 to 16 seconds.
6. The velocity of the arm shall follow a sinusoidal pattern to provide smooth operation. The arm shall begin and end its full motion path with zero velocity and accelerate smoothly to maximum velocity at mid-travel.
7. An internal heater with thermostat shall be furnished and installed in the housing and electrical enclosure, sized by the manufacturer to prevent condensation inside the gate. Disconnection of the motor from the local disconnect switch shall also de-energize the heater circuits.
8. Each gate arm lights shall be mounted on the arm of each gate. Each light shall be high impact plastic double-faced with lenses units. Each light assembly shall be mounted to the gate arm using an aluminum adapter plate. The lights shall be interconnected with four-conductor plus ground portable cord using watertight connectors at the fixtures.
9. A 120 volt, 100,000-hour LED lamp shall be installed in each fixture. The lights shall be connected so that adjacent units flash alternately while the headlamp burns steady through a 120 volt flasher. The flasher shall contain two alternating circuits, and one steady circuit and shall be rated for 10 amperes. Fuses for the warning lights and flasher shall be midget cartridge fuses, rated for 250 volt and sized base on the load.
10. Each gate shall be furnished with a new gate arm. The arms shall have a length to cover the roadway leaving no gaps, which shall open through an angle of 90 degrees from the horizontal to the vertical.
11. The warning gate arms shall be 4” (102mm) square, 6005-T5 aluminum extruded tubing with 3” square end section of high-strength UV-resistant fiberglass or 3” square extruded aluminum when required. The connection to the new warning gate arms shall be a shear pin type connection as recommended by the

manufacturer. The barrier gate arms shall be double rail aluminum tube. Stainless steel truss cables, energy absorbing cables and a damping type bumper rod shall be furnished as required.

12. Front and rear arm surfaces of all arms shall be covered with alternating red and white high intensity reflective sheeting. Stripes shall be 16" wide, and vertical according to MUTCD. Remaining exposed surfaces shall be painted white.
13. Barrier gate shall be provided with passive arm end locks mounted on the arm tip which shall engage a rigidly mounted and anchored socket on the guard rail as shown on the contract plans. End locks shall not require powered actuation for proper engagement and shall be provided with a proximity sensor to indicate the gate is locked.
14. At each barrier gate housing, heavy duty side arm locks shall be mechanically linked to the operating mechanism to automatically engage and lock the side arm tubes into a rigid configuration when the arm is lowered, to assist in transferring the load into the housing in the event of an impact. Separate limit switches shall be provided for indication of the position of the arm locks.
15. Each gate arm shall be adequately braced transverse to its motion to resist wind loads and to reduce whipping and shall be guyed to prevent sagging. Each assembled gate arm shall be designed for a 75 miles-per-hour wind load. A bumper rod with compression spring shall be provided near the end of each gate arm to stop the travel at the closed position without undue shock. Gate arms shall be equipped with guy wires configured in such a way that they do not project beyond the gate housing into the sidewalk when the gate is in the vertical position.
16. New door switches shall be furnished and installed on each access door to open the control circuit and de-energize the motor controls when the door is open. The door switches shall be lever type limit switches and shall be mounted to the new housing. The limit switches shall be heavy duty industrial, rated for 10A, 120VAC and shall be Square D 9007C with 1NO/1NC contact.
17. Each gate limit switch assembly shall be a self-contained rotating cam limit switch. The assembly shall provide 8 independent SPDT control switches. Switches shall be rated for 15 amps at 480 VAC. Switches shall be controlled by individually micro-adjustable and have provisions for internal vernier adjustments. The limit switch shall allow for a one-quarter ($\frac{1}{4}$) degree contact operation repeatability. Each contact of the limit switch shall be single-pole, double-throw, precision-type, snap-action switches. The limit switch assembly design shall permit adjustment of any cams with the gate in any position without disrupting the other cams. The limit switch assembly shall have a removable cover to help prevent accidental contact with switch terminals. Shaft, cams, bushings and housing pieces shall be of non-ferrous corrosion resistant materials. The rotary cam limit switch shall be approved equal to the GEMCO series 1980. The warning gate may require a custom housing (VW-5) to accommodate the GEMCO rotary cam limit switch.
18. Each gate shall also be provided with a hand crank lever and limit switch installed on the output shaft of the motor. Each limit switch shall be watertight and rated NEMA 4X. Insertion of the hand crank mechanism or drill shall disable gate operation. The hand crank limit switch shall have a plunger style head and limit switch body.
19. A new disconnect switch shall be furnished and installed in each warning and barrier gate housing. The switches shall be compact and capable of disconnecting motor and brake incoming power, heating power and provide a status signal to the PLC system indicating when the unit is off. The mechanism shall utilize a rotary switch or lever arm switch, and the status of the switch shall be easily identifiable from the face of the unit. Motor disconnect switches shall have a minimum rating of 10 amperes, be rated NEMA 3R or 4 (for outdoor use) and include 3 poles and auxiliary contacts as shown on the plans in a common disconnect switch enclosure.
20. Terminal blocks shall meet the requirements as specified elsewhere in these specifications and all wiring shall be terminated to terminal blocks and components using wire ferrules or fork tongue terminals. All wire tag, wire labels and terminal block labels shall match the control system vendor supplied drawings.

21. Each gate shall be provided with a TENV squirrel cage motor with size as recommended by the gate manufacturer. The motor shall be a C-face design and shall be mounted directly to the transmission. The motor shall be instantly reversing and be provided with an internal motor winding heater. The motor shall be provided with a solenoid release, automatic braking unit attached to the back end of the motor. The brake shall be provided with a manual release lever to permit manual operation of the gate.

T. Traffic Signals

1. Two new mast arm assemblies shall be furnished and installed as shown on the plans. DelDOT shall provide and install the mast arm assembly. The traffic signals foundations, anchor, conduit and wiring shall be installed by the Contractor as specified elsewhere and shown on the plans.

U. Camera System

1. A camera system shall be furnished and installed by DelDOT as shown on the plans. Under this item all conduit and wire related to the set of cameras on the northwest corner of the bridge shall be furnished and installed as well as the base for the camera pole. DelDOT's on-call contractor shall furnish and install the camera pole on top of the base.

V. Disconnect Switches

1. Motor disconnect switches shall be unfused safety switches, for use as disconnects, and shall be installed within sight of each span lock motor, cooling motor and pump motors. Each unit shall be capable of being locked in the off position. Disconnect switches for the warning and barrier gates shall be as specified elsewhere.
2. The switches shall be 3 pole, non-fusible, heavy-duty, safety switches in watertight and dust-tight NEMA 4X, stainless-steel enclosures with a rating of 30 amperes for the span locks, cooling motor, warning gates, barrier gates and 60 amperes for pump motors. Each disconnect switch shall be furnished with two auxiliary contacts that open when the disconnect switch is in the OFF position and phenolic nameplate to identify the corresponding motor. Size shall be based on the actual full load current of each motor. All NEMA 4X disconnect switches current carrying components shall be copper.
3. A new fused disconnect switch shall be furnished and installed for the new incoming service as shown on the plans. The new service disconnect switch shall be a 200A, 600VAC, NEMA 4X, S.S. unit and service entrance rated. The location, type and installation shall be coordinated with Delaware Power Co-Op.

W. Wire and Cable

1. Except where otherwise noted, wiring in conduits shall be single-conductor. All wire and cable shall conform to the requirements of NEMA Pub. No. WC70-2021. The minimum number of conductors provided in each cable shall be as shown on the Contract Plans. The cable installation in conduit, wireway and troughs shall conform to the latest edition of NEC and according to any other applicable code under local jurisdiction.
2. All conductors shall be soft annealed copper wire conforming to the requirements of NEMA Pub. No. WC70. All conductors shall have Class K stranding.
3. The insulation shall be a chemically cross-linked polyethylene compound conforming to the requirements of Part 3.6 of NEMA Pub. No. WC70. The wire type for all conductors except shop wiring installed within the confines of the control cabinets or control desk shall be XHHW-2 as listed under NEC Table 310-13. "Conductor Application and Insulations". The wire type for all shop-wired conductors installed within the confines of the control cabinets and control desk shall be SIS as listed under NEC Table 310-13. "Conductor Application and Insulations".
4. All wire and cable shall be of a nationally recognized brand, acceptable to DelDOT or authorized representative, and shall have marks always used on the particular brand for identifying it. Acceptable manufacturers are as follows Houston Wire and Cable, Service Wire Company, Clifford of Vermont,

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Alpha Wire Company, Allied Wire and Cable, Okonite Company, General Wire and Cable, and Draka USA.

5. Equipment ground conductors shall be bare, stranded, coated copper conforming to the requirements of NEMA Pub. No. WC70, Part 2. When required by the National Electrical Code (NEC), equipment ground conductors shall be provided with approved insulation.
6. Flexible cable for specified connections shall be rubber insulated, multiple-conductor portable cords conforming to the requirements of NEMA Pub. No. WC3, Part 7.7 or NEMA Pub. No. WC8, Part 7.4 for hard service. Each cable shall be provided with a heavy-duty neoprene jacket conforming to the requirements NEMA Pub. No. WC3, Part 7.7.5.1 or NEMA Pub. No. WC8, Part 7.4.5.1. Flexible cables shall conform to the National Electrical Code, Article 400 for hard service.
7. The flexible control cables shall be Type SOOW -A portable cord rated 600 volts, 90-degree C. Conductors shall be flexible stranded bare annealed copper provided with ethylene propylene rubber (EPR) insulation. Cable jacket shall be chlorinated polyethylene (CPE).
8. New fiber optic and industrial Ethernet cables shall meet or exceed the following. The Contractor shall ensure system compatibility with all cables, equipment and systems.
9. Fiber optic Cables: Multi-mode, 62.5 microns core size, 125 micron cladding, less than 3.4 dB/km at 850nm and less than 1.0 dB/km at 1300 nm attenuation, greater than 200 MHz/km at 850 nm and greater than 500 MHz/km at 1300 nm bandwidth.
10. Industrial Ethernet Cables: Cat 6 shielded cable for use in high noise environment, 600 Volt rated PVC jacket rated for -4°F to 176°F.
11. Fiber optic cables and Ethernet cables shall be installed and connected per manufactures recommendations. Splices for fiber optic cables shall be made with fiber optic splice kits inside an isolated enclosure and with necessary connectors.
12. Wire markings and tags shall be provided for all the conductors and shall be factory-applied heavy duty, waterproof, permanently marked, and resistant to ultraviolet light deterioration. Numbers and letters shall be black or blue on a white background. Each wire and cable shall be preprinted with labels for each wire and/or cables entire length. Each preprinted label should match the interconnection diagram shop drawing. The proposed wire marking system shall be submitted with a sample of the wire markers to be installed to the Engineer for approval. The labels shall be polyolefin heat shrink tubing, approved equal to Panduit LS5 labeling system.
13. With the exception of connections outside the control house where flanged forks shall be used, when it becomes necessary to connect a cable and/or wire No. 8 AWG or smaller insulated wire ferrules shall be used. The ferrules shall be attached to the wire using the manufacturers approved tool.
14. Cable grip bushings shall grip the cable jacket to provide a watertight seal at the point of cable entry. Cable grip bushings shall be OZ Gedney Type SR or approved equal.
15. Strain relief devices shall grip the cable jacket with an entwining cable mesh to support the weight of the cable where it enters the terminal box. Strain relief devices shall be Kellem cable grips or approved equal.

X. Aerial Cables

1. Aerial cables, messenger cables, termination boxes and supporting poles shall be as shown on the plans and meet the following minimum requirements.
2. At a minimum, provide one power and one control aerial cable (2 total cables). Roadway lighting cable requirements shall be specified elsewhere.
3. Aerial cables shall be fabricated 600 Volt Type TC-ER control cables are suited for use in wet and dry areas, conduits, ducts, troughs, trays, direct burial, aerial supported by a messenger, and where superior electrical properties are desired.

4. These cables are capable of operating continuously at the conductor temperature not in excess of 90°C for normal operation in wet and dry locations, 130°C for emergency overload, and 250°C for short circuit conditions. For uses in Class I, II, and III, Division 2 hazardous locations per NEC Article 501 and 502. Exposed runs (TC-ER) per NEC 336.10. VW-1 Rated.
5. Aerial cables submitted for use under this item shall be specifically made for use as a messenger supported aerial cable and shall include the following:
 - a. (Qty: 3) 37C#12, TCC 12-7 37C Cu 600V PN PVC Bk 4kR by Southwire
 - b. Roadway Lighting Cable (as specified elsewhere).
6. Messenger cables pole clamps, saddle rings, supports, and all other accessories shall be furnished and installed as shown on the plans between the two aerial cable poles to support the full weight of the cable assemble including power, control and roadway lighting cables.
7. Packaging of the finished cable shall be on suitable non-returnable reels capable of supporting the weight during transportation and normal handling. Cable ends shall be suitably sealed to prevent moisture from entering the conductor core area during shipment and storage only.

Y. Conduit System

1. All new conduits and fittings as shown on the plans shall be as specified herein.
 - a. Where installed encased in concrete or in a trench, including within the roadway, the conduit shall be schedule 80 PVC.
 - b. Conduit installed within the conditioned space of the control house shall be rigid galvanized steel.
 - c. All other conduits shall be type 304 stainless steel. Where conduit is partially encased the entire run shall also be stainless steel including sections that are buried in concrete and trench in the ground.
2. In general, conduits shall not be less than $\frac{3}{4}$ inches in diameter. Sections of conduit shall be connected to each other with screw couplings made up so that the ends of both conduits will butt squarely against each other inside of the coupling.
3. Where conduit is routed to hubs and connectors that will not accept $\frac{3}{4}$ " conduit a reducer/enlarger fitting shall be furnished and installed to connect to a minimum of $\frac{3}{4}$ " conduit.
4. All conduit of the same type including PVC and Stainless-Steel conduit, associated fittings, and associated supporting products shall be provided by the same manufacturer. Conduit systems from different manufacturers to make up the completed raceway system will not be permitted.
5. Flexible conduit where required shall be liquid tight steel conduit conforming to the requirements of UL 360. Fitting and connectors used in conjunction with flexible conduit shall also be steel liquid tight fitting with hot dipped galvanized finish.
6. Unless otherwise noted the conduit supports shall consist of S.S. U-bolts attached to hot dipped galvanized steel supports (after fabrication) connected to the steel members, surrounding structure or concrete. All references to galvanized steel conduit and limit switch supports as shown in the plans shall be hot dipped galvanized after fabrication, field cuts will not be permitted. All U-bolts and bracket hangers shall be provided with medium-series lock washers and hexagonal nuts. Type 316 stainless steel strut conduit supports may be used as a contractor-initiated substitution at no additional cost for specific areas to meet the construction schedule with the exception of on the span. Submit cut sheets and installation drawings for such supports for review and approval.
7. In general, conduit fittings shall be of the same type and material as the associated conduit. Where used with S.S. conduit the fittings shall be S.S.

8. Conduit expansion/deflection fittings shall be provided with flexible bonding jumpers to maintain the electrical continuity across the joints unless the fitting is specifically designed to maintain the ground connection. The fittings shall permit a total conduit movement of 1.5 inches as may be required.
9. Install drain/breather fittings in all enclosures and conduit systems. Fittings shall be fabricated of stainless steel, rated for NEMA 4X and shall be capable of passing 25 cc of water per minute. Where the fitting is not designed to drain all water in an enclosure a conduit nipple with coupling shall be welded to the box.
10. Conduit hubs shall be provided with a ground bushing to connect the equipment ground conductors and enclosure ground lugs. The hubs shall be S.S. when used in conjunction with S.S. coated conduit.
11. Conduit tags for new conduit shall be 1/8" thick flexible acrylic white nametag with black lettering. Each tag shall be a minimum of 1 1/4" x 3 3/4" with space for three lines of text. Engraving shall include the conduit reference number which can be referred back to the as-built documents, conduit size, wire size and quantity. Conduit tags shall be connected to each end of conduit with two plastic ties.
12. For core drill penetrations, the required hole size shall be core drilled and sealed with a fireproof foam sealer intended to be used with conduit systems. For outdoor boxes each conduit shall be sealed as it exits the box or enclosure with a conduit duct sealer. The duct sealer shall be approved equal to the Polywater FST-250 foam duct sealant. The sealers shall be installed per manufacturer recommendations.
13. A weatherhead fitting shall be provided at the top of each aerial pole as shown on the plans. The weatherhead shall seal all aerial cables from water entering the conduit or pole. A minimum of 4 insulator holes shall be provided for each fitting and shall have a hole diameter greater than the approved aerial cable diameter. The fitting shall be hot dipped galvanized and shall be threaded to connect to the conduit.

Z. Wireway and Troughs

1. Wireways or troughs shall be furnished and installed in the control house as shown on the plans or as otherwise required to facilitate the installation of wiring. The Wireways shall be NEMA 12 inside the control house unless otherwise noted and constructed of No. 14 gauge steel, suitably reinforced with structural steel angles, and welded continuously at all seams and joints.
2. Wireways and troughs in areas outside the control house shall be NEMA 4X stainless steel and constructed of 14-gauge type 316 stainless steel, suitably reinforced with structural steel angles, and welded continuously at all seams and joints.
3. Wireways and troughs shall have a sealed removable hinged cover on one side to provide access to the interior. Stainless steel screw clamps spaced no more than 8 inches apart shall secure the cover. Intermediate steel barriers shall be provided to separate power and control wiring when possible.

AA. Boxes

1. All junction boxes, pull boxes, terminal boxes, and cabinets shall be NEMA 4X, 14-gauge, type 316L stainless steel enclosures with hinged, 14-gauge, stainless steel doors supported by a continuous stainless steel hinge with removable pin unless otherwise noted on the plans. Seams shall be continuously welded and ground smooth. Each enclosure shall be provided with stainless steel fast operating door clamp assemblies and oil-resistant gasket to insure a watertight seal. No box shall be drilled for more conduits or cables than actually enter it.
2. Boxes and cabinets shall be Bulletin A51S and A4S with clamp assemblies A-L23SS as manufactured by Hoffman Engineering Company, equivalent manufactured by Henessey or Wiegmann or Engineer approved equal.
3. Junction wells for roadway equipment as shown on the plans shall meet the requirements of DelDOT standard construction details.
4. Terminal boxes shall be of sufficient size to provide ample room for the terminal blocks and interior wiring, and for the installation of conduit terminations and multi-conductor cable fittings. The

manufacturer's optional, S.S. 316L back panel, shall be provided with tapped holes for mounting the terminal blocks. Requirements for terminal and power distribution blocks shall be as specified elsewhere.

5. The interior of all boxes shall be provided with insulated supports from which bundled cables may be supported.

BB. Hardware and Supports.

1. Mounting bolts, nuts, washers and other detail parts used for fastening boxes, disconnect switches, limit switches, conduit clamps, cable/conduit supports, brackets and other electrical equipment shall be of stainless steel conforming to the requirements of ASTM A276, Type 316. Bolt heads and nuts shall be hexagonal, and shall be provided with medium series lock washers. Bolts smaller than 1/2 inch in diameter shall not be used except as may be necessary to fit the mounting holes in small limit switches, boxes and similar standard devices.
2. Unless fabricated from type 316 stainless steel, which has a minimum thickness of 5/16 inch, supports for conduits, cables, boxes, cabinets, disconnect switches, limit switches and other separately mounted items of electrical equipment shall be fabricated from structural steel not less than 3/8 inch in thickness. Channels, angles, bent plates, clip angles, other structural steel supporting members, hardware and gaskets for supporting electrical equipment shall be paid for under this item. Structural steel supporting members detailed under this item shall conform to the requirements specified elsewhere in this Contract.
3. Full neoprene gasket shall be furnished and installed for each box not less than 1/8-inch thick, between the equipment and the surface of the concrete.
4. Anchoring system for fastening equipment or brackets to concrete surfaces shall consist of stainless steel threaded rods and adhesive epoxy. All parts of the anchors shall be of Type 316 stainless steel. The Contractor is also responsible for furnishing any installation tools as required by the manufacturer to properly install the anchoring system. Threaded rods shall be HAS type 316 stainless steel threaded rods as manufactured by Hilti Corporation or approved equal, epoxy shall be HIT RE 500 Adhesive Epoxy as manufactured by Hilti Corporation or approved equal.

CC. General Requirements for Standby Generator

1. This section describes the requirements for providing, all labor, materials, tools and equipment, and putting into permanent operating condition a standby liquid propane (LP) engine generator set of the latest commercial type and design rated for standby service at a minimum of 125 KW, at 0.8-PF, 60-hertz, 480-volts, 3-phase, 4-wire. The system will be a package of new equipment consisting of:
 - a. A liquid propane (LP) fueled, engine-driven electric generating set, complete with battery pack and charger.
 - b. An engine start-stop control system mounted on the generating set.
 - c. A cooling system
 - d. Mounted accessories as specified.
 - e. A remote control/annunciator panel to be mounted in the Control Room
2. To ensure that there is one source of supply and one responsibility, the whole engine-generator system (engine, generator, engine control system, and all major items of auxiliary equipment) will be built, tested and shipped by the same manufacturer. The manufacturer will be completely responsible for providing, testing and placing in proper operating condition the engine-generator set. The equipment supplier must be the authorized distributor for each component of the products specified herein. Independent vendors that buy the engine, generator and auxiliary equipment from various manufacturers and then assemble the equipment together relying on the individual manufacturers for their supply of spare parts and engineering expertise do not meet the criteria of this Special Provision and will not be acceptable. It is

the intent of these Special Provisions to have a single source responsibility for the generator set, and transfer switch.

3. The equipment will be produced by a manufacturer who has produced this type of equipment for a period of at least 5 years and who maintains a service organization available twenty-four hours a day throughout the year.
4. The equipment will be produced by a manufacturer who is ISO 9001 certified for the design, development, production, installation, and service of their complete product line.
5. The system design is based on Cummins Propane Generator C125-N6, alternate make/model may require adjustment to generator size based of manufacturers recommended sizing. Acceptable manufacturers include Caterpillar, Kohler, Cummins or Engineer approved equal.

DD. Standby Generator Requirements

1. Generator Set Requirements: The generator set will be Standby rated at 125 kW (electrical), minimum 156 kVA, 0.8 power factor, 480 VAC, 3-phase, 4-wire, 60 hertz. The generator set will be capable of this rating while operating in an ambient condition of 95°F. The total allowable instantaneous voltage dip will be a maximum of 20%. The maximum instantaneous frequency dip will be 10%.
2. Engine: The engine will be a liquid propane (LP) fueled, full-ignition type, four-cycle, 6-cylinder inline and heavy-duty, turbo-charged, after-cooled unit. (Two-cycle engines will not be accepted.) The engine will be operable under a liquid propane (LP) service with a nominal pressure of 10" to 11" of water column and 674 CFH (cubic feet per hour) at 100% load. The engine will be equipped with the following:
 - a. Fuel filters, lube oil, and intake air filters, fuel pressure gauge, lube oil cooler, lube oil pressure gauge, temperature gauge, service hour meter, and water pump.
 - b. An electronic isochronous governor capable of +0.25% steady-state frequency regulation
 - c. Positive engagement solenoid shift-starting motor
 - d. 10-Ampere minimum automatic battery charging alternator with solid-state voltage regulation.
 - e. Dry-type replaceable air cleaner elements for heavy-duty applications
 - f. The engine will be provided with a thermostatically controlled, immersion-type, jacket water heater capable of maintaining a minimum coolant temperature of approximately 90° Fahrenheit in an ambient temperature of 40° Fahrenheit. The heater will be automatically de-energized when the engine is started.
3. Generator and Exciter
 - a. The alternator will be salient-pole, brushless, 12-lead reconnectable, self-ventilated of drip-proof construction with amortisseur rotor windings and skewed stator for smooth voltage waveform.
 - b. The insulation will meet the NEMA standard (MG1-22.40 and 16.40) for Class H and be insulated with epoxy varnish to be fungus resistant.
 - c. Temperature rise of the rotor and stator will be limited to 130°C (Class F requirements).
 - d. The excitation system will be of brushless construction controlled by a solid- state voltage regulator capable of maintaining voltage within +/- 2% at any constant load from 0% to 100% of rating. The AVR will be fed a separately excited power feed as generated through the use of a permanent magnet generator. The regulator must be protected from the environment by conformal coating. Surge suppressors will be included to protect the diodes from voltage spikes. The voltage regulator will be factory-tested with the generator to insure proper operation of the regulating system in accordance with the requirements hereinafter specified. The AVR will utilize a three phase sensing circuit to monitor the alternator output voltage.

- e. The generator set will meet the transient performance requirements of ISO 8528-5, level G-2.
- f. The generator will be inherently capable of sustaining at least 250% of rated current for at least 10 seconds under a 3-phase symmetrical short circuit without the addition of separate current support devices.
- g. The generator, having a single maintenance-free bearing, will be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.

4. Governing System

- a. The engine governor will be a close-regulating, solid-state, electronic governor, capable of holding the engine speed constant to within plus or minus 0.33 percent for any constant value of load between 1/4 load and full load. Speed regulation from no load to full load will not exceed 3 percent.
- b. The governing system will re-establish stable engine operating conditions within three seconds, without excessive oscillation, following the sudden change in load imposed by the acceleration or deceleration of the span motors. The maximum change in engine speed during the three-second surging period will not exceed 5 percent of rated speed.

5. Control Panel

a. Generator Mounted Control Panel

- i. Provide a generator mounted control panel for complete control and monitoring of the engine and generator set functions. Panel will include automatic start/stop operation; adjustable cycle cranking, digital AC metering (0.5% true rms accuracy) with phase selector switch, digital engine monitoring, shutdown sensors and alarms with horn and reset, adjustable cool down timer and emergency stop push-button. Panel will incorporate self-diagnostics capabilities and fault logging. Critical components will be environmentally sealed to protect against failure from moisture and dirt. Components will be housed in a NEMA 12 enclosure with hinged lid for indoor installations. It will be integrally mounted on the generator set.
- ii. The enclosed control panel (in conjunction with the automatic transfer) will provide automatic starting of the generator set in the event of failure of the regular power supply. The engine starting control will operate from a single pole auxiliary contact of the automatic transfer switch.
- iii. Alarm terminals for a remote annunciator will be incorporated. The control panel will also include a 3-position switch to select "Stop", "Automatic", or "Engine Test".
- iv. Each device on the generator control panel will be suitably named or identified by means of engraved nameplates or dials.
- v. In addition, four normally open dry contacts rated 120-volts, 5-amps will be provided. One contact will be arranged to close when the generator is running and capable of providing bridge power and the other will be arranged to close when the generator is running but fails to provide power.
- vi. Provide programmable protective relay functions inside the control panel to include the following:
 - (1) Under voltage, Over voltage, Over frequency, Under frequency, Reverse power, Overcurrent (phase and total), KW level (overload), Readouts, Provide the following readouts: Engine oil pressure, Coolant temperature, Engine RPM, System DC Volts, Engine running hours, Generator AC volts, Generator AC amps, Generator frequency; KW meter, Percentage of rated Power, KVA meter, kVAr meter, Power Factor meter, KWHR meter, Alarm NFPA 110.
- vii. Provide the following indications for protection and diagnostics according to NFPA 110 level 1:

- (1) Low oil pressure, High water temperature, Low coolant level, Over speed, Over crank, Emergency stop depressed, Approaching high coolant temperature, Approaching low oil pressure, Low coolant temperature, Low voltage in battery, Control switch not in auto. Position, Low fuel main tank, Battery charger ac failure, High battery voltage, EPS supplying load.

b. Remote Annunciator Panel

- i. A remote alarm indicator will be furnished and mounted near the control desk in the control house to give visual indication of impending alarm conditions and engine failure condition plus indication of low battery voltage and low fuel supply pressure. The annunciator will provide remote annunciation of all points stated above. Provide alarm indication for "generator ground fault" to meet NEC. The equipment will conform to the requirements of NFPA 99, and NFPA 110, Level 1. This remote annunciator panel will include a ten (10) relay dry contact box for connection to the controller terminal strip. The panel will have the capability to be either flush-mounted or surface-mounted. The remote annunciator panel will have the capability to "Estop" the generator as well as put it into engine exercise mode.

6. Starting System

- a. A DC electric starting system with positive engagement will be furnished. The motor voltage will be as recommended by the engine manufacturer.
- b. The starting system will consist of a storage battery and an engine-starting panel wired in conjunction with the starting motor on the engine. A battery charger including float-charger type will be furnished and installed to maintain the battery at full charge.
- c. The storage battery will comprise a block assembly of heavy-duty, pocket-type, nickel cadmium cells of the alkaline type connected in series to provide the required voltage. Each cell will be designed specifically for liquid propane (LP) - engine starting service. The storage battery will be installed on a battery rack. The battery rack will be rigidly mounted on the non-vibrating generator set skid base. The battery rack will not be installed on the vibrating engine-generator base.
- d. The starting battery will be maintained at full charge by a solid-state battery charger with fully automatic charge control. The charger will be a single-phase 120-volt AC unit capable of sufficiently charging the battery, and will be of the silicon controlled rectifier type. It will be provided with independently adjustable float and recharge voltages and will include current limiting to 110 percent of rated current for all load conditions. The charger will be equipped with a DC voltmeter, DC ammeter, AC and DC fuses and low voltage alarm relay. The charger will be capable of sensing current discharges of the battery and of automatically recharging it without interruption of AC power to the rectifiers. The battery charger will be approved for use with the batteries provided.

7. Fuel Supply System

- a. Furnish and install a 1000-gallon capacity steel above ground propane tank as shown on the plans to fuel the stand-by generator. The tank, piping, installation and all accessories shall meet the requirements of NFPA. The tank shall be cable of operating the generator 48 hours at 50% load.
- b. Furnish required fuel lines, vents, gauges, sensors, and fittings and install fuel lines between the tank and propane gas engine and will be of the type recommended by the manufacturer. The generator fuel piping system will meet the requirements of NFPA 58 and all local code requirements.
- c. The buried pipe run from the meter to the generator will be adjacent to the buried electrical conduit and will be installed in pvc conduit and encased in concrete. The pvc conduit will be sealed on the ends and vented to the exterior as required per code.
- d. The size of the piping will be per the generator manufacturer's requirements and NFPA 58. Piping will be mounted in a manner to reduce vibration. Piping will be schedule 40 steel piping in

accordance with ASTM A53 and NFPA 58. When selecting materials, piping in the generator room will be treated as exterior piping. Piping will be tested in accordance with NFPA 54 and all local code requirements. All piping and fittings will be painted in accordance with a 3 coat epoxy paint system.

8. Exhaust System

- a. The engine exhaust line will be directed upward from the engine to a silencer all housed within the weather/sound enclosure. The silencer will be mounted so that its weight is not supported by the engine nor will exhaust system growth due to thermal expansion be imposed on the engine. The exhaust piping will be as required to fit within the custom weather/sound enclosure. The Contractor will provide and install a super critical-grade silencer, constructed of Type 316 Stainless Steel. The silencer will reduce total engine exhaust noise by 35 dBA including all exhaust piping as installed). The silencer and exhaust piping will be designed to minimize backpressure on the engine to the minimum manufacturer's recommendation.
 - b. A UL approved wall thimble constructed in conformance with NFPA 37 and NFPA 110 will be installed where the exhaust pipe penetrates the exterior wall. The thimble will include a support collar and exterior flashing on the opening surface, welded to the outer sleeve of the thimble. The thimble will have a rain collar and screen. Furnish and install an interior flashing piece to go on the inside of the structure. The thimble will be of carbon steel construction with a galvanized protective coating.
 - c. All connections in the exhaust system will be made with standard weight, flat faced, slip-on welded flanges, welded back and front to the piping. All flanges will be 150 PSIG, flat faced, slip-on, hot-dipped galvanized, carbon steel per ASTM A105 with dimensions per ANSI Standard B 16.5. All joints will be provided with full face, 1/16-inch thick, woven graphite, wire-inserted, 150 PSIG rated gaskets. Fasteners for flanged joints will be bolts per ASTM A193, Grade B7 bolts with nuts per ASTM A194, Grade 2H. Flange bolt threads will be coated with an anti-seize, copper-based, thread lubricant.
 - d. The muffler, exhaust piping and all ductwork (both in the generator room and above it) will be insulated by the contractor to maintain a surface temperature not to exceed 150F and to reduce noise. Insulation material will be rated for outdoor use and jacketed with a 304 or 316 stainless steel mesh (or approved equal) for protection against damage. No asbestos or asbestos bearing products will be used.
9. Generator Line Circuit Breaker: Provide a generator mounted circuit breaker, 150-amp trip, 3-pole, which will conform to the requirements given under the item Control System Vendor. Breaker will utilize a thermal magnetic trip unit and shunt trip. The breaker will be UL listed with shunt trip device connected to engine/generator safety shutdowns. Breaker will be housed in an extension terminal box mounted on the side of the generator. Mechanical type lugs, sized for the circuit breaker feeders shown on drawing, will be supplied on the load side of breaker.

10. Exhaust and Intake Louvers and Duct

- a. Ventilation exhaust and intake louvers for the generator will be provided as shown on the Plans and specified under these special provisions. The louvers will be the stationary type, and will be furnished and installed in the Generator House as shown on the Plans. The size and free area of the louvers will be as shown on the Plans, but no smaller than the minimum recommended size as required by the generator set manufacturer.
- b. The louver frame and blades will be No. 16 gauge stainless steel. The frame will be reinforced channel construction, welded at the corners and will be equipped with an angle flange for fastening.
- c. The Contractor will furnish and install a galvanized sheet metal cooling duct directing cooling air from the radiator fan to the exhaust louver. The duct will contain drainage for any moisture, which

may enter the louver from outside. Provisions will be made to ensure easy disassembly and access to the interior of the duct, louver, and other concealed parts that require periodical cleaning and access for maintenance personnel. The sheet metal ducting will be a minimum of No. 22 gauge steel with reinforcement as required to prevent excessive vibration.

EE. Panelboards

1. A new panelboard shall be furnished and installed as shown on the plans for distribution of the bridge miscellaneous control circuits for traffic signals, navigation lights, motor heaters, generator accessories, etc. The panelboards shall be of the dead-front type and shall be provided with quick-make, quick-break, thermal-trip, E-frame, both-on branch circuit breakers. Each breaker shall trip free of the operating handle, and the handle shall indicate the position of the breaker. The panelboards shall be provided with an internally mounted surge protection device rated for use in the panelboard it is mounted in.
2. Each panelboard shall be provided with a circuit breaker in the mains and with a full-sized neutral bar. All branch circuits shall be numbered, and a typewritten directory shall be provided on the inside of each door. Circuit breakers shall meet the requirements of UL Standard 489. Panelboards shall be provided with number of spaces and spare breakers as indicated on the Plans.
3. Panelboard circuits breakers shall be rated for the connected operating voltage and have a minimum interrupting rating of at least 35KAIC. Each circuit breaker shall be bolt on type units and shall be connected to the panelboard as shown on the plans.
4. Bridge control panelboard L1 shall be 120/240-Volt, 1-phase, 3-wire panel. The panelboard shall be code-gauge galvanized steel with ANSI 61 light gray enamel finish unless otherwise noted. Other panelboards required shall be as specified on the drawings or in relevant sections of these specifications.
5. The panelboards installed in a climate controlled environment shall be rated NEMA 12. Panelboards and circuit breakers shall be NQ/NF and QOH type as manufactured by Square D with ratings and number of circuits as shown on the plans.

FF. Transformer

1. Two general purpose transformers shall be furnished and installed in the control house as shown on the plans.
2. The control house lighting transformer shall be a three phase, four-wire, 480-volt primary, 208/120-volt secondary. The miscellaneous transformer shall be single phase, 3 wire, 480 primary, 240/120V secondary. Both transformers shall be epoxy resin encapsulated, non-ventilated transformer with copper windings with size as shown on the plans. The transformer shall be located and sized as shown on the plans in a NEMA 12 enclosure. Control transformer shall be as specified elsewhere.

GG. Marine Air Horn

1. The required bridge sound signals to marine vessels shall be a heavy duty, compressed air horn with separately mounted projectors. The compressor and projectors shall be furnished and installed on the control house as shown on the plans.
2. Each projector shall point in opposite directions (north and south) and parallel to the navigable channel. The compressor shall be mounted within the control house on a wall bracket.
3. Each projector shall be diaphragm type, four (4) inch vibratory horn having a frequency of about 300 cycles per second. Each projector shall be of weatherproof construction with a bell of bronze. Each projector shall connect to the compressor with a hose.
4. The rotary air compressor shall be driven by an integral one (1) horsepower electric motor which shall actuate the air horn. The motor shall be a 120-volt, single-phase, 60-cycle unit. The air horn unit shall be approved equal to the B&B Roadway AHR-2.

HH. Navigation Lights

1. It is the intent of this specification to sole source B&B Roadway BS, GL and PL navigation lighting with accessories as specified herein or shown on the drawings. No substitutions are permitted.
2. Fender Navigation Lights: Vandal resistant fender lights shall be mounted on the fender system as shown on the Plans. Each pile cluster light shall be a dual unit, 8-inch outside diameter, 180 degree, red fresnel lens and shall be mounted on a short section of 1 ½” stainless steel pipe with a flange at the bottom and bronze castings. Each pile cluster light housing shall be cast-bronze, securely bolted in position with bronze or stainless steel lag screws not less than 3/8 inch in diameter. Each pile cluster light shall be equipped with 120 volt, 100,000-hour LED lamp. New fender light shall be the PL pier light as manufactured by B&B-Roadway. No substitutions are permitted.
3. Red/Green Span Navigation Lights: At the outboard toe of each bascule girder, there shall be mounted a new double-unit navigation light. Each unit shall have a green light mounted above a red light. The red light shall have an 8-inch, 180-degree, red fresnel lens. The green light shall have an 8-inch, 180-degree, green fresnel lens. Each bascule span light shall be suspended by a stainless steel pipe hanger from a pivot bracket mounted on the steel work. The pivot assembly shall be provided with an anti-swing brake to prevent oscillation under windy conditions. The retriever chains shall be arranged to allow the lights to swing freely and so that the unit can be readily withdrawn for lamp replacement. The connections to the span lights shall be made with four-conductor, No. 10 AWG, flexible cable. One conductor shall ground the span light housing. New red/green navigation lights shall be the BS bascule span light as manufactured by B&B-Roadway. No substitutions are permitted.
4. Gauge Lighting: Each gauge light fixture shall contain a housing body fabricated with precision die cast aluminum with a durable powder coat finish. All components shall be corrosion resistant. Construction shall be rain-tight and shall be equipped with a retained gasket. Lens shall be thermal-tempered shock-resistant glass. Fixture head rotation shall be adjustable and incorporate locking teeth and internal gasket for secure, leak-free positioning of the head. Hinge pins and external fasteners shall be of stainless steel. Each gauge light assembly shall include the flood light fixture housing, NEMA 4X enclosure. Lamps shall be a 12V LED array. Nominal life shall exceed 50,000 hours life. Supply power shall 120VAC and a step transformer and rectifier shall be provided in the junction box to convert power to 12VDC supply. Each lamp shall be serviceable without tools and shall pivot and rotate to provide multi-directional lighting adjustment. The enclosure shall be constructed of stainless steel with a cover. The cover shall be attached to the enclosure with stainless steel swing bolts, which shall include a watertight gasket. The enclosure shall have provisions for mounting to a platform with four 3/8 – inch diameter bolts. A 1-inch Meyers hub shall be supplied with the assembly for wiring.
5. All bascule span navigation lights shall have gasketed doors and lenses, and each entire unit shall be completely weatherproof. Fittings shall be non-corroding, and the sockets shall be porcelain mounted on shock absorbers. The housings for all units shall be cast-bronze, and a 100-watt 120-volt, 5-year lamp with brass base shall be installed in each socket. A dual lamp and transfer relay kit shall be provided in each navigation light housing. A bronze retriever chain shall be provided for each pivoted bascule span light.
6. All navigation lights shall be provided with type 316L S.S. hardware and built and installed in accordance with the rules and regulations of the United States Coast Guard.

II. Lighting Equipment:

1. Receptacles: All indoor receptacles shall be GFCI, 20-ampere, 125-volt, three-wire, grounding type, polarized, duplex convenience outlets. Ground fault receptacle outlets shall be installed in locations as shown on the drawings or as required by the National Electrical Code. Outdoor receptacles shall be similar except each receptacle shall be provided with a watertight cast iron cover plate. Receptacles shall be specification grade manufactured by Hubbell, Arrow Hart, Leviton, or approved equal.

2. Switches: All lights shall be controlled from tumbler switches located in a convenient, accessible location. All tumbler switches shall be specification grade, 20-ampere, 125-volt switches. Outdoor switches shall be mounted in waterproof, cast-iron, hot-dipped galvanized, surface mounted boxes. Switches shall be mounted 4 feet above the adjacent floor or platform. Switches shall be Specification Grade switches manufactured by Hubbell, Arrow Hart, Leviton or approved equal.
3. Light Fixtures: Each exterior light fixture shall be wall mounted above each entrance door and outdoor rated with cast aluminum housing. Each fixture shall be gasketed with swing out door for maintenance. Each lamp shall be rated for 120VAC with 3400 lumens (33 watts). The light assembly shall be Appleton LED Wall Luminaire Model TWR1 with 33 watt bulb or approved equal.

JJ. Lightning Protection

1. Furnish and install 24" air terminals on top of the movable span balance frame and counterweight. Crimp type connectors will not be acceptable in any part of the lightning protection system. Conductor guards shall be non-metallic. Transit sleeves shall be non-metallic.
2. The Contractor shall furnish and install down conductors as required by NFPA 780. The conductors shall be copper with a tinned outer protective covering, and shall meet Class I lightning protection standards for composition, size of conductors, and weight as per NFPA 780 table 4.1.1.1.1. All conductors shall be supported at three-foot intervals both horizontally and vertically on the bridge structure and control house using lightning system approved clamps. Stainless steel supports shall be used to support conductors down the piers.
3. Air terminals shall be furnished and installed to achieve the protection envelope as achieved by a rolling 150' diameter sphere as required under NFPA 780. The air terminals along the bridge structure shall not be taller than 24 inches. The air terminals shall not be spaced more than 25 feet from any other adjacent air terminal.
4. Each of the air terminals shall terminate at 24" x 24", 10 gauge copper grounding plate with a heavy-duty clamp, buried a minimum of 18" underwater to meet standard NFPA 780, 3.13.6.
5. An additional cable will bond the electrical service and the telephone service to the lightning protection system to meet NFPA 780, 4.14.3. A lightning protection surge suppressor shall be installed on both the electrical service and generator set service point.

KK. Grounding and Bonding

1. The bridge steel work on each side of the channel and the control house shall be solidly bonded and grounded to ground rods installed in the piers as shown on the plans, using No. 1/0 AWG bare, stranded, tinned copper cable.
2. Exothermic welds shall be used to connect ground conductors to ground rods and ground bus bars. The resistance to ground shall be no more than 5 ohms. Exothermic welds shall be molded fusion, type as required, as manufactured by Cadweld, Thermoweld, Metalweld, or approved equal.
3. Utility service and the generator neutral conductors, the bridge grounding conductor and grounding electrode conductors shall all be exothermically welded together where required by NEC 250.30.
4. Grounding system terminals, where required, shall be solderless lugs made from high copper content alloy and shall be secured by means of hexagonal-head, copper plated, steel machine bolts with lock washers or lock nuts.
5. Equipment ground conductors shall be seven-strand, soft-drawn, bare, tinned copper wire conforming to ASTM B33 and not smaller than No. 8 AWG.
6. Ground rods shall be made of copper or copper-clad steel and shall not be less than 1/2 inch in diameter and 8-feet in length unless otherwise specified. A permanent, exothermic weld connection to the piling at the bridge piers is an acceptable grounding means. If the steel sheet piling is not accessible, ground

rods shall be used as grounding electrodes. Insulated green ground conductor shall be used when exposed to wet environment.

LL. Weather Station

1. A weather station shall be furnished and installed within the control house to display current wind speed with direction, temperature, humidity, dew point, etc. The weather station shall consist of a sensor, console and support. The system shall operate from -40° to +150°F and include CR0123 3V battery for the sensor and AC adapter with 3 C cell battery back-up for the console.
2. The weather station console shall be located on top of the upper portion of the control console. The outdoor sensor shall be mounted on the operators' house with required manufacturer supplied support.
3. The weather station shall be the Vantage Vue Weather Station with WeatherLink Console a manufactured by Davis or Engineer approved equal.

MM. Technical Manuals

1. Maintenance Manuals shall contain descriptive material, catalog cuts with non-pertinent data blocked out, as-built drawings, spare parts list, troubleshooting techniques and any and all information necessary for successful maintenance of the bridge functional systems and each piece of equipment furnished by the Contractor. Bridge functional systems shall be understood to include all operating machinery, lock machinery, electrical service equipment, electrical and control systems, and all other equipment for which periodic maintenance and operation is desirable. Subsequent to acceptance of the bridge by DelDOT following successful completion of acceptance testing, errata or addenda to the manuals should address any revisions required.
2. Operations Manuals shall contain written descriptions of the functional systems of the movable bridge, step-by-step operating instructions for each of these systems and any and all information and directions required for their successful operation. Subsequent to the break-in period, errata or addenda to the manuals should address any revisions required.
3. All printed matter, data, drawings, diagrams, etc., shall be accurate, distinct and clearly and easily legible. Illustrations shall be clear; and printed matter, including dimensions and lettering on drawings, shall be legible. If reduced drawings are incorporated to manuals, the original lines and letters shall be darkened as necessary to retain their legibility after reduction. Larger drawings may be folded into manuals to page size.
4. Operating and maintenance manuals shall be bound in heavy-duty nickel-plated three-hole binders with three trigger positions: lock, unlock and open. Binder shall have metal hinges. Locking mechanism shall allow sheets to lie flat (i.e. channel lock). Covers shall be stiff heavy-duty plastic or other approved material.
5. The printed material shall be bound into each manual between rigid covers. The manuals shall be approximately 9 inches by 12 inches to contain the drawings without excessive folding so that they may be easily opened. The books shall be neatly entitled with a descriptive title, the name of the project, the location, year of installation, the name of the manufacturer, the engineering firm and the Contractor. Copies of drawings shall be in black on white background and shall be legible. The arrangements of the books, the method of binding, material to be included, and the text shall all be submitted to and approved by the Engineer.
6. Paper used in these manuals shall be 20-pound, punched paper, water resistant, and acid free of a quality suitable for archival use. Paper shall have 5/16-inch minimum diameter holes, reinforced with plastic or cloth at the standard three (3)-hole spacing. The paper shall be standard 8½"x11", or, in the case of larger foldout diagrams and illustrations, folded to approximately 8½"x11" size. No paper or other material shall extend beyond the manual covers.

7. In addition, the approved manuals shall be scanned into PDF files, which will then be placed on a USB thumb drive and submitted over to the Delaware Department of Transportation after final acceptance by the Engineer

NN. Spare Parts

1. Spare parts shall be as specified below and include the specified quantity.
 - a. Control Equipment:
 - i. One fully programmed touchscreen display for each size provided.
 - ii. One spare loose PLC card and module for each type/size furnished including processors, I/O, power and communication cards.
 - iii. One spare Ethernet switch for each type supplied.
 - iv. One spare power supply for each size and type installed.
 - v. Six fuses of each kind and size installed.
 - vi. One miniature circuit breaker of each type installed.
 - vii. One completely assembled and wired Reversing and one completely assembled Non-reversing contactor for each type installed.
 - viii. One control relay for every ten installed (minimum of 1 relay). For fixed contact relays supply one spare per ten for each contact arrangement.
 - ix. One spare safety relay module.
 - x. One complete relay timer and time delay relay for every ten installed (minimum of 1 relay and two sets of contacts).
 - xi. One door limit switch.
 - xii. One selector switch and push-button for each type supplied.
 - xiii. One indicating light for each type and color supplied.
 - xiv. 10 spare bulbs for each color indicating light.
 - xv. Three indicating light covers for each type supplied.
 - xvi. Two hydraulic amplifiers for each type supplied.
 - b. Limit Switches:
 - i. Two completely assembled span lock lever limit switches.
 - ii. Two-cylinder position transducer, including all accessories.
 - iii. Four proximity sensors for each type supplied including cord sets.
 - iv. Two position inclinometers
 - c. Traffic Gates
 - i. Two door switches for each type supplied.
 - ii. Two flashers for each type supplied.
 - iii. Six fuses of each kind and size installed.
 - iv. Two proximity sensor for the barrier gates.
 - v. One limit switch for each type of gate installed.

- d. Miscellaneous Equipment (E15, E33)
 - i. Two panelboard circuit breakers for each type and size supplied
 - ii. Six spare bulbs for each type of light fixtures including navigation lights.
- 2. Arrange the spare parts in uniform size cartons of substantial construction, with typed and clearly varnished labels to indicate their contents, and store them where directed by the DelDOT. Large spare parts shall be provided with moisture-proof wrapping. Provide a directory of permanent type, describing the parts. The directory shall state the name of each part, the manufacturer's number thereof, and the rating of the device.
- 3. The spare parts shall be maintained during construction until final acceptance of the project from DelDOT.

Construction Methods:

A. Scope of Work

- 1. E1 - Control Cabinets
 - a. The work under control cabinets shall include the following:
 - i. Furnish and install a new enclosure to house the PLC (Programable Logic Controller) and associated equipment and install in the control house as specified and as shown on the plans.
 - ii. Program and make adjustments to the PLC system as specified herein and submit ladder logic for review and approval.
 - iii. Furnish and install firewall network switch in PLC Cabinet and connect to DelDOT's network.
 - iv. Furnish PLC software.
 - v. Furnish install Square D control equipment as specified and shown the drawings.
 - vi. Furnish and install Allen Bradley PLC equipment as specified and shown on the drawings.
 - vii. Furnish spare parts as specified herein and deliver to DelDOT.
 - viii. Develop shop drawings related to the new back panel and new cabinet including component cut sheets and submit for review and approval.
 - ix. Furnish programming laptop and load all specified software and as-built PLC program.
 - x. Coordination of the PLC system with the TMC (Traffic Management Center) network.
- 2. E2 - Control Desk
 - a. The work under control desk shall include the following:
 - i. Develop shop drawings including component cut sheets related to the new control desk and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install new control desk in the Control Room as specified and shown on the plans.
 - iii. Furnish install Square D control equipment as specified and shown the drawings.
 - iv. Furnish spare parts as specified and deliver to DelDOT.
 - v. Coordination of the PLC system with the TMC network.
- 3. E3 - Motor Control Enclosure (MCE)
 - a. The work under motor control center shall include the following:

- i. Develop shop drawings including component cut sheets related to the MCE and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install new MCE in the control house as specified and shown on the plans
 - iii. Furnish install Square D control equipment as specified and shown the drawings.
 - iv. Furnish spare parts as specified herein and deliver to DelDOT.
- 4. E4 - Automatic Transfer Switch Cabinet (ATS)
 - a. The work under automatic transfer switch shall include the following:
 - i. Develop shop drawings including component cut sheets related to the ATS system and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install new Automatic Transfer Switch (ATS) and associated equipment in a new enclosure as specified and shown on the plans.
 - iii. Furnish install Square D control equipment as specified and shown the drawings.
 - iv. Furnish spare parts as specified herein and deliver to DelDOT.
- 5. E5 - Limit Switches
 - a. The work under limit switches shall include the following:
 - i. Furnish and install the following limit switches and sensors as specified and shown on the plans: position/speed encoders, position inclinometer, fully closed, over travel, span locks and gates.
 - ii. Adjust all limit switches with the settings as shown on the plans. Readjustment will be required for proper operation during final testing.
 - iii. Furnish spare parts as specified herein and deliver to DelDOT.
 - iv. Develop shop drawings including component cut sheets and mounting details related to the limit switches and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
- 6. E6 - Motors
 - a. The work under motors shall include the following:
 - i. Develop shop drawings including component cut sheets related to the motors and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and electrically connect span lock and pump motors as specified.
 - iii. Perform motor shop testing as specified for all motors supplied.
 - iv. Furnish spare parts as specified herein and deliver to DelDOT.
- 7. E7 - Warning and Barrier Gates
 - a. The work under warning and barrier gates shall include the following:
 - i. Develop shop drawings including component cut sheets and mounting details related to the new warning and barrier gates and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install new warning and barrier gates manufactured by B&B Roadway as shown on the plans.

- iii. Furnish and install new gate foundations as shown on the contract plans.
 - iv. Furnish spare parts as specified herein and deliver to DelDOT.
8. E8 - Traffic Signals, Pole and Foundations
- a. The work under traffic signals shall include the following:
 - i. Coordination of installation for new traffic signals and NW camera as shown on the contract plans.
 - ii. Furnish and install new foundations and anchors as shown on the contract plans.
 - iii. Coordination with DelDOT and DelDOT's on-call contractor for installation of new signal poles, camera poles, mast arms and traffic signals as shown on the plans.
9. E9 - Motor Disconnect Switches
- a. The work under motor disconnect switches shall include the following:
 - i. Develop shop drawings including component cut sheets and mounting details related to the motor disconnect switches and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install motor disconnect switches in sight of each motor as specified and connect as shown on the plans.
 - iii. Furnish spare parts as specified herein and deliver to DelDOT.
10. E10 - Electrical Cable, Wire and Connections
- a. The work under electrical cable, wire and connections shall include the following:
 - i. Develop shop drawings including component cut sheets and mounting details related to the electrical wire and cable and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install new wiring inside conduit, wireways and other raceways as specified and shown on the plans.
 - iii. Furnish and install ground systems and conductors as specified and shown on the plans.
 - iv. Furnish and install new flexible droop cables as specified and shown on the plans.
 - v. Test, tag and connect each conductor at termination points inside control enclosures, the control desk, limit switches, gates, motors, termination boxes and all other devices.
11. E11 - Electrical Conduit, Fittings and Boxes
- a. The work under electrical conduit, fittings and boxes shall include the following:
 - i. Furnish and install new conduit, wireways, troughs, boxes, vaults, junction wells and fittings as specified and shown on the plans.
 - ii. Furnish and install new conduit and box supports as specified and shown on the plans.
 - iii. Clean the interior of each section of new conduit prior to installation of wire.
 - iv. Core drill and/or cast in place through walls and floors to accommodate new conduit and associated equipment.
 - v. Furnish and install trenches as required to accommodate new conduit.
 - vi. Remove existing conduit in trench and/or roadway as required or to accommodate the location of new conduit. Repair all damaged conditions in an as new condition.

- vii. Furnish and install new back panels in the specified new terminal boxes as specified and shown on the plans.
- viii. Tag each conduit with a designation number noted in the approved conduit shop drawings.
- ix. Develop shop drawings including component cut sheets, mounting and installation details, and conduit block diagram related to the electrical conduit, fittings, and boxes and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
- x. Coordinate with DelDOT's security contractor for installation of conduit associated with the security system.

12. E12 - Incoming Service

- a. The work under incoming service shall include the following:
 - i. Develop shop drawings including component cut sheets related to the incoming service and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install incoming service equipment such as meter, enclosure and service disconnect switch.
 - iii. Coordination with local electrical utility company, Delaware Electric Co-Op (DEC) to furnish, install, connect and energize the new incoming services shown on the plans.
 - iv. Provide DEC with access to the bridge, roadway and surrounding areas to furnish and install conduit, wire and other related incoming service equipment which may include road closures, MOT and other safety measures and equipment.

13. E13 - Aerial Cables and Termination Boxes

- a. The work under incoming service shall include the following:
 - i. Develop shop drawings including component cut sheets related to the aerial cables, termination boxes, cable supports and support poles, submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install new aerial cables, termination cabinets, supporting pole structure, supporting cables, and anchor bolts as shown on the plans.
 - iii. Perform factory and field testing on the aerial cables as specified.
 - iv. Tag and terminate aerial cables following approval of test results as specified.

14. E14 - Stand-By Generator

- a. The work for the stand-by generator shall include the following:
 - i. Develop shop drawings including component cut sheets related to the new stand-by generator including propane tank and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install propane fuel lines between the generator and fuel tank.
 - iii. Furnish propane stand-by generator and all accessories as specified.
 - iv. Furnish and install concrete slab, tank and anchorages.
 - v. Fill the generator fuel tank with propane fuel at project completion to 80% capacity and provide fuel as required to maintain generator operation throughout construction and testing.

15. E15 - Bridge Operation during Construction

- a. The work under bridge operation during construction shall include the following:
 - i. Develop shop drawings related to the bridge operation during construction including component cut sheets for any temporary equipment along with operation and maintenance procedures and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Coordination with all trades and work throughout the duration of the contract to maintain operability of the bridge until DelDOT and USCG approval for a navigation and traffic closure.
 - iii. Furnish and install mechanical and electrical equipment required to operate the bridge in a temporary fashion as specified.
 - iv. Provide qualified and trained bridge operators and other personnel to operate the bridge in accordance with USCG requirements.
 - v. Testing of temporary bridge operations using approved methods and equipment in the presence of DelDOT and the Engineer.
 - vi. Maintenance of new and existing mechanical and electrical equipment per manufacturers recommendations and DelDOT's latest Operation and Maintenance Manuals for the bridge until completion of the contract.

16. E16 - Miscellaneous Equipment

- a. The work under miscellaneous equipment shall include the following:
 - i. Develop shop drawings including component cut sheets related to the miscellaneous equipment noted below and submit for review and approval. All shop drawings and the information contained within shall become the sole property of DelDOT.
 - ii. Furnish and install panelboards and transformers as specified and shown on the plans.
 - iii. Furnish and install lighting and receptacles on the span lock and maintenance platforms.
 - iv. Furnish and install photo cells for navigation lighting.
 - v. Furnish and install new B&B Roadway span and fender navigation lights.
 - vi. Furnish and install marine air horn and compressor in the control house.
 - vii. Furnish spare parts, as specified herein, and deliver to DelDOT.

17. E17 - Testing

- a. The work under testing shall include the following:
 - i. Submit for review and approval test procedures and forms to be used during factory and field testing. Following successful testing, submit all completed forms and procedures.
 - ii. Perform the specified factory inspection and testing on the control system, including control enclosures, PLC's and motors.
 - iii. Perform start-up and commissioning in the field once control equipment is installed.
 - iv. Perform insulation resistance testing on all motors, wires and cables
 - v. Perform factory load testing using actual motors and drives connected to a dynamometer.
 - vi. Perform field acceptance testing on the completed mechanical and electrical system as specified.
 - vii. Perform testing of the PLC alarms with the TMC network.

18. E18 - Technical Manuals and Training

- a. The work under technical manuals and training shall include the following:
 - i. Perform training as specified on operational, maintenance and troubleshooting of mechanical and electrical equipment.
 - ii. Compile cut sheets, manufacturer's literature, maintenance instructions, test data, shop drawings, contact information for mechanical and electrical equipment and submit for review and approval.
 - iii. Develop an operational manual covering all modes of operation and submit for review and approval. All the information contained within shall become the sole property of DelDOT.
 - iv. Develop and compile as-built drawings for mechanical and electrical equipment and systems and submit for review and approval. All drawings and the information contained within shall become the sole property of DelDOT.

19. E19 - Removal of Electrical Equipment

- a. The work under removal of electrical equipment shall include the following:
 - i. Removal and disposal of existing electrical equipment related to movable bridge operation, roadway lighting and traffic control devices.
 - ii. Travel to and from disposal sites by the Contractor to dispose of equipment.
 - iii. Coordination with DelDOT for all salvaged equipment and associated removal, shipping and/or travel cost to deliver salvaged equipment to DelDOT.
 - iv. Disposal costs to deliver and unload existing equipment.
 - v. All equipment and access means to properly remove indicated equipment.

20. E20 - Lightning Protection and Bonding/Grounding Systems

- a. The work under lightning protection and bonding/grounding systems shall include the following:
 - i. Furnish and install lightning protection system as specified and shown on the plans.
 - ii. Employ the services of a certified UL inspector to master label the entire lightning protection system.
 - iii. Furnish and install bonding and grounding in the control house, maintenance platform, movable span, roadway, and rest pier as required and shown on the plans.
 - iv. Bonding all metal components such as rebar, railings, and structural steel to the ground system.
 - v. Develop shop drawings including component cut sheets, mounting and installation details and submit for review and approval.

B. Working Drawings, Samples and Submittals.

- 1. Create and produce working installation drawings in accordance with the requirements below and herein in CAD format. The reproduction of the contract drawings will not be acceptable as part of any submitted shop drawings and will be immediately rejected and returned to the Contractor for revision. The required drawings will be submitted in as a hard copy or electronic pdf as required by the DelDOT standard specifications and shall have the Contractor border on each submitted drawing.
- 2. Within 30 days after the award of the Contract a completed schedule of electrical submissions that outline when all of the electrical submittals will be made. No more than 90 days shall pass between the award of the contract and the Contractor's first submission.

3. Certified dimension prints of the apparatus shall be provided and state in the certification the name of the job, the application of the apparatus, device designation, number required, right-hand or left-hand assembly, electrical rating, number of poles or contacts, material, finish, and any other pertinent data to show that the apparatus meets the specified requirements.
4. Upon completion of the work, correct all electrical shop or working drawings to show the work as constructed and provide one (1) set of 11X17 pdf drawings, as well as the associated CAD files.
5. Submit for inspection and test, if directed by the Engineer, samples of any apparatus or device that he proposes to use as a part of the electrical installation.
6. As a minimum supply the following shop drawings and submittals prior to the start of associated field work.
 - a. Control System Vendor Submittals:
 - i. Certified dimension prints of all limit switches, proximity sensors, motor encoders, control cabinets, PLC cabinet, control desk, back panels, panelboards and other electrical apparatus external to the control desk, are required. All pertinent electrical data, ratings, calculations and mounting details are to be included on the prints.
 - ii. A complete schematic diagram and wiring diagram, including all power, communication and control connections. Each electrical device and each wire between devices shall be identified by an individual designation of letters, numbers, or a combination of both; and such designations shall be used wherever the devices or wires appear on other drawings.
 - iii. Layout drawings and internal connection wiring diagrams of the control desk, control cabinet, back panels, PLC cabinets and motor control enclosure.
 - iv. A schedule of electrical apparatus for each cabinet or panel which shall list each electrical device by its manufacturers designation as shown on the schematic wiring diagram and shall state for each device its rating, number of poles or contacts, function, catalog number, and location. A complete set of catalog cuts for materials furnished shall be included for each piece of apparatus.
 - v. A point-to-point complete interconnection diagram(s) for all bridge control electrical apparatus and equipment used in the operation of the span. The diagram(s) shall be of the elementary type and shall show the external connections of all devices and equipment from all terminal blocks installed. Computer-generated inter-connection lists will not be acceptable in lieu of a true interconnection diagram.
 - vi. Shop and field testing procedures, including test forms with acceptance criteria, and schedule of testing of all equipment shall be furnished by the vendor.
 - vii. All drawings and the information contained within shall become the sole property of DelDOT.
 - b. Contractor Installation Work Submittals: Develop point-to-point electrical conduits and wiring runs for the entire electrical system. Coordination with all other disciplines is required as part of the development of the drawings. The required drawings shall include, but not be limited, to:
 - i. A complete schematic conduit diagram showing the interconnection of all devices and equipment, including terminal and junction boxes. The size of each conduit, and the wire number and size of each conductor in conduit, shall be shown on the diagrams. Each conduit shall be suitably numbered or lettered, and percent wire fill shall be shown.
 - ii. Prior to the start of field work, a complete set of layout and installation drawings for the electrical work shall be submitted for review and approval. The drawings shall include and detail the location of equipment, installation procedures/methods, support and mounting details of equipment, electrical apparatus and equipment. These drawings shall be made to scale and

shall show the exact location of all conduits, supports, cables, boxes, motors, limit switches, disconnect switches, and other electrical equipment and the method of supporting them on the structure. No work shall proceed without the approval of these drawings by the Engineer.

- iii. Construction drawings of all multi-conductor droop and flexible cables, including the sizes of conductors, type and thickness of insulation, jackets and other components, and giving the outer diameter of each finished cable.
- iv. Detail drawings showing the construction of cabinets, brackets, and special supports required for the installation of the droop cables for circuit connections between the movable span and fixed pier including conduit installation and expansion/deflection conduit fittings.
- v. Test results from all factory and field test specified.
- vi. Outline drawings, catalog cut sheets and mounting details shall be submitted for the following equipment:
 - (1) Control Cabinets
 - (2) Motor Control Enclosure
 - (3) PLC Cabinet
 - (4) Back Panels
 - (5) Control Desk
 - (6) Automatic Transfer Switch
 - (7) Generator
 - (8) Wiring Devices
 - (9) Panelboards
 - (10) Circuit Breakers, Relays, Contacts, etc.
 - (11) PLC system and equipment
 - (12) Transformers
 - (13) Safety Disconnect Switches
 - (14) Grounding Equipment
 - (15) Conduit
 - (16) Wireway
 - (17) Boxes
 - (18) Wire and Cable
 - (19) Lugs
 - (20) Wire and Conduit Tags
 - (21) Limit Switches and Proximity Sensors
 - (22) Cylinder position transducers
 - (23) Position Inclinator
 - (24) Lock Motors
 - (25) Pump Motors
 - (26) Warning Gates

(27) Barrier Gates

(28) Marine Horn

(29) Any new equipment required to maintain safe operation of existing bridge during construction.

vii. Any other drawings, which may, in the opinion of the Engineer, be necessary to show the electrical work.

viii. All drawings and the information contained within shall become the sole property of DelDOT.

C. Factory Inspection and Testing of Bridge Control System.

1. The motor control enclosure equipment, control desk, back panels, and other apparatus supplied, assembled or fabricated by the vendor of the electrical control system shall be subjected to shop inspections and testing to demonstrate compliance with all specified requirements. The complete factory inspection and testing of the bridge control system shall be witnessed by DelDOT or their authorized representative.
2. Factory tests for equipment other than the bridge control system shall be as specified in the various materials sections throughout these specifications.

D. Field Testing.

1. Upon completion of the electrical work for the bridge, arrange for and provide all the necessary field tests, as directed and approved by the Engineer, to demonstrate that proper operation of the entire electrical system for the bridge is achieved and in accordance with the Contract Plans and Specifications. All field testing shall be witnessed by DelDOT or their authorized representative. The complete acceptance testing procedure and requirements shall be as specified herein.

E. Manufacturer's Field Start-up Service.

1. In addition to furnishing the major items of electrical equipment, the system vendor shall furnish all necessary field supervisory start-up material and labor to facilitate proper adjustment of all the electrical equipment so as to achieve functioning of the span to the satisfaction of the Engineer.
2. The systems vendor's field service engineering personnel shall be experienced in the adjustment and functioning of the particular control equipment furnished under this item. The personnel shall be capable of locating and correcting faults or defects and of obtaining from the manufacturer, without delay, new parts or replacements for apparatus that, in the opinion of the Engineer, does not perform satisfactorily.

F. Suggested Sequence of Construction.

1. Sequence the construction and coordinate the various activities such that the contract is satisfactorily completed in accordance with the scheduling requirements of the Contract including maintaining vehicular traffic and navigation. Submit the proposed sequence of construction to the Engineer for approval, and construction shall not commence without the approval of the Delaware Department of Transportation.

G. Delivery and Storage; Protection for Shipment.

1. The specified electrical equipment shall be shipped from the manufacturer's facility once all test results have been approved. A portion of the equipment such as motors, control cabinets, ATS, etc. shall be shipped to the drive manufacturer and control system vendor's facility for testing.
2. Equipment shall be stored in a humidity and temperature controlled environment. Damage to any of the equipment caused by moisture and/or weather conditions will require replacement. The Contractor will be responsible for maintaining the equipment in like-new condition. Equipment which is damaged in any

way shall require replacement at the Engineers discretion at no additional cost to the Delaware Department of Transportation.

H. Fabrication of Control Cabinets and Back Panels

1. Follow the testing guidelines as specified herein and paid for under this item, and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the general requirements herein.
2. All work performed for fabrication and testing as specified shall be performed by an acceptable control system vendor. Requirements for the control system vendor shall be as specified under "Bridge Control System Vendor."
3. Install the assembled back panel and enclosures in the control house as shown on the plans for the Control Cabinets and ATS Cabinet. Adjustments to the positions and layout of the back panels and enclosures shall be made by the Contractor for proper fit at no additional cost to DelDOT.
4. The wiring within the control desk, motor control enclosure, ATS cabinet and PLC cabinet shall be insulated switchboard wire conforming to the requirements hereinbefore specified for wiring in the control cabinets. The wiring shall be arranged systematically so that all circuits can be readily traced. All conductors shall be terminated on easily accessible terminal blocks mounted inside the desk at the rear. Spare terminals totaling at least 20 percent of those actually used shall be provided. Wiring shall be identified at equipment terminals by marking the adjacent area with bright yellow printed numbers to correspond to conductor designations appearing on the Contractor's wiring diagrams.

I. PLC Programing and Sequence of Operation

1. Software Programing
 - a. The control system vendor shall be fully responsible to generate a complete operating system and develop the PLC program and alarm messages using:
 - i. The Software Programming, Sequence of Operation, Other PLC Functions, and Alarm sections provided in this section.
 - ii. All logic and wiring shown on the plans
 - iii. The testing requirements shown in Start Up and Commissioning Requirements.
 - iv. Allowing for specific requirements of the Allen-Bradley PLC as supplied, the program ladder logic shall follow the above items and this Specification as closely as possible.
 - b. The control system vendor shall furnish a laptop computer, interconnection cables, power supplies, software, PanelView programming, and PLC programming to accomplish the specified operation of the bridge and its auxiliaries. Software for the PLC, touchscreen, drives, and laptop computer shall be loaded and coordinated by the Contractor to achieve the correct designed operation of all software.
 - c. The control system vendor shall be fully responsible for developing the PLC, and touchscreen, and desktop computer software and software programming to accomplish the specified operation of the bridge and its associated equipment. Software debugging shall occur in the shop as well as in the field during start-up and subsequent testing. No additional payment shall be made for software debugging due to logic changes made in the field.
 - d. The control system vendor shall be responsible for coordination with DelDOT's TMC department for testing an integration of the remote monitoring system.
 - e. The PLC program shall be in accordance with the following items:
 - i. The ladder logic shall be easy to understand and troubleshoot.
 - ii. The ladder logic shall be fully documented, including rung comments and address comments.

- iii. The ladder logic shall be written with regards to the operational sequence of the bridge, containing separate sections for each of the major equipment areas such as gates, locks, etc.
 - iv. From the Operator's standpoint, the bridge shall operate as before in terms of sequence of operation.
 - v. The ladder logic shall become the property of DelDOT and not have passwords. The program shall not utilize or contain the following flaws:
 - (1) Latched coils: PLC logic shall be based upon real world conditions and reset when required. When the PLC loses power, and then power is returned, the PLC will determine the position of the leaves and other electrical equipment, but not expect the bridge to be in the exact same position. If any equipment was operated manually, the PLC program will determine the new position of the equipment and operate normally.
 - (2) Unnecessary internal coils: PLC logic shall be as simplified as possible and not use multiple relays for a single function. The intent of this is to make the program easy to troubleshoot and understand.
 - (3) Improper bypass logic: When the bypass switch is utilized the bypass will bypass only the required interlocks. The intent of this item is to provide programming that will utilize the bypasses and only bypass the correct interlock, but does not remain active in the logic or bypass other interlocks in the program.
 - (4) Loss of alarms: PLC logic shall be written to record and store the alarms and display on the touchscreen.
 - (5) Switch and Push button time delays: PLC logic shall not add time delays to control desk switches and pushbuttons.
 - (6) Problems transferring between automatic and manual modes of operation: PLC logic shall allow simple transfer from automatic and manual modes without generating unnecessary alarms for causing failures in the program. The intent of this item is to provide programming that transfers between manual and automatic mode without problems or inaccurate alarms.
 - (7) Faulty timing logic: The intent of this item is to provide programming that does not have internal timers to determine when problems occur or provide inaccurate alarms.
 - vi. All timer settings shown in the sequence of operation shall be clearly documented in the program. They shall be adjusted to match the selected equipment and adjusted during shop and field testing for proper operation.
 - vii. Modify and add alarm messages and associated alarm ladder logic as required.
 - viii. The PLC shall communicate information through the Ethernet connections with multiple pieces of equipment. The information shall be identified as an Ethernet input into the PLC.
 - f. Submit a fully documented and cross-referenced copy of the new PLC program for review and approval.
 - g. The touchscreen alarm panel shall be programmed to timestamp, print, and store each PLC alarm. The alarms shall be stored in chronological order and the operator shall be able to scroll through the alarm screen to review alarms. The alarms shall be stored in the touchscreen and being identified by a numerical identifier. When the PLC processor transmits the numerical identifier alarm bit to the touchscreen, the touchscreen shall display the alarms, send the alarms to the printer, and store the alarms in an alarm history screen stored in chronological order.
 - h. In the event of CPU failure, all outputs shall turn off.
2. General Sequence of Operation

- a. The sequence of operation shall be as described below. Interlocking shall be achieved in correct sequence to permit safe operation of the bridge and ancillary equipment. The normal sequence of operation shall be achieved through buttons located on the control desk touchscreen. As a back-up to the touchscreens, selector switches and push-buttons can be used should the screens fail to operate.
 - b. When the proper interlock for a specific device has not been met that push-button for that device on the HMI will not be visible to the operator. Once the interlock condition has been met or the bypass for that device is active the push-button shall appear.
 - c. A selector switch on the control desk shall select the mode of operation: either through the touchscreen or the hard-wired control devices on the control desk. In touchscreen mode, the positions of the push-buttons and switches shall be ignored for the traffic signals, gates, locks and span motor. Indicators on the desk shall illuminate in either mode.
 - d. The touchscreen display located in the switchboard room shall mimic the alarm and status display of the touchscreen on the upper portion of the control desk. Parameters such as incoming service voltage, drive amperes, angle of opening, span motor speed, alarms, and status indication shall be viewable from this screen.
 - e. When the PLC is required to generate an alarm, it shall send a bit from the defined bit array to the touchscreen. When the touchscreen receives the alarm bit numeric identifier, the touchscreen will display the alarm, provide the time and date of the alarm, print the alarm, and store the alarm in an alarm history screen. A screen will be provided to allow the operator to scroll down the alarm history.
 - f. The following operation examples are for a complete bridge operation. It is the intent of the control logic that the operator can stop the operation at any time while attempting to open the bridge and 'back out' of the operation to safely allow vehicular traffic on the bridge. To 'back out' of an operation means to change the operation from opening to closing the bridge. For example, after lowering the on-coming traffic gate, the operator could 'back out' of the operation by raising the on-coming traffic gate and turning the red traffic warning signal off to release vehicular traffic.
 - g. The PLC system shall be programmed to send information to DelDOT via a remote server. Coordinate the required information with DelDOT as part of this work and add these features to the PLC program. DelDOT will be responsible for the remote monitoring system off site (at DelDOT TMC), the contractor will be responsible for all equipment on the bridge and vicinity including but not limited to the PLC system, communication, Ethernet and fiber cable and connections.
3. Sequence of Operation
- a. Fault/Reset
 - i. At any point where an alarm message is generated, the fault/reset illuminated push-button shall be turned on and remain on until the fault is cleared and the reset push-button is pressed.
 - ii. For critical faults including emergency stops, opening of specified electrical enclosure doors, and over travel, the main circuit breaker to the motor control enclosure shall be turned off through the main contactor circuit as shown on the plans.
 - iii. All faults generated when control power is turned off or if any emergency stop is pressed, shall be suppressed (not displayed on the HMI). Only the specific initiating critical fault shall be displayed on the HMI. The intent is to filter the HMI fault display from superfluous downstream faults.
 - b. Control Power Selector Switch (CS-CP)
 - i. The operator shall turn the control desk Control Power (CS-CP) switch to the 'On' position.
 - ii. Control Power switch in the 'On' position is provided as an energized input 'Control Power On' to the PLC.

- iii. The Control Power switch (CS-CP) activates bridge control relay as long as there is no power or if a fault condition (Power Fault Alarm) as indicated by the phase failure relay.
 - iv. When the PLC has control power, the PLC shall verify all PLC Input card circuit breaker check inputs are energized.
 - v. If at any time during an operation, if a single or multiple PLC inputs of the above are de-energized while the 'Control Power On' PLC input is energized, the PLC shall de-energize all outputs, generate and provide an alarm, and shall not attempt any bridge operation until the PLC inputs are energized.
 - vi. The PLC input Power Fault Alarm (Phase Failure Fault) shall be energized if there is a power fault. If there is a power fault the PLC shall de-energize all outputs, generate and provide an alarm, and shall not attempt any bridge operation until the PLC input is de-energized.
- c. Emergency Stop Push-Buttons (PB-ES1 and PB-ES2) and Safety Relays
- i. If at any time during an operation, the 'Control Power On' PLC input is energized and the 'Emergency Stop' push-buttons or safety relay inputs de-energized (the 'Emergency Stop' button is pressed), the PLC shall de-energize all outputs, generate an alarm, and shall not attempt any bridge operation until the Emergency Stop inputs are energized.
 - ii. If any Emergency Stop push-button is depressed or safety relays are energized, or the emergency stop push-buttons are depressed during bridge operation, then the PLC input 'Emergency Stop' from PB-ES or safety relay inputs shall de-energize. The PLC shall stop all bridge operations and generate an alarm. The PLC shall not allow any other operation until all the Emergency Stop push-buttons are pulled out to the not depressed position.
 - iii. If any Emergency Stop push-button is depressed, the hardwired Master Control Relays will de-energize the control output power busses and the PLC shall verify that the emergency stop inputs are de-energized.
 - iv. If any of the inputs are not de-energized when the 'Emergency Stop' PLC inputs are de-energized, then the PLC shall generate an alarm.
- d. Bridge Status Indication - Upon the 'Control Power On' PLC input energizing, the PLC will scan the bridge for the status of the following items to illuminate or gray out the touchscreen indicators as follows:
- i. Indication Lights
 - (1) The PLC shall verify the span, warning gate, barrier gates, span locks, alarms, and other status indications and positions and illuminate the appropriate indicators on the touchscreen.
 - ii. Ethernet Communication
 - (1) The PLC shall verify the Ethernet inputs for the two PLC racks. If there are any alarms or faults then the PLC shall prevent span operation, send an alarm to the touchscreen, store the alarm and illuminate the fault/reset illuminated push-button. If an alternate path exists between the PLC racks, the alarm shall remain displayed, but operation shall be permitted.
 - iii. Circuit Breaker - The PLC shall monitor the inputs for each control circuit breaker. If any circuit breaker trips, the PLC shall prevent operation of that equipment associated with that input card, send an alarm to the touchscreen and store the alarm.
 - (1) Bypass Operation: If there is a circuit breaker failure, the circuit breaker operated interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm. Bypass shall not be permissive without first receiving an alarm.

iv. Bypass Operation

- (1) If an interlock does not function, the interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual bypass switch.
- (2) Whenever a bypass is used, the PLC shall generate an alarm. When any bypass switch is active the PLC shall send an alarm message to the HMI display screen describing the bypass used. When a bypass is not permissible the bypass button on the HMI shall not be visible.
- (3) No more than two bypass switches shall be operated at any given time. If more than two are active an alarm message shall be displayed of the HMI display screen.
- (4) Bypass switches shall be reset when the traffic lights are turned to green.

v. Position Transmitter Status Indication

- (1) The PLC input 'Position Inclinometer' shall receive an analog input from the position inclinometers. The PLC located in the control house shall transmit the analog signal position information to the control desk PLC and all touchscreens. The PLC shall transmit the signal to the control desk touchscreen Span Position Indicator. The display shall provide the span position in degrees, from zero degrees while fully closed to 80 degrees when fully open. The PLC shall continually update the position information while control power is on.
- (2) The PLC shall monitor the analog inputs and internally monitor the span position in degrees. The PLC shall compare the position to the PLC inputs the other position inclinometers. If the PLC analog degree is more than 3 degrees off (as shown on the Plans) the PLC shall generate an alarm. This alarm shall not prevent operation.
- (3) If no analog signal is received from a position transmitter, then the PLC shall generate an alarm. If both position inclinometers have an error where no position information is received the PLC shall prevent span operation.
- (4) If signal received from the inclinometer is out of range and beyond an acceptable limit, then the PLC shall generate and print an alarm.
- (5) A zeroing function shall be provided on the HMI screen that will calibrate the position display to zero degrees when the fully closed limit switches are active and indicate the bridge is seated. The PLC shall automatically zero the displays after the traffic signals are changed from, red to green.

vi. Cylinder Position Transducer Status Indication

- (1) The PLC input 'Cylinder Position Transducer' shall receive an analog input from the cylinder position transducers. The PLC located in the control house shall transmit the analog signal position information to the control desk PLC and all touchscreens. The PLC shall transmit the signal to the control desk touchscreen Wire Draw Indicator. The display shall provide the operation speed of the span in feet per minute (ft/min), from 0 ft/min to 5 ft/min for the north and south trunnions. The PLC shall continually update the speed information while control power is on.
- (2) The PLC shall monitor the analog inputs and internally monitor the position and speed. The PLC shall compare the speed to the PLC inputs for the other cylinder position transducer. If the PLC analog degree is more than 20% off, the PLC shall generate an alarm. This alarm shall not prevent operation.
- (3) If no analog signal is received from a cylinder position transducer, then the PLC shall generate an alarm but allow operation from data received from the redundant encoder. If both cylinder position transducers have an error where no speed or position information is received the PLC shall prevent span operation.

- (4) If signal received from the cylinder position transducer is out of range and beyond an acceptable limit, then the PLC shall generate an alarm.
- (5) A zeroing function shall be provided on the HMI screen that will calibrate the speed display to zero degrees when the fully closed limit switches are active and indicate the bridge is seated. The PLC shall automatically zero the displays after the traffic signals are changed from, red to green.

vii. Non-Automatic Control

- (1) The PLC shall verify that no equipment is being operated in non-automatic mode. The PLC shall verify that the PLC inputs from the manual-off-auto switch are in the 'auto' position. If the switches are not in the 'auto' position and are in the 'MAN' or 'off' position, then the PLC shall de-energize all outputs, generate an alarm, and shall not attempt any bridge operation until the PLC inputs are energized.

viii. Manual Operation Limit Switches

- (1) When any hand crank limit switch is open, the PLC shall disable control of the associated motor and send an alarm message to the HMI display screen.
- (2) When any hand crank limit switch is engaged the PLC shall disable motor operation for three (3) minutes unless bypassed on the HMI screen.

ix. Disconnect Switch Status for All Motors

- (1) The PLC shall verify that no motors are disconnected.
- (2) At any time, if any of the PLC disconnect switch inputs are de-energized, the PLC shall de-energize all outputs, generate an alarm identifying the specific motor that has had its disconnect operated, and shall not attempt any bridge operation until the PLC inputs are energized.
- (3) Bypass Operation:
 - 1. If there is a motor disconnect switch operated, the disconnect operated interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

x. HPU Start Indication

- (1) The PLC shall verify that the pumps are ready to start. If there are no faults or alarms and permissive interlocks are satisfied, then the PLC shall illuminate the indicator lights on the HMI.
- (2) If any HPU's are not ready after all interlocks are met, the PLC program shall generate an alarm.

xi. HPU Stop Indications

- (1) The PLC shall verify that all pumps are running and can be stopped. If there are no faults or alarms and permissive interlocks are satisfied, then the PLC shall illuminate the indicator lights on the HMI.

xii. HPU Alarm Indications

- (1) The PLC shall monitor the alarm inputs for High temperature warning, high temperature shut down, low oil warning, low oil shut down, clogged filter, low temperature warning, cylinder disabled warning, pump disabled warning.

- (2) Alarms shall be arranged to energize in the normal state and de-energize alarm state. The PLC shall monitor each and illuminate the indicator lights on the HMI.
- (3) For any HPU alarm, the PLC program shall generate an alarm.
- (4) If the pumps are running during non-critical alarms (as identified in these Special Provisions as “warnings”), the PLC shall allow operation to continue. If the pumps are not running, the PLC shall prohibit operation until the fault is cleared or acknowledged.
- (5) If the pumps are running during critical alarms, as identified in these Special Provisions, the PLC shall decelerate to a stop by slowly closing the proportional displacement valve and prohibit operation.
- (6) Bypass Operation:
 1. If there is an active HPU alarm it can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm. A maximum number of 2 alarms can be bypassed.

xiii. Pump Isolation Valve Closed

- (1) A limit switch on each pump isolation valve shall be arranged to energize in the normal state (open to flow) and de-energize alarm state (close to flow). The PLC shall monitor each valve and illuminate the indicator lights on the HMI.
- (2) If the pump isolation valve is closed, the PLC shall prevent operation using it’s associated pump. The bridge may be operated at a reduced speed using the other pump.
- (3) Bypass Operation:
 1. If there is an active Pump Isolation Valve alarm it can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm. No more than one pump isolation valve alarm can be bypassed.

xiv. Cylinder Isolation Valve Closed

- (1) A limit switch on each cylinder isolation valve shall be arranged to energize in the normal state (open to flow) and de-energize alarm state (close to flow). The PLC shall monitor each valve and illuminate the indicator lights on the HMI.
 - (2) When the PLC detects that one cylinder on either the rod or blind side has been closed (locked-out), the PLC shall limit operation to two cylinders at reduced speed.
- xv. If a cylinder isolation valve is closed, a local limit switch will be made. If either valve is closed for a given cylinder, reduce pump output by 25% by closing the proportional valve to 25%.
- (1) Bypass Operation: If there is an active Cylinder Isolation Valve alarm it can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm. No more than one cylinder isolation valve alarm can be bypassed.

xvi. HPU Idle

- (1) When the HPU is energized from the control desk, pump 1 shall start and after a 5 second time delay pump 2 shall start and the HPU shall idle. There is an unloading valve that shall be energized while the HPU is idle. Note: The pump will start under no load conditions.

xvii. Two-, Three- or Four-cylinder operation

- (1) The number of cylinders shall be selectable on the HMI screen. Specific alarm conditions as defined herein will also automatically limit cylinder operation.

- (2) When the number of cylinders is limited by the PLC or selected by the operator, the HMI shall generate an alarm message. To bypass the alarm, the operator must use the control console bypass switch in conjunction with the HMI bypass screen. Once the bypass is selected a warning screen shall be displayed requiring acknowledgement that the wind speed is less than 50 MPH or other defined condition.
- (3) Operation under a reduced number of cylinders will be performed automatically at a reduced speed.

xviii. One pump operation

- (1) One vs. two pump motor operation shall be selectable on the HMI screen. Specific alarm conditions as defined herein will also automatically limit pump motor operation.

xix. HPU Fluid Cooling Motor

- (1) The HPU Fluid cooling motor will operate any time the HPU is energized.

xx. Hydraulic System Trouble

- (1) When the pumps are energized and operating the bridge but no movement is detected from the cylinder position transducer, inclinometer or no pump motor current is detected, the PLC shall stop the bridge within one second, send an alarm to the touchscreen and store the alarm.

xxi. Ammeters and Voltmeters

- (1) Incoming service current and voltage values shall be transmitted to the control desk touchscreen and switchboard room touchscreen through the ethernet connection. The PLC shall transmit the values to the remote rack in the control desk. The PLC shall continually update the information while control power is on.
- (2) Pump motor current and voltage values for motor load shall be transmitted to the control desk touchscreen and switchboard room touchscreen through an analog connection to the PLC. The PLC shall transmit the values to the remote rack in the control desk. The PLC shall continually update the information while control power is on.
- (3) When current and voltage levels for motor and/or incoming service exceed 20% of the nominal values an alarm shall be generated but it shall not prevent operation. The 20% threshold shall be suppressed during motor start-up.

xxii. Deceleration Alarm

- (1) The PLC shall monitor the span position and speed from each inclinometer and each cylinder position transducer. If the span after the nearly closed position or after the nearly open position has not slowed down to 10% speed, the speed check alarms shall be generated and illuminate an indicator.
- (2) If any deceleration alarms are active, the PLC program shall generate an alarm. Span operation shall be stopped within one second if a deceleration alarm is detected.
- (3) If deceleration alarm is generated on the north or south trunnion, the operator may turn off the faulty sensors and operate the bridge using the functional sensors. If both sides indicate a fault the span cannot be operated unless a bypass operation is selected in which speed or position cannot be monitored. When this bypass is selected the span shall be operated at 25% speed.

xxiii. Alarm Reset

- (1) The PLC shall illuminate and flash the alarm reset push-button when any alarm is active. When any alarm is acknowledged but not reset the PLC shall illuminate (steady) the alarm

reset push-button. When all alarms are cleared the PLC shall turn off the alarm reset push-button once the reset push-button is hit.

- (2) When any critical alarm is active the PLC shall prohibit operation of any device until the alarm push-button is pressed, regardless of if the alarm has reset. If a critical alarm is active during a span operation the PLC shall decelerate the span to a stop.
- (3) When any warning alarm is active the PLC shall display an alarm but not prevent operation unless otherwise defined.

xxiv. Stand-by Generator

- (1) When low battery and any other generator fault is detected, the PLC shall send an alarm message to the touchscreen and store the alarm.
- (2) When the generator is energized and the PLC receives a generator running status signal the PLC shall send an alarm to the touchscreen and store the alarm.

xxv. ATS

- (1) When the ATS is in the normal position, the PLC shall send an alarm to the touchscreen and store the alarm.
- (2) When the ATS is in the emergency position, the PLC shall send an alarm to the touchscreen and store the alarm.
- (3) When the ATS has a fault, the PLC shall disable operation of the bridge, send an alarm to the touchscreen and store the alarm.

xxvi. Span Operation Faults

- (1) When a deceleration fault is active the PLC shall operate as defined under "Deceleration Alarm."
- (2) When a proportional valve failure occurs as defined below, span operation shall be stopped within one second. An indicator shall turn on and alarm shall be generated. The bridge can be restarted by using one pump motor operation.
 1. When the proportional valve does not report a feedback signal.
 2. When the proportional valve reports an incorrect feedback signal.
- (3) When a span motor warning alarm is detected, the PLC shall send an alarm message to the HMI display screen and ramp the drive down to a stop.
- (4) When an overcurrent is detected on any of the pump motors and the motor circuit breaker trips or the motor current recorded by the current transducer at any time reaches 150% of the full load current after a start-up time delay, the PLC shall send an alarm to the touchscreen and store the alarm.

xxvii. Phase Failure

- (1) When the phase monitor/phase failure relay has tripped, the PLC shall send an alarm to the touchscreen and store the alarm.

xxviii. Limit Switch Failure

- (1) When the two fully closed limit switches do not activate within 20 seconds (to be field verified) of each other, the PLC shall send an alarm to the touchscreen and store the alarm.
- (2) When any span lock, barrier gate or warning gate limit switch does not activate within 30 seconds (to be field verified) of the opposing contact, the PLC shall send an alarm to the touchscreen and store the alarm.

- (3) When any over travel limit switches is activated, the PLC shall send an alarm to the touchscreen and store the alarm. An over travel alarm shall only prevent raise operation but should have no impact on lower operation. The over travel alarm once activated shall not reset until the fully closed limit switch is engaged.
- (4) When any manual operation limit switch is activated, the PLC shall send an alarm to the touchscreen and store the alarm. A manual operation alarm shall prevent automatic operation for three (3) minutes upon activation.

xxix. Warning or Barrier Gate Door Switch

- (1) When any door switch is open, the PLC shall disable control of the associated motor and send an alarm to the touchscreen and store the alarm.

e. Traffic Signal Selector (Switch)

- i. When the selector switch for the traffic signals is in the 'Go' position the PLC shall:
 - (1) Energize the touchscreen traffic signal green indicator if traffic signal selector switch in the "Go" position, all gates are raised, all barriers are open, the span locks are driven, and the span is fully closed.
 - (2) De-energize the touchscreen traffic signal red indicator if all gates are raised, all barriers are open, the span locks are driven, and the span is fully closed.
 - (3) De-energize the PLC outputs feeding the red traffic signals and gongs.
- ii. When the selector switch for the traffic signals is placed in the 'Stop' position the PLC shall:
 - (1) Energize the red signal relay to activate the gongs.
 - (2) De-energize the touchscreen traffic signals green indicator.
 - (3) Energize the touchscreen traffic signal red indicator.
 - (4) The timing for the traffic signals shall be operated by control relays to ensure safe operation.
 - (5) The PLC shall monitor the inputs from CR-RSR and CR-ASR as shown on the plan to verify proper operation of the traffic signals. The PLC shall generate an alarm if the relays operate out of sequence.
- iii. Interlocks:
 - (1) The only interlock to prevent the operator from activating the traffic signals is the red signal and timing relay is closed.

iv. Bypass Operation:

- (1) No Bypass Interlock for Traffic Signal

f. On-coming Warning Gate Selector (Switch or push-button on Touchscreen)

- i. When the PLC input 'NE Warning Gate Raised' is energized, the NE gate is fully raised and the PLC shall display the indicator on the touchscreen.
- ii. When the PLC input 'SW Warning Gate Raised' is energized, the SW gate is fully raised and the PLC shall display the indicator on the touchscreen.
- iii. When the PLC input 'NE Warning Gate Lowered' is energized, the NE gate is fully lowered and the PLC shall display the indicator on the touchscreen.
- iv. When the PLC input 'SW Warning Gate Lowered' is energized, the SW gate is fully lowered and the PLC shall display the indicator on the touchscreen.

- v. When both PLC inputs 'NE Warning Gate Lowered' and 'NE Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.
- vi. When both PLC inputs 'SW Warning Gate Lowered' and 'SW Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.
- vii. The PLC shall monitor the inputs for the gate door open, disconnect switch open and hand crank inputs for the gate. If any gate door is open, disconnect switch is open or the hand crank activated, then the PLC shall prevent gate operation, send an alarm to the touchscreen and store the alarm.
- viii. When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'NE Warning Gate Raise' and 'NE Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the on-coming gate. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.
 - (1) De-energize the PLC output NE Warning Gate Lower
 - (2) De-energize the PLC output NE Warning Gate Raise
- ix. When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'SW Warning Gate Raise' and 'SW Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the on-coming gate. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.
 - (1) De-energize the PLC output SW Warning Gate Lower
 - (2) De-energize the PLC output SW Warning Gate Raise
- x. Turn On-Coming Warning Gate Selector Switch to the Lower Position (Switch or push-button on Touchscreen)
- xi. When the selector switch or touchscreen On-Coming Warning Gate is held in the 'Lower' position, PLC inputs 'NE Warning Gate Lower' and 'SW Warning Gate Lower' shall be energized.
- xii. While PLC input 'NE Warning Gate Lower' is energized and the PLC input 'NE Warning Gate Lower Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'NE Warning Gate Lower'
 - (2) De-energize the PLC output 'NE Warning Gate Raise'
- xiii. While PLC input 'SW Warning Gate Lower' is energized and the PLC input 'SW Warning Gate Lower Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'SW Warning Gate Lower'
 - (2) De-energize the PLC output 'SW Warning Gate Raise'
- xiv. Note: If PLC input 'NE Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'NE Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NE Warning Gate Lower'
- xv. Note: If PLC input 'SW Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'SW Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Warning Gate Lower'
- xvi. Lower Interlocks:

- (1) The NE Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power and the traffic signals are red.
 - (2) The SW Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power and the traffic signals are red.
- xvii. Lower Bypass Operation: There is no bypass operation for the loss of control power or traffic signals red.
- xviii. Turn On-Coming Warning Gate Selector Switch to the Raise Position (Switch or push-button on Touchscreen)
- xix. When the selector switch or touchscreen On-Coming Warning Gate is held in the 'Raise' position, PLC inputs 'NE Warning Gate Raise' and 'SW Warning Gate Raise' shall be energized.
- xx. While PLC input 'NE Warning Gate Raise' is energized and the PLC input 'NE Warning Gate Raise Stop' is de-energized, the PLC shall:
- (1) De-energize the PLC output 'NE Warning Gate Raise'
 - (2) De-energize the PLC output 'NE Warning Gate Lower'
- xxi. While PLC input 'SW Warning Gate Raise' is energized and the PLC input 'SW Warning Gate Raise Stop' is de-energized, the PLC shall:
- (1) De-energize the PLC output 'SW Warning Gate Raise'
 - (2) De-energize the PLC output 'SW Warning Gate Lower'
- xxii. Note: If PLC input 'NE Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'NE Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NE Warning Gate Raise.'
- xxiii. Note: If PLC input 'SW Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'SW Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Warning Gate Raise.'
- xxiv. Raise Interlocks:
- (1) The NE Warning Gate shall be interlocked such that it cannot be raised unless there is bridge control power, the traffic signals are red, off-going gates are raised, barrier gates are open, span locks are pulled, and the span is seated.
 - (2) The SW Warning Gate shall be interlocked such that it cannot be raised unless there is bridge control power, the traffic signals are red, off-going gates are raised, barrier gates are open, span locks are pulled, and the span is seated.
- xxv. Raise Bypass Operation: If there is a failure with either off-going gate, barrier gate or span seated limit switch, the on-coming gate raised interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.
- g. Off-Going Warning Gate Selector Switch (Switch or push-button on Touchscreen)
- i. When the PLC input 'NW Warning Gate Raised' is energized, the NW gate is fully raised and the PLC shall display the indicator on the touchscreen.
 - ii. When the PLC input 'SE Warning Gate Raised' is energized, the SE gate is fully raised and the PLC shall display the indicator on the touchscreen.
 - iii. When the PLC input 'NW Warning Gate Lowered' is energized, the NW gate is fully lowered and the PLC shall display the indicator on the touchscreen.

- iv. When the PLC input 'SE Warning Gate Lowered' is energized, the SE gate is fully lowered and the PLC shall display the indicator on the touchscreen.
- v. When both PLC inputs 'NW Warning Gate Lowered' and 'NW Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.
- vi. When both PLC inputs 'SE Warning Gate Lowered' and 'SE Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.
- vii. The PLC shall monitor the inputs for the gate door open, disconnect switch open and hand crank inputs for the gate. If any gate door is open, disconnect switch is open or the hand crank activated, then the PLC shall prevent gate operation, send an alarm to the touchscreen and store the alarm.
- viii. When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'NW Warning Gate Raise' and 'NW Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the off-going gates. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.
 - (1) De-energize the PLC output NW Warning Gate Lower
 - (2) De-energize the PLC output NW Warning Gate Raise
- ix. When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'SE Warning Gate Raise' and 'SE Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the off-going gates. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.
 - (1) De-energize the PLC output SE Warning Gate Lower
 - (2) De-energize the PLC output SE Warning Gate Raise
- x. Turn Off-Going Warning Gate Selector Switch to Lower (Switch or push-button on Touchscreen)
- xi. When the selector switch or touchscreen Off-Going Warning Gate is held in the 'Lower' position, PLC inputs 'NW Warning Gate Lower' and 'SE Warning Gate Lower' shall be energized.
- xii. While PLC input 'NW Warning Gate Lower' is energized and the PLC input 'NW Warning Gate Lower Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'NW Warning Gate Lower'
 - (2) De-energize the PLC output 'NW Warning Gate Raise'
- xiii. While PLC input 'SE Warning Gate Lower' is energized and the PLC input 'SE Warning Gate Lower Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'SE Warning Gate Lower'
 - (2) De-energize the PLC output 'SE Warning Gate Raise'
- xiv. Note: If PLC input 'NW Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'NW Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Warning Gate Lower'
- xv. Note: If PLC input 'SE Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'SE Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SE Warning Gate Lower'

- xvi. Lower Interlocks:
- (1) The NW Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red and both on-coming gates are lowered.
 - (2) The SE Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red and both on-coming gates are lowered.
- xvii. Lower Bypass Operation: If there is a failure with either oncoming gate, the off-going gate lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.
- xviii. Turn Off-Going Warning Gate Selector Switch to the Raise Position (Switch or push-button on Touchscreen)
- xix. When the selector switch or touchscreen Off-Going Warning Gate is held in the 'Raise' position, PLC inputs 'NW Warning Gate Raise' and 'SE Warning Gate Raise' shall be energized.
- xx. While PLC input 'NW Warning Gate Raise' is energized and the PLC input 'NW Warning Gate Raise Stop' is de-energized, the PLC shall:
- (1) De-energize the PLC output 'NW Warning Gate Raise'
 - (2) De-energize the PLC output 'NW Warning Gate Lower'
- xxi. While PLC input 'SE Warning Gate Raise' is energized and the PLC input 'SE Warning Gate Raise Stop' is de-energized, the PLC shall:
- (1) De-energize the PLC output 'SE Warning Gate Raise'
 - (2) De-energize the PLC output 'SE Warning Gate Lower'
- xxii. Note: If PLC input 'NW Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'NW Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Warning Gate Raise'
- xxiii. Note: If PLC input 'SE Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'SE Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SE Warning Gate Raise'
- xxiv. Interlocks for Raise:
- (1) The NW Warning Gate shall be interlocked such that it cannot be raised unless there is bridge control power, the traffic signals are red, barrier gates are open, span locks are driven, and the span is seated.
 - (2) The SE Warning Gate shall be interlocked such that it cannot be raised unless there is bridge control power, the traffic signals are red, barrier gates are open, span locks are driven, and the span is seated.
 - (3) Raise Bypass Operation: If there is a failure with the span locks, barrier gates or span seated limit switch, the barrier gate raised interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.
- h. Barrier Gate Selector Switch (Switch or push-button on Touchscreen)
- i. When the PLC input 'SW Barrier Gate Raised' is energized, the SW barrier gate is fully raised and the PLC shall display the indicator on the touchscreen.

- ii. When the PLC input 'NW Barrier Gate Raised' is energized, the NW barrier gate is fully raised and the PLC shall display the indicator on the touchscreen.
- iii. When the PLC input 'SW Barrier Gate Lowered' is energized, the gate is fully lowered and the PLC shall display the indicator on the touchscreen.
- iv. When the PLC input 'NW Barrier Gate Lowered' is energized, the NW barrier gate is fully lowered and the PLC shall display the indicator on the touchscreen.
- v. When both PLC inputs 'SW Barrier Gate Lowered' and 'SW Barrier Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.
- vi. When both PLC inputs 'NW Barrier Gate Lowered' and 'NW Barrier Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.
- vii. The PLC shall monitor the inputs for the gate door open, disconnect switch open and hand crank inputs for the gate. If any gate door is open, disconnect switch is open or the hand crank activated, then the PLC shall prevent gate operation, send an alarm to the touchscreen and store the alarm.
- viii. When the touchscreen buttons are in the 'Off' position, both PLC inputs 'SW Barrier Gate Raise' and 'SW Barrier Gate Lower' shall be de-energized.
- ix. While both inputs are de-energized, the PLC shall not attempt to operate the SW barrier gate.
 - (1) De-energize the PLC output SW Barrier Gate Lower
 - (2) De-energize the PLC output SW Barrier Gate Raise
- x. While both inputs are de-energized, the PLC shall not attempt to operate the NW barrier gate.
 - (1) De-energize the PLC output NW Barrier Gate Lower
 - (2) De-energize the PLC output NW Barrier Gate Raise
- xi. Turn the Barrier Gate Selector Switch to Lower (Switch or push-button on Touchscreen)
- xii. When the selector switch SW Barrier Gate is held in the 'Lower' position, PLC inputs 'SW Barrier Gate Lower' shall be energized. While PLC input 'SW Barrier Gate Lower' is energized and the PLC input 'SW Barrier Gate Lower Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'SW Barrier Gate Lower'
 - (2) De-energize the PLC output 'SW Barrier Gate Raise'
- xiii. When the selector switch NW Barrier Gate is held in the 'Lower' position, PLC inputs 'NW Barrier Gate Lower' shall be energized. While PLC input 'NW Barrier Gate Lower' is energized and the PLC input 'NW Barrier Gate Lower Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'NW Barrier Gate Lower'
 - (2) De-energize the PLC output 'NW Barrier Gate Raise'
- xiv. Note: If PLC input 'SW Barrier Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'SW Barrier Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Barrier Gate Lower'
- xv. Note: If PLC input 'NW Barrier Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'NW Barrier Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Barrier Gate Lower'
- xvi. Lower Interlocks:

- (1) The SW Barrier Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red, NW barrier gate is lowered and all warning gates are lowered.
- (2) The NW Barrier Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red and all warning gates are lowered.
- xvii. Lower Bypass Operation: If there is a failure with any warning gate or opposing barrier gate, the barrier gates lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.
- xviii. Turn the Barrier Gate Selector Switch to Raise (Switch or push-button on Touchscreen)
- xix. When the selector switch SW Barrier Gate is held in the 'Raise' position, PLC inputs 'SW Barrier Gate Raise' shall be energized. While PLC input 'SW Barrier Gate Raise' is energized and the PLC input 'SW Barrier Gate Raise Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'SW Barrier Gate Raise'
 - (2) De-energize the PLC output 'SW Barrier Gate Lower'
- xx. When the selector switch NW Barrier Gate is held in the 'Raise' position, PLC inputs 'NW Barrier Gate Raise' shall be energized. While PLC input 'NW Barrier Gate Raise' is energized and the PLC input 'NW Barrier Gate Raise Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'NW Barrier Gate Raise'
 - (2) De-energize the PLC output 'NW Barrier Gate Lower'
- xxi. Note: If PLC input 'SW Barrier Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'SW Barrier Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Barrier Gate Raise'
- xxii. Note: If PLC input 'NW Barrier Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'NW Barrier Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Barrier Gate Raise'
- xxiii. Raise Interlocks:
 - (1) The SW Barrier Gate shall be interlocked such that it cannot be raised unless there is bridge control power, traffic signals are red and all warning gates are lowered.
 - (2) The NW Barrier Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red, SW barrier gate is raised and all warning gates are lowered.
- xxiv. Raise Bypass Operation: If there is a failure with any barrier gate, the barrier gates lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.
- i. Span Lock Selector Switch (Switch or push-button on Touchscreen)
 - i. When the PLC input 'NW Span Lock Pulled' is energized, the NW span lock is fully pulled and the PLC shall display the indicator on the touchscreen.
 - ii. When the PLC input 'NW Span Lock Driven' is energized, the NW span lock is fully driven and the PLC shall display the indicator on the touchscreen.
 - iii. When the PLC input 'SW Span Lock Pulled' is energized, the SW span lock is fully pulled and the PLC shall display the indicator on the touchscreen.

- iv. When the PLC input 'SW Span Lock Driven' is energized, the SW span lock is fully driven and the PLC shall display the indicator on the touchscreen.
- v. When both PLC inputs 'NW Span Lock Pulled and 'NW Span Lock Driven' are de-energized, the PLC shall flash alternately the touchscreen indicators.
- vi. When both PLC inputs 'SW Span Lock Pulled and 'SW Span Lock Driven' are de-energized, the PLC shall flash alternately the touchscreen indicators.
- vii. The PLC shall monitor the inputs for the disconnect switch open and hand crank inputs for any span lock. If any disconnect switch is open or the hand crank activated, then the PLC shall prevent automatic span lock operation, send an alarm to the touchscreen and store the alarm.
- viii. When the touchscreen buttons are in the 'Off' position, PLC inputs 'NW Span Lock Pull', 'NW Span Lock Drive' shall be de-energized. While these inputs are de-energized, the PLC shall not attempt to operate the NW Span Lock.
 - (1) De-energize the PLC output NW Span Lock Drive
 - (2) De-energize the PLC output NW Span Lock Pull
- ix. When the touchscreen buttons are in the 'Off' position, PLC inputs 'SW Span Lock Pull', 'SW Span Lock Drive' shall be de-energized. While these inputs are de-energized, the PLC shall not attempt to operate the SW Span Lock or SW Span Lock.
 - (1) De-energize the PLC output SW Span Lock Drive
 - (2) De-energize the PLC output SW Span Lock Pull
- x. Turn the Span Lock Selector Switch to Pull (Switch or push-button on Touchscreen)
- xi. When the Span Lock selector switch is turned to the 'Pull' position, PLC input 'NW Span Lock Pull' shall be energized. While PLC input 'NW Span Lock Pull' is energized and the PLC input 'NW Span Lock Pull Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'NW Span Lock Pull'
 - (2) De-energize the PLC output 'NW Span Lock Drive'
- xii. Note: If PLC input 'NW Span Lock Pull' is energized continuously for more than 15 seconds and the PLC input 'NW Span Lock Pull Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Span Lock Pull'
- xiii. When the Span Lock selector switch is turned to the 'Pull' position, PLC input 'SW Span Lock Pull' shall be energized. While PLC input 'SW Span Lock Pull' is energized and the PLC input 'SW Span Lock Pull Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'SW Span Lock Pull'
 - (2) De-energize the PLC output 'SW Span Lock Drive'
- xiv. Note: If PLC input 'SW Span Lock Pull' is energized continuously for more than 15 seconds and the PLC input 'SW Span Lock Pull Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Span Lock Pull'
- xv. Pull Interlocks:
 - (1) The Span Locks shall be interlocked such that either span lock cannot be pulled unless there is bridge control power, traffic signals are red, all warning gates are lowered, both barrier gates are lowered, and the span is seated.
- xvi. Pull Bypass Operation: If there is a failure with any warning or barrier gate or the span seated limit switch, the span lock pull interlocks can be bypassed by using the touchscreen bypass in

conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

- xvii. Turn the Span Lock Selector Switch to Drive (Switch or push-button on Touchscreen)
- xviii. When the Span Lock selector switch is turned to the 'Drive' position, PLC input 'NW Span Lock Pull' shall be energized. While PLC input 'NW Span Lock Drive' is energized and the PLC input 'NW Span Lock Drive Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'NW Span Lock Drive'
 - (2) De-energize the PLC output 'NW Span Lock Pull'
- xix. Note: If PLC input 'NW Span Lock Drive' is energized continuously for more than 15 seconds and the PLC input 'NW Span Lock Drive Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Span Lock Drive'
- xx. When the Span Lock selector switch is turned to the 'Drive' position, PLC input 'SW Span Lock Drive' shall be energized. While PLC input 'SW Span Lock Drive' is energized and the PLC input 'SW Span Lock Drive Stop' is de-energized, the PLC shall:
 - (1) De-energize the PLC output 'SW Span Lock Drive'
 - (2) De-energize the PLC output 'SW Span Lock Pull'
- xxi. Note: If PLC input 'SW Span Lock Drive' is energized continuously for more than 15 seconds and the PLC input 'Span Lock Drive Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Span Lock Drive'
- xxii. Drive Interlocks:
 - (1) The Span Locks shall be interlocked such that either span lock cannot be driven unless there is bridge control power, traffic signals are red, all warning gates are lowered, both barrier gates are lowered, and the span is seated.
- xxiii. Drive Bypass Operation: If there is a failure with any warning, barrier gate or the span seated limit switch, the span lock pull interlocks can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.
- j. Hydraulic Pumps
 - i. When the PLC input 'Hydraulic Pump No. 1' is energized, the hydraulic pump motor No. 1 is ON and the PLC shall display the indicator on the touchscreen.
 - ii. When the PLC input 'Hydraulic Pump No. 1' is de-energized, the hydraulic pump motor No. 1 is OFF and the PLC shall gray out the touchscreen indicator.
 - iii. When the PLC input 'Hydraulic Pump No. 2' is energized, the hydraulic pump motor No. 2 is ON and the PLC shall display the indicator on the touchscreen.
 - iv. When the PLC input 'Hydraulic Pump No. 2' is de-energized, the hydraulic pump motor No. 2 is OFF and the PLC shall gray out the touchscreen indicator.
 - v. The PLC shall monitor the inputs for the disconnect switch open for any of the pump motors. If any disconnect switch is open, then the PLC shall prevent automatic pump operation, send an alarm to the touchscreen and store the alarm.
 - vi. The PLC shall monitor the inputs for the AC current transducer for any of the pump motors. If the pump motor current is above nameplate value, then the PLC shall send an alarm to the touchscreen and store the alarm. The pump motor shall be disabled when the motor current exceeds 20% of the nameplate value after a start-up delay.

- k. Span Control Selector Switch (Switch or push-button on Touchscreen)
- i. All logic shall be fail safe in a stopped condition if a failure occurs or a wire breaks.
 - ii. The PLC shall verify it is safe to energize the pump motors. If any pump has a critical alarm condition the PLC shall prohibit operation of that specific pump unless the pump is already running, and the span is in operation in which case the pumps shall de-energize after a span is decelerated to a stop.
 - iii. The PLC shall verify it is safe to operate the span and energize the pump motor starter if all the following criteria are met: The span shall not be operated if the manual non-automatic system is engaged, the pump motor has its motor disconnected, the motor temperature sensor indicates a high temperature, the motor load contactor is off, the span lock is not pulled, the barrier gates are not closed, the warning gates are not lowered or the traffic signals are green. (See prior steps for details.)
 - iv. When the PLC input 'Fully Closed' is energized, the span is fully closed and the PLC shall display the indicator on the touchscreen.
 - v. When the PLC span position analog input reached the scaled setting for the 'Nearly Closed' position, the span is nearly closed and the PLC shall display the indicator on the touchscreen.
 - vi. When the PLC span position analog input reached the scaled setting for the 'Nearly Open' is energized, the span is nearly open and the PLC shall display the indicator on the touchscreen.
 - vii. When the PLC input 'Fully Open' is energized, the span is fully open and the PLC shall display the indicator on the touchscreen.
 - viii. The PLC shall monitor the inputs for the pump disconnect switch open. If any disconnect switch is open is activated, then the PLC shall prevent automatic span operation, send an alarm to the touchscreen and store the alarm.
 - ix. Stop - If the operator presses the Stop push-button while the span is in operation, both PLC inputs 'Span Raise' and 'Span Lower' shall be de-energized. When both inputs are de-energized during a raising operation, the PLC shall continue to open the span and decelerate (ramp down) to stop in 5 seconds.
 - x. Hydraulic System Warning Alarms - If at any time during an operation (both opening and closing) any hydraulic warning alarm becomes active, continue to open/close the respective span and decelerate (ramp down) to stop in 5 seconds. The following warnings are only an alarm message on the HMI:
 - (1) Clogged Filter Warning (from filter sensors)
 - (2) High Temperature Warning (from temperature sensors)
 - (3) Low Temperature Warning (from temperature sensors)
 - (4) Low Fluid Warning (from fluid level sensors)
 - (5) Cylinder Disabled Warning (from valve limit switch)
 - xi. Hydraulic System Shut down Alarms - If at any time during an operation (both opening and closing) any hydraulic shut down alarms active, the span shall immediately stop within one second:
 - (1) High Temperature Shut Down (from temperature sensors)
 - (2) Low Fluid Shut Down (from fluid level sensors)
 - xii. Turn the span control selector switch to Raise (Switch or push-button on Touchscreen)

- (1) When Span control selector switch is in the Raise position, the PLC input 'Span Raise' will energize and the following action will take place:
 1. The PLC shall command the pump motors and valves operate the bridge in the raise direction. The PLC shall set the proportional valves to the pre-defined full speed or reduced setting based on the speed selected and monitor the valve opening as reported from the linear transducer. If the feedback signal and the command do not agree, the PLC shall send an alarm to the HMI and stop the pump motors and span from operating.
 2. During span operation, the PLC will control the valves using outputs from the PLC to control the hydraulic interface modules located in the new PLC cabinets. These modules will then control the valves directly. Feedback from the closed loop valves will be reported to the PLC.
 3. The PLC, valves and interface modules shall accelerate the span to full speed within 10 seconds (field adjustable). If any valve does not operate within 2 seconds of the command, the PLC shall not continue span operation and shall generate and store an alarm on the touchscreen.
 - (2) When the PLC inputs 'Span Raise' are energized and all valves are operational, the PLC shall command the valves to raise each leaf, ramping up ten seconds to full operating speed. Commanding the pump motors to raise shall initiate the span to rotate in the direction that opens the leaf. The PLC shall monitor the pump and valve operation to verify proper motor control. At any point if a fault occurs, key parameters such as speed, position, and fault identifier shall be stored to the touchscreen.
 - (3) Note: If the PLC command to raise either span is sent continuously for more than 5 seconds and no change in position or speed is detected, the PLC shall stop the span and generate and store an alarm on the touchscreen.
 - (4) Span Position - The PLC shall continuously monitor the PLC analog input for 'Span Position' and compare with the limit switch contacts inputs for 'Nearly Closed' and 'Nearly Open'. If the PLC detects a variation between the limit set points and the span position angular value, then the PLC shall generate and store an alarm.
 - (5) Stop - If the operator presses the Stop push-button while the span is in operation, the respective PLC ethernet input 'Span Raise' shall be de-energized. When the input is de-energized during a raising operation, the PLC shall continue to open the span and decelerate (ramp down) to stop in 5 seconds. The span operation can be restarted by following the procedure as shown above.
- xiii. Open the Leaf to Nearly Open - The PLC shall maintain the full speed raise operation of each leaf until it reaches the nearly open position. When PLC analog input reaches the scaled setting for 'Span Nearly Open', then the leaf is nearly open.
- (1) When the leaf is nearly open, the PLC shall command the leaf and valves to continue opening and reduce speed to creep speed and the following actions will take place:
 1. The PLC shall command the pump motors and valves operate the bridge in the raise direction in creep speed. The PLC shall set the proportional valves to the pre-defined creep speed setting and monitor the valve opening as reported from the linear transducer. If the feedback signal and the command do not agree, the PLC shall send an alarm to the HMI and stop the pump motors and span from operating.
 2. The PLC, valves and interface modules shall decelerate the span from full speed to creep speed within 10 seconds (field adjustable). If any valve does not change within 2 seconds of the command, the PLC shall not continue span operation and shall generate and store an alarm on the touchscreen.

- (2) Once the leaf is at creep speed the PLC shall check the speed of the leaf to verify it has slowed down by monitoring the feedback from the cylinder position transducer. If the span has not slowed down then the PLC shall command the valves to stop the span immediately and the PLC shall generate and store an alarm.
- (3) Open the Span to Fully Open - The PLC shall maintain opening the span in creep speed until the span reaches the fully open position. When PLC input for the full open limit switch 'Span Fully Open' is energized, then the span is fully open and the following actions will take place:
 1. The PLC shall command the pump motors and valves to ramp the span to a stop in less than one second. The PLC shall set the proportional valves to the pre-defined zero speed setting and monitor the valve opening as reported from the linear transducer. If the feedback signal and the command do not agree, the PLC shall send an alarm to the HMI and stop the pump motors and span from operating.
 2. If any valve does not change within 2 seconds of the command, the PLC shall stop the span and generate and store an alarm on the touchscreen.
- xiv. Leaf Overtravel - If the leaf travels beyond the full open position as detected by the span position inclinometer or over travel limit switch, the PLC shall command the span to ramp to a stop in less than one second, and the PLC shall generate and store an alarm. Once the overtravel limit switch is activated the raise operations shall be disabled until the span is lowered past the nearly open position.
- xv. Interlocks - The span lock shall be interlocked such that the span cannot be opened unless the span locks are pulled, all gates are fully lowered, the traffic signals are red, the pumps are running, and there is bridge control power.
- xvi. Raise Bypass Operation - If there is a failure with any piece of equipment preventing the span from raising, the bypass can be used to operate the span. Bypass switches can only be used when an alarm condition is present such as "Nose Lock Failed to Pull." Whenever a bypass is used and activated, the PLC shall generate an alarm and a warning is generated on the touchscreen which shall require acknowledgement
- xvii. Turn the span control selector switch to Lower (Switch or push-button on Touchscreen)
 - (1) When Span control selector switch is in the Lower position, the PLC input 'Span Lower' will energize, and the following action will take place:
 1. The PLC shall command the pump motors and valves operate the bridge in the lower direction. The PLC shall set the proportional valves to the pre-defined full speed or reduced setting based on the speed selected and monitor the valve opening as reported from the linear transducer. If the feedback signal and the command do not agree, the PLC shall send an alarm to the HMI and stop the pump motors and span from operating.
 2. During span operation, the PLC will control the valves using outputs from the PLC to control the hydraulic interface modules located in the new PLC cabinets. These modules will then control the valves directly. Feedback from the closed loop valves will be reported to the PLC.
 3. The PLC, valves and interface modules shall accelerate the span to full speed within 10 seconds (field adjustable). If any valve does not operate within 2 seconds of the command, the PLC shall not continue span operation and shall generate and store an alarm on the touchscreen.
 - (2) When the PLC inputs 'Span Lower' are energized and all valves are operational, the PLC shall command the valves to lower the span, ramping up ten seconds to full operating speed.

Commanding the pump motors to lower shall initiate the span to rotate in the direction that closes the leaf. The PLC shall monitor the pump and valve operation to verify proper motor control. At any point if a fault occurs, key parameters such as speed, position, and fault identifier shall be stored to the touchscreen.

- (3) Note: If the PLC command to lower either span is sent continuously for more than 5 seconds and no change in position or speed is detected, the PLC shall stop the span and generate and store an alarm on the touchscreen.
 - (4) Span Position - The PLC shall continuously monitor the PLC analog inputs for 'Span Position' and compare with the limit switch contacts inputs for 'Nearly Closed' and 'Nearly Open. If the PLC detects a variation between the limit set points and the span position angular values, then the PLC shall generate and store an alarm.
 - (5) Stop - If the operator presses the Stop push-button while the span is in operation, the respective PLC ethernet input 'Span Lower' shall be de-energized. When the input is de-energized during a lowering operation, the PLC shall continue to lower the span and decelerate (ramp down) to stop in 5 seconds. The span operation can be restarted by following the procedure as shown above.
- xviii. Close the Leaf to Nearly Closed - The PLC shall maintain the full speed lower operation of each leaf until it reaches the nearly closed position. When PLC analog input reaches the scaled setting for 'Span Nearly Closed', then the leaf is nearly closed.
- (1) When the leaf is nearly closed, the PLC shall command the leaf and valves to continue closing and reduce speed to creep speed and the following actions will take place:
 1. The PLC shall command the pump motors and valves to operate the bridge in the lower direction in creep speed. The PLC shall perform the following:
 - a. Set the proportional valves to the pre-defined creep speed setting and monitor the valve opening as reported from the linear transducer. If the feedback signal and the command do not agree, the PLC shall send an alarm to the HMI and stop the pump motors and span from operating.
 - b. Turn the creep Valve to ON and continue to lower the span. The creep valve will remain ON until either a raise command is initiated, or the span locks are driven.
 2. The PLC, valves and interface modules shall decelerate the span from full speed to creep speed within 10 seconds (field adjustable). If any valve does not change within 2 seconds of the command, the PLC shall not continue span operation and shall generate and store an alarm on the touchscreen.
 - (2) Once the leaf is at creep speed the PLC shall check the speed of the leaf to verify it has slowed down by monitoring the feedback from the cylinder position transducer. If the span has not slowed down to 10%, then the PLC shall command the valves to stop the span immediately and the PLC shall generate and store an alarm.
 - (3) Close the Span to Fully Closed - The PLC shall maintain closing the span in creep speed until the span reaches the fully closed position. When PLC input for the fully closed limit switch 'Span Fully Closed' is energized, then the span is fully closed and the following actions will take place:
 1. The PLC shall command the pump motors and valves to ramp the span to a stop in five seconds of receiving the fully closed signal to allow the span to wind-up into the live load bearings at reduced pressure/torque. The PLC shall then set the proportional valves to the pre-defined zero speed setting and monitor the valve opening as reported from the

linear transducer. If the feedback signal and the command do not agree, the PLC shall send an alarm to the HMI and stop the pump motors and span from operating.

2. If any valve does not change within 2 seconds of the command, the PLC shall stop the span and generate and store an alarm on the touchscreen.
- xix. Interlocks - The nose lock shall be interlocked such that the span cannot be opened unless the Nose locks are pulled, all gates are fully lowered, the traffic signals are red, the pumps are running, and there is bridge control power.
- xx. Lower Bypass Operation - If there is a failure with any piece of equipment preventing the span from lowering, the bypass can be used to operate the span. Bypass switches can only be used when an alarm condition is present such as "Nose Lock Failed to Pull." Whenever a bypass is used and activated, the PLC shall generate an alarm and a warning is generated on the touchscreen which shall require acknowledgement
- xxi. Interlocks:
 - (1) The span shall be interlocked such that the span cannot be opened unless the span locks are pulled, both barrier gates are closed, all warning gates are fully lowered, the traffic signals are red, and there is bridge control power.
 - (2) Bypass Operation:
 1. The PLC shall check the number of interlocks bypassed during an opening and limit the amount to a maximum of two interlocks bypassed.
 2. If the span lock fails to pull, the span lock pulled interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.
 3. If either barrier gates fails to lower, the barrier gates lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.
 4. If any of the warning gates fails to lower, the warning gates lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.
 5. The span position failure can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.
 6. The cylinder position transducer failure can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

4. Hardwired Switch Only

- a. The PLC shall operate in the same manner as noted above while using the hardwired switch with exceptions noted below.
- b. When the PLC input 'Screen Operation' is energized the PLC shall disable touchscreen operation from any location on the bridge.
- c. Before operation of any piece of equipment using the hardwired switches and push-buttons the PLC shall check the PLC input "Control Desk Operation" prior to each component being operated.

J. Touchscreen Operation

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1. General programming and operating requirements for each HMI touchscreen display screen is specified below. Each display screen shall consist of multiple selectable screens which are also noted below that are activated via the touchscreen. Adjust and add to the HMI screen program as directed by the Engineer during HMI and network testing as specified herein. It is the intent of these requirements to match HMI displays for Rehoboth Avenue Bridge located in Rehoboth, Delaware. A copy of the HMI screen shots can be provided upon request.
2. Home Screen
 - a. Username
 - b. Password
 - c. Date
3. Operation Screen
 - a. Includes general layout of selector switches, pushbuttons, and indicators to mimic the layout of the hardwired switches on the control desk unless otherwise specified.
 - b. Each device on the bridge shall have an individual button or switch represented pictorially which when selected shall operate the device as specified.
 - c. Selectable cylinder operation.
 - d. Selectable pump operation.
 - e. Automatically synced time and date stamp
 - f. Angle of opening display
 - g. Active alarm message display
 - h. Selection tabs of alternate screens
 - i. Time of traffic stopped display
4. Main Display Screen:
 - a. Includes general layout of the bridge including pictorial image of gates, locks, signals, etc. and their status (green for open to traffic, red for closed to traffic). When a device is running it should change color on the screen.
 - b. Automatically synced time and date stamp
 - c. Angle of opening display
 - d. Active alarm message display
 - e. Selection tabs of alternate screens
 - f. Time of traffic stopped display
 - g. Includes status of incoming service, generator and ATS
 - h. Includes voltage and current values for each phase on the incoming service and generator
5. Traffic and Gates Screen:
 - a. Includes pictorial image of each traffic gates and signals and their status (green for open to traffic, red for closed to traffic).
 - b. Indicator for status of each gate including limit switch contact set point and status (open or closed) and activate alarms.
 - c. Automatically synced time and date stamp

- d. Angle of opening display
 - e. Active alarm message display
 - f. Selection tabs of alternate screens
 - g. Time of traffic stopped display
 - h. Operational status of each gate when selected including limit switch contact set point and status (open or closed) and activate alarms.
6. Locks Screen:
- a. Includes pictorial image of span locks and their status (green for open to traffic, red for closed to traffic).
 - b. Indicator for status of each span lock including limit switch contact set point and status (open or closed) and activate alarms.
 - c. Automatically synced time and date stamp
 - d. Angle of opening display
 - e. Active alarm message display
 - f. Selection tabs of alternate screens
 - g. Time of traffic stopped display
7. Hydraulic Equipment Screen:
- a. Includes pictorial image and layout of hydraulic equipment and their status (green for open to traffic, red for closed to traffic) including a flow diagram with status of each valve.
 - b. Indicator for status of each cylinder and pump including limit switch contact set point and status (open or closed) and activate alarms.
 - c. Automatically synced time and date stamp
 - d. Angle of opening display
 - e. Span operating speed
 - f. Active alarm message display
 - g. Selection tabs of alternate screens
 - h. Time of traffic stopped display
8. Alarm Screen:
- a. Includes alarm history page with last 12 alarms with date and time stamps and active or inactive status.
 - b. Acknowledge alarm button
 - c. Silence alarm button
 - d. All alarms shall be generated per operator username
9. Maintenance and Bypass Screen
- a. Warning acknowledgement
 - b. Directions screen when selected
 - c. Password protected bypass operation for manual operation, warning gate door switches, deceleration failure

- d. Password protected manual operation of ATS and Generator
- e. Adjustable parameters and set points
- f. Any other operator commended which only intended for maintenance staff.
- g. Drift Span Operation

K. Limit switches

- 1. All work to properly install and adjust new limit switches and sensors shall be covered under this item in accordance with the plans and specified herein. All work performed for fabrication and testing as specified shall be performed by an acceptable control system vendor.
- 2. Field work for installation of the limit switches and sensors including mounting and adjustments shall be performed by the Contractor as well as fabrication of targets and mounting brackets. The alignment and fastening of the cylinder position transducer, hydraulic equipment sensors and valves shall conform to and be paid for under the requirements specified under the item 615503-Bridge Mechanical System.

L. Motors

- 1. Follow the testing guidelines as specified and paid for under the item "Testing", and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the requirements as listed herein.
- 2. All work performed for fabrication and testing as specified shall be performed by an acceptable control system vendor unless otherwise noted.
- 3. A complete set of speed-torque-current curves for one pump motor and one span lock motors shall be prepared and submitted by the manufacturer to the Engineer for approval. Curves corresponding to full-load speed shall be provided. The curves shall cover the interval from breakaway torque to breakdown driving torque, referred to full-load motor torque. All motors shall be subjected to a standard routine test including a full load heat run test.
- 4. All motors shall be subjected to an insulation resistance test per NEMA standard MG-1, Section Nos. 12.02 and 12.03. Insulation resistance values and test voltage shall be included on the test reports.
- 5. Tests shall be reported on the standard forms for induction motors of the National Electrical Manufacturers Association. All test reports and curve sheets shall be certified by the manufacturer, and three copies of each shall be submitted. Motors shall not be shipped from the plant of the manufacturer until the test reports have been approved by the Engineer.

M. Traffic Control Equipment

- 1. New traffic signals, warning and barrier gates shall be furnished and installed as shown on the plans and specified herein. All work shall follow the requirements specified under MUTCD.
- 2. Follow the testing guidelines as specified and paid for under the item "Testing," and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the requirements as listed herein.

N. Wire and Cable

- 1. Size of all conductors shall be as indicated on the Contract Plans. If no size is indicated or the conductor size and number as shown on the approved electrical schematics vary from that shown on the Contract Plans, conductors of sufficient size and number shall be provided to accommodate the circuits to be installed. These conductors shall be sized in conformance with the National Electrical Code and any other applicable codes. Provide wiring and cables of sufficient ampacity and number as may be required for the installation in accordance with the wiring diagrams on his approved working drawings and these specifications without extra cost to Delaware Department of Transportation.

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2. In each conduit and multi-conductor cable, at least two spare conductors shall be provided for every ten conductors of control wire and at least one conductor shall be provided for every ten conductors of power (or fraction thereof) actually used.
3. Internal shop wiring for control cabinets and the control stations shall not be smaller than No. 14 AWG. External control wiring shall not be smaller than No. 12 AWG.
4. Wiring shall not be installed in any conduit before all joints are made up tightly and the conduits rigidly secured in place. The drawing of conductors into conduits shall be done without injury to the wire, insulation or jacket.
5. For all conductors No. 8 AWG or smaller, approved wire ferrules terminal lugs shall be installed on each end of said conductors in all locations except for the aerial cable terminal cabinets, where flanged fork terminals shall be used. Where connections to pilot devices are required, either flanged forks or wire ferrules shall be used at the Contractor's discretion.
6. Terminal lugs shall be installed per lug manufacturer recommendations using the proper tools approved by the manufacturer. The terminal lugs for all outgoing wires (No. 8 AWG or smaller) in terminal boxes, control cabinets, control stations and other enclosures shall be connected to terminal blocks herein after specified. Each terminal of all terminal blocks shall be permanently marked to show the same number or designation as appears on the wire connected thereto. Under no circumstance will splicing of wires be permitted without the use of a terminal block. Wherever it becomes necessary to join or branch conductors, terminal blocks shall be used and wires shall be clearly tagged.
7. New aerial cables routed across the channel shall be connected as shown on the plans and specified herein. Flanged fork tongue terminals and terminal blocks shall be used to connect the individual conductors to the terminal blocks.
8. Fiber optic cables and Ethernet cables shall be installed and connected per manufactures recommendations. Splices for fiber optic cables shall be made with fiber optic splice kits inside an isolated enclosure.
9. Sufficient slack shall be left in all cables to permit proper connections in boxes, cabinets and enclosures. Conductors inside terminal boxes, control cabinets, control stations and other enclosures shall be neatly formed into cables and laced with approved cable ties with the individual conductors leaving the bundled cable at their respective termination points. Each conductor shall be looped to allow not less than three (3) inches of free conductor when disconnected from its respective terminal. The bundled cables shall be held securely away from the terminals and from contact with the enclosure by means of approved insulating supports and ties.
10. Equipment ground conductors shall be installed in all conduits and multi-conductor cables per the National Electrical Code latest edition, and all other applicable local codes.
11. Both ends of every single length of conductor shall be permanently and clearly tagged in accordance with the same numbers or designations appearing on the approved wiring diagrams.
12. All wiring shall be carefully tested after installation. Administer continuity tests, insulation resistance tests and any other required test for any conductor run as directed by the Engineer at no additional cost to the Delaware Department of Transportation.
13. All droop cables shall be provided with sealing bushings where they enter terminal cabinets or junction boxes.
14. Fabrication and installation for the "Electrical Cable Wire and Connectors" and all associated equipment shall be paid for under this Section. Follow the testing guidelines as specified and paid for under the item "Testing", and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the requirements as listed herein.

O. Conduit Systems

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1. All conduits to be installed in outdoor locations and/or corrosive environments shall be stainless steel as hereinafter specified. Conduit embedded underground or in concrete shall be schedule 80 PVC. Conduit installed in the control house shall be rigid galvanized. Conduit fittings, including couplings, unions, elbows, expansion and deflection fittings, and other items, shall be the same type of material as the conduit system in which they are connected.
2. Unions to connect sections of conduit that cannot be joined to each other or to boxes in the regular manner shall be the same type as the installed conduit systems.
3. The interior surfaces shall have a smooth finish and be free of burrs or projections, which might cause injury to the cables. All conduits shall be free from blisters, cracks, or injurious defects and shall be reamed at each end after being threaded. Conduits shall be installed to be continuous and watertight between boxes or equipment. Conduits shall be protected at all times from the entrance of water or other foreign matter by being well-plugged overnight or when the work is temporarily suspended.
4. All bends shall be made with factory-bent, standard or large radius conduit elbows. When approved by the Engineer, bends and offsets can be made with a hydraulic or power pipe bender, provided with standard shoes for conduit as required. Field bends shall be made without kinking or damaging the conduit. The radius of curvature of pipe bends made in the field shall not be less than eight times the inside diameter of conduit. All bends shall be long sweep, free from kinks, and of such easy curvatures as to permit the drawing of conductors without injury. The use of a pipe tee or vise for bending conduit will not be permitted. Conduit that has been crushed, deformed or damaged shall be discarded. Conduit runs shall be made with as few couplings as standard lengths will permit, and the total angle of all bends between any two boxes or cabinets shall not exceed 270 degrees, unless otherwise approved by the Engineer. Long running threads will not be permitted. Pull boxes shall be used whenever necessary to facilitate the installation of the wire.
5. The use of condulets or conduit bodies for pulling conductors, for making turns in conduit runs, or for branching conductors shall only be permitted for lighting and heating conduit.
6. All conduits in the control house, wherever practicable, shall be concealed. Where conduits pass through the floors or walls of the control house, they shall be cast-in-place, or they shall be provided with galvanized pipe sleeves for free passage of the conduits. After the conduits are installed, the openings shall be caulked with an elastic compound and escutcheon plates provided on the interior walls, ceilings, and floors. Conduits shall be securely clamped and supported at intervals not exceeding 5 feet in length.
7. Conduit runs exposed on the steel structure shall be securely clamped to the steelwork. Supports shall be arranged so that conduits rest on top of the support and conduit U-bolts rest on top of the conduits. The use of J-bolts to fasten structural supports or to clamp conduits will not be permitted.
8. Where conduits are to be mounted exposed on non-steel surfaces, they shall be securely clamped to the surface using bent plate pipe supports with back spacers held by not less than two bolts.
9. Exposed conduits shall be installed parallel to, or at right angles to ceilings, walls and partitions. Where changes in direction of exposed conduit cannot be made with neat and orderly bends, pull boxes shall be used. Exposed conduits shall be securely clamped and supported at intervals not exceeding five (5) feet in length. All boxes and fixtures shall be provided with structural supports independent of associated conduit. No boxes nor fixtures shall be cantilevered from nor supported by conduit. The conduit supports shall be as specified elsewhere under this item.
10. At any point where a conduit crosses an expansion joint longitudinally or where movement between adjacent sections of conduit can be expected, conduit expansion fittings shall be installed. The fittings shall be bronze expansion fittings and shall be provided with flexible bonding jumpers to maintain the electrical continuity across the joints. The fittings shall permit a total conduit movement of 8 inches.
11. At any point where a conduit crosses a joint laterally or where an offsetting type movement between adjacent sections of conduit can be expected, expansion and deflection fittings shall be installed. The

fittings shall permit a movement of $\frac{3}{4}$ inch from the normal in any direction. Flexible bonding jumpers shall be required to maintain bonding integrity whenever expansion fittings are required.

12. Flexible conduits for the connections between the rigid conduit system and all limit switches, motors, and other equipment subject to vibration shall be made with sections of approved flexible conduit. Approved liquid-tight connectors shall be provided for connections between rigid and flexible conduit. Each flexible, liquid-tight conduit section shall not exceed eighteen (18) inches in length without prior approval of the Engineer.
13. All conduit embedded in concrete, insofar as possible, shall be completely encased by concrete of not less than 3 inches, measured in any direction, and shall be securely held in place during pouring and construction operations. A group of conduits terminating together shall be held in place by a template.
14. All cutting and threading of conduit shall be performed as recommended by the conduit manufacturer. After being threaded, conduits shall be reamed at each end. All threads shall be degreased before connection. All field cut threads shall be National Pipe Taper. Running threads will not be permitted.
15. Conduit lengths shall be connected to each other with approved screw couplings assembled hand-tight and then, using strap wrenches, tightened two more turns. Conduit runs shall be made with as few couplings as standard lengths will permit. No conduit runs with a total angle of bends between any two boxes shall exceed (270) two hundred and seventy degrees, unless otherwise approved by the Engineer.
16. Ends of conduits left empty, including stubs, shall be capped, with a cap of the same size and material as the conduit, during construction, and care shall be taken to ensure that no moisture or other matter is in or enters the conduits.
17. All conduits shall be pitched where feasible to allow for water drainage. Where conduits cannot be drained to pull boxes, a drain "T" with drain/breather fitting shall be installed at the low point and drained. Drain/breather fittings shall be of stainless steel and shall be capable of passing 25 cc of water per minute.
18. Conduit hubs shall be provided at the ends of all conduits entering boxes and enclosures furnished with slip holes.
19. The ends of all conduits projecting into boxes and equipment enclosures shall be provided with insulated grounding bushings or hubs. All bushings or hubs in any box or enclosure shall be bonded together to the ground lugs in each box with No. 8 AWG bare copper wire.
20. All conduit, enclosures, and fittings shall be mechanically joined and electrically bonded together to form a continuous electrical conductor to provide effective electrical continuity. An equipment ground conductor shall be provided in every conduit and enclosure throughout the raceway. Conduits shall be installed so as to be continuous and watertight between boxes or equipment. Conduits shall be protected at all times from the entrance of water or other foreign matter by being well plugged overnight or when the work is temporarily suspended. End of abandoned conduits, spare conduits, and empty conduits and stubs shall be capped during and after construction, and care shall be taken to ensure that no moisture or other matter is in or enters the conduit.
21. Both ends of each conduit run shall be provided with conduit tags as specified.
22. All conduits and fittings shall be carefully examined and cleaned both before and after installation. Upon completion of the conduit and box installation, clear each conduit by snaking with a mandrel of a diameter not less than 85 % of the nominal inside diameter of the conduit, and shall then draw in the cables. All conduits shall be free from blisters, cracks, deformations and defects. Conduits with any damage or injurious defects as judged by the Engineer shall be removed from the site and replaced by the Contractor at no extra cost to DelDOT.
23. The minimum size of conduits shall be as indicated on the Contract Plans. If no size is indicated or conduit fill varies from that shown on the Plans, conduit shall be sized to accommodate the conductors

to be installed therein in conformance with the National Electrical Code. No conduit smaller than $\frac{3}{4}$ inch shall be installed.

24. Conduit shall be installed in accordance with the manufacturer's installation manual. The manufacturer's installation manual shall be kept on the job site and made available to the Engineer at all times.
25. As required under Working Drawings and Samples, layout and installation drawings for the electrical work, which includes the conduit system, shall be submitted prior to pertinent structural and mechanical shop drawings so that the conduit installation details may be incorporated by the structural and mechanical fabricators and erectors. A drawing showing the assembly and complete construction details of the conduit system shall be prepared and submitted for approval prior to fabrication. Follow the assembly and details of the system as shown on the plans.
26. Coordination of the raceway installation with all other trades shall be performed as part of this work.

P. Boxes.

1. Boxes shall be furnished and installed where required and shown on the plans.
2. Pull boxes shall be used whenever necessary to facilitate the installation of the wire. Conduit bodies shall not be used for pulling conductors, for making turns in conduit runs, nor for branching conductors, for lighting and heating conduit runs only.
3. Surface mounted interior and exterior boxes shall be provided with external mounting lugs. No box shall be drilled for more conduits or cables than actually enter it. Exterior boxes shall be provided with $\frac{1}{2}$ inch combination drain and breather fittings.
4. Terminal blocks shall be provided in each terminal box for the connection of all conductors including spare conductors entering the box plus at least twenty percent spare terminals for any control conductors and ten percent for any power conductors. All terminal blocks and boards shall be mounted on suitable straps or structural steel brackets in such a manner as to permit routing the conductors behind the terminal blocks. Terminal blocks shall be one-piece blocks suitable for use in highly corrosive atmospheres and shall conform to the requirements hereinbefore specified.
5. Each power distribution block shall be constructed of one-piece molded phenolic compound and shall conform to the requirements hereinbefore specified. A cover of insulating material shall be provided for each block.
6. All manholes, junction boxes, pull boxes, and terminal boxes shall be inspected for proper duct entries, terminators, bell ends, pulling-in-irons, concrete seal around ducts, caps or plugs, pull lines, ladders, grout seals between the frame and chimney.

Q. Hardware and Supports.

1. The Contractor is responsible for developing all conduit details consistent with applicable codes and these specifications. Structural steel brackets, boxes and other equipment mounted on concrete surfaces shall be provided with a full neoprene gasket as specified.
2. The anchoring system shall be used to fasten all electrical equipment to concrete as specified. The Contractor is required to use all accessories for installing the anchoring system as recommended by the manufacturer including but not limited to wire brush, air nozzle with air compressor and epoxy dispenser.
3. Prepare and submit details of all electrical equipment supports to the Engineer for approval.
4. Each electrical device and enclosure shall be provided with a rigid structural steel support. No enclosure or device shall be permitted to cantilever from conduit unless specifically permitted in writing by the Engineer.
5. All Enclosures shall be mounted to concrete floor using stainless steel bolts as required.

6. If the Contractor elects to field drill certain electrical supports, the Engineer prior to any installation actually taken place must approve all details and locations.

R. Pull Wire.

1. After Installation, all conduit which will be left empty shall have a pull wire or cord installed. Pull wire or cord shall be made of corrosion resistant material with a minimum tensile strength of 400lb.

S. Incoming Electrical Service

1. Furnish and install the new incoming service as shown on the plans. All work shall be coordinated with Delaware Power Co-Op (DEC).
2. As part of this work DEC will furnish and install the primary conduit, wire and pole mounted transformer. Under this item, the Contractor will furnish and install the secondary conduit and wire, meter, support stand and disconnect switch. The Contractor will be responsible for any coordination related to the incoming service between the Contractor, DelDOT and DEC. All fees related to the incoming service shall be paid for directly by DelDOT.
3. The new service shall not be connected and energized by the Contractor until all equipment on the bridge is compatible with the new operating voltage. Any work required to be performed to use either incoming service for bridge operation and construction activities shall be paid for by the Contractor under this item. Adjustment to the incoming service equipment as previous defined shall also be performed under this item.
4. It shall be the responsibility of the contractor to notify the DEC twenty four (24) hours in advance of performing any work so that the city inspector may be present to witness the work.

T. Stand-By Generator Testing

1. The engine-generator set, complete with all set-mounted accessories and auxiliary equipment, will be factory-assembled by the manufacturer.
2. The engine and generator will be coupled through a non-backlash type, flexible coupling, and mounted on a self-supporting, structural steel base (skid) using coiled-spring type vibration isolators. The structural steel base will be bolted to the structural support bolts of size and number as recommended by the manufacturer.
3. The generator shall be tested by the Contractor as follows:
 - a. Factory Testing
 - i. The components of the engine-generator set will be factory assembled, and with all accessories connected and in place, will be subjected to full-load test runs at the manufacturer's plant, as hereinafter specified. Prototype testing will not be accepted in lieu of testing the actual set to be supplied.
 - ii. The engine will be run continuously for no less than 4 hours without stoppage, and will include at least 1 hour's operation at 50 and 75 percent and 2 hour's operation at 100 percent of rated load. A record will be kept of the water temperature in the engine head until a stabilized temperature is reached. When the engine is stopped, the temperature of the water will rise to not more than 200 degrees F.
 - iii. The tests will include complete performance tests of the entire generator set to show that the generator voltage regulator and the engine governor perform properly to meet all specified requirements.
 - iv. The generator and exciter will be subjected to a full load heat run, and the test results will be reported on the Standard Performance Specification Forms of the National Electrical Manufacturer's Association.

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- v. The manufacturer of the generator set will provide an insulation resistance test per NEMA Standard MG-1, section numbers 12.02 and 12.03. Test results will be reported on the standard forms for generators of the National Electrical Manufacturers Association. The manufacturer will certify all test reports and curve sheets and five copies of each will be submitted and approved by the Engineer prior to shipment from the factory.
 - vi. All factory tests will be witnessed by an Engineer approved third party, and all factory test results and observations certified by such third party.
 - vii. Six certified copies of the results of the above tests will be submitted for review. The units of the engine-generator set will not be shipped from the plant of the manufacturer until the certified tests thereon have been accepted by the Engineer. A certified copy of the test results will be included in the aforementioned instruction books.
 - viii. Contractor to take notice that some or all of the above testing may be considered as non-routine and may require an extra cost by the manufacturer. The Contractor will coordinate with the manufacturer all testing requirements and include the cost for all tests in the bid price.
- b. Field Testing
- i. The Contractor will arrange for and provide all the necessary field tests prescribed by the manufacturer, as directed by the Engineer, to demonstrate that the entire engine-generator installation is in proper working order and in accordance with the Plans and Special Provisions.
 - ii. The Contractor will test the insulation resistance of the generator prior to installation by dielectric absorption utilizing 1000 volts DC. Tests will follow recommendations of IEEE Standard No, 43. Approved test equipment will be provided and used by the Contractor. Test instruments will have been calibrated within the last six months by a calibration facility with traceability to NBS approved by the manufacturer of the test instruments. Written certification of calibration will be provided to and approved by the Engineer prior to executing the tests.
 - iii. Accessories that normally function while the set is standing by will be checked prior to cranking the engine. These will include: block heaters, battery charger, generator strip heaters, louvers, remote annunciator, etc.
 - iv. During the testing period, the Contractor will arrange to have at the site a representative of the manufacturer of the engine-generator. This representative will be a service engineer experienced in the installation of generator sets, and he will be capable of making adjustments to the equipment; of locating faults or defects and correcting them, if possible; and of obtaining from the manufacturer, without delay, new parts or replacements for apparatus which does not perform satisfactorily.
 - v. Field-testing will also include complete operating tests to show that the engine-generator, automatic transfer switch and all components operate satisfactorily to sustain the loads imposed during operation of the span and its auxiliaries. All alarms and safety shutdown devices will be tested for proper operation and annunciation
 - vi. At least three complete bridge opening/closing sequences will be performed with the generator supplying electric power to the pump motors and auxiliary equipment.
 - vii. Automatic start-up by means of simulated power outage to test remote-automatic starting, transfer of the load, and automatic shutdown will also be performed. Prior to this test, all transfer switch timers will be adjusted for proper system coordination. Engine coolant temperature, oil pressure, and battery charge level along with generator voltage, amperes, and frequency will be monitored throughout the test. The tests will be performed with both the external load bank and the bridge load for a minimum of three additional openings.

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- viii. Should the tests show that the engine-generator or any component piece of equipment or apparatus, in the judgment of the Engineer, is defective or functions improperly, such adjustments and/or replacements will be made by the Contractor as to make the installation satisfactory to the Engineer and at no extra cost.

U. Manual Operation/Temporary Operating System

1. Utilize the existing electrical and mechanical systems with upgrades as needed to operate the existing bridge during construction.
2. The warning gates, screw jack, span lock, span motor shall be manually operated as necessary for marine vessels and construction activities once electrical controls and power are removed. When the warning gates become manually inoperable a separate traffic barricade shall be used.
3. A maximum of 100 bridge openings (for vessels only) shall be assumed for estimating purposes, any required additional opening for vessels shall be negotiated with DelDOT. Any required openings as a result of construction activities shall be incidental to the relevant pay items and shall not be of any additional cost to DelDOT. A copy of the bridge opening log from 2020 is provided below as a reference.

South District Bridge Opening Log Summary													
Bridge	2020												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
3-164	4	22	56	143	138	88	124	139	120	96	***	23	953
Notes: *** Bridge opening count not available													

4. Bridge operation during the construction period, from the first day work will be performed by the Contractor until acceptance of the bridge by DelDOT. Under this item, provide and train personnel to operate the bridge, during scheduled bridge openings. Any fines by the US Coast Guard shall be the responsibility of contractor.
5. Each Bridge Operator shall be familiar with the bridge layout as well as be trained in the operation and maintenance of the bridge. Included in the Contractor's training program shall be subjects such as troubleshooting, repair of electronic motor controls, drive circuit logic, maintenance and adjustment of all new, existing, and temporary electrical equipment and hardware, and other items required for full bridge operation and maintenance.
6. Upon completion of training, each of the Operators will be required to demonstrate safe operation of the swing span, in the presence of the Engineer, prior to being assigned to duty as a Bridge Operator.

V. Bridge Opening Delay

1. Upon a call from a vessel to open the bridge per the USCG requirements 33 CFR 117.239, the Contractor must open the existing or new bridge as scheduled unless a closure period is permitted. The time to operate the bridge shall not exceed 20 minutes which includes the time to stop traffic, stop conflicting construction activities, and operate bridge equipment. The Contractor may need to operate the existing bridge utilizing temporary controls and drives or manual devices such as hand cranks, etc. while equipment is being removed and installed. Any fines by the US Coast Guard shall be the responsibility of contractor.

W. Demonstration of Temporary Bridge Operating System

1. A demonstration of any Temporary Bridge Operating System shall be performed in the presence of DelDOT or their authorized representative in which interlocking and operating procedure will be verified.
2. A minimum of 3 complete opening cycles with no operational issues shall be required and cycling of the gates, locks and jacks as required for verification of interlocking. The contractor shall obtain a copy of the previous inspection report to made aware of the pre-bid condition. The contractor shall not be required to repair any existing equipment more than the condition noted in this report.

3. Prepare a procedure for demonstration, which shall be submitted at a minimum of 14 days prior to the test date for review and approval. The procedure shall list in numbered steps each device to be demonstrated, the action required by the operator and the expected results.

X. Bridge Maintenance

1. Maintain all operating equipment on the bridge throughout the duration of construction on the new and existing bridge and associated equipment. This shall include but not be limited to; inspection, lubrication, general maintenance and servicing of all newly installed equipment as well as existing equipment. Maintenance of equipment shall be performed in accordance with manufacturer's recommendations, and bridge maintenance manuals.

Y. Technical Manuals

1. The following are suggested tables of contents for each of the manuals. They are not intended to be complete tables of contents and shall include all information which may be helpful in maintaining the bridge functional systems, in the case of the Maintenance Manual, or in operating the bridge functional systems, in the case of the Operating Manual. The tables of contents are given here are in general terms and include information and material on items provided under mechanical and electrical pay items. This is done intentionally to call attention to the need for coordination between the Contractor and all mechanical and electrical sub-contractors in the preparation of these manuals.
2. Maintenance Manual – Suggested Table of Contents:
 - a. Description of all bridge functional systems and sub-systems.
 - b. Layout of all bridge functional systems and sub-systems.
 - c. Listing of any warnings, cautions, or safety issues or procedures that must be followed as a part of any maintenance work, either specific or general.
 - d. Listings of all parts suppliers' local representatives, including suppliers' and representatives' names, addresses, telephone and fax numbers, and websites, if any. The names, addresses, telephone and fax numbers, and websites of the Contractor, all subcontractors installing any of the bridge functional systems or subsystems, and the Engineer shall also be provided.
 - e. Listing of all spare parts and components provided by the Contractor.
 - f. Preventative maintenance procedures, including the frequency at which the various procedures should be done.
 - g. Lubrication schedule charts and diagrams.
 - h. Maintenance testing and procedure equipment lists.
 - i. Troubleshooting procedures and checklists.
 - j. Repair procedures and repair procedure equipment lists, including suggested procedures for installation and removal of machinery, electrical and control items.
 - k. Description of the proper theoretical approach to installing and aligning machinery and installing and testing electrical and control systems.
 - l. As-Built Drawings
 - m. Conduit and electrical equipment layout and installation drawings, including mounting details.
 - n. Control desk, motor control panels and drive panel layouts and wiring diagrams.
 - o. Schematic-wiring diagrams
 - p. Certified Drawings

- q. Manufacturers' brochures, literature and composite schedule of apparatus, including any suggested installation, alignment, maintenance, troubleshooting and repair procedures.
 - r. Any and all other material or information which in the opinion of the Engineer may be desirable to include in order to assist in maintaining the bridge functional systems and sub-system.
3. Operating Manual – Suggested Table of Contents:
- a. Description of all bridge functional systems and sub-systems.
 - b. Description of functional relationships between bridge functional systems and sub-systems.
 - c. Listing of any warnings, cautions, or safety issues or procedures that must be followed as a part of any bridge functional system or sub-system operation, either specific or general.
 - d. Theory of operation, detailed operating instructions, which shall cover in full the step-by-step sequence of normal operation of the movable bridge functional systems, all precautions required for the correct and safe operation of all bridge functional systems, adjustment instructions, and operational limits and restrictions.
 - e. A similar description for the use of the bypass switches, noting all precautions for their correct and safe operation.
 - f. Description of control, which shall describe in full the functions of all protective devices, limit switches, contactors, relays, and all other equipment used in all bridge functional systems, in connection with each step in the operating sequence. Wire and apparatus numbers appearing on the wiring diagrams shall be used in this description for identifying the various devices and circuits.
 - g. Block diagrams illustrating the sequencing and operation of and functional relationships between all bridge functional systems and sub-systems.
 - h. Any and all other material or information which in the opinion of the Engineer may be desirable to include in order to assist in the operation the bridge functional systems and sub-systems.
4. A preliminary submittal of the technical manuals shall include, two copies of sample formats and outlines of contents in draft form 90 days prior to final inspection, acceptance tests, or return of span operation to the Department, showing proposed methods of binding, methods of printing and reproduction.
5. A draft submittal of the technical manuals shall include two copies of completed manuals in final form 30 days prior to the final inspection, acceptance tests or return of span operation to the Department. At the Engineers discretion, additional submittals of the draft technical manuals may be required as a result of inaccurate information or omitted information.
6. A final submittal of three (3) copies of approved manuals and (1) electronic copy in pdf format ten days after final inspection and acceptance tests. One of the seven copies shall become the property of the Engineer; the remaining copies shall become the property of the Department. The final submittal of technical manuals shall only be made once the draft version as noted about has been review and approved.

Z. Training

- 1. After submission of copies of the manuals in their final form and prior to the return of span operation to DelDOT, instruction and training shall be provided for DelDOT Maintenance and Operator Personnel for a period of 10 days.
- 2. The instructors shall be skilled persons competent to operate the bridge and be completely familiar with the operating equipment of the bridge. They shall be able to make any adjustments required to the electrical and mechanical equipment.
- 3. During the training period specified above, the instructor(s) shall be in attendance at the bridge during bridge opening and maintenance procedures.

4. Included in the training and instruction period, there shall be an on-site training of DelDOT electricians, maintenance workers, and other personnel as indicated by the Department on subjects such as troubleshooting, repair of motor controls, maintenance and adjustment of all electrical equipment and hardware, and other items required for full bridge operation and maintenance. Three 8-hour sessions shall be devoted to hardware and maintenance related topics. In addition, two 8-hour sessions shall be devoted to software requirements.
5. Instruction pertaining to hardware and maintenance shall be offered on two separate occasions to allow bridge personnel to coordinate the course with their normal activities. Furnish all necessary instruction sheets, student training aids, books, paper, and booklets to supplement training. Submit to DelDOT, a minimum of 2 weeks prior to training session, an outline of topics to be covered and training material for review. It shall also be the Contractor's responsibility to coordinate with DelDOT the location where training sessions will be held. Supplying of visual aid equipment and other miscellaneous items required for training shall be the responsibility of the Contractor.

AA. General Testing Requirements

1. The necessary field tests, as directed by the Engineer and specified herein shall performed by the Contactor in the presence of DelDOT or their authorized representative to demonstrate that the entire electrical system is in proper working order and in accordance with the Plans and Specifications. Thirty (30) days advanced notice is required for all witness testing. The tests shall include, but not be limited to continuity and insulation resistance testing of wire and cables, duct test for all conduit, operational and interlock testing of the bascule span, span locks, navigation lights and signals, warning gates, barrier gates traffic signals, standby generator and the automatic transfer switch.
2. Coordination of the bridge PLC system with the TMC center's network shall be performed as well as all associated testing to confirm proper operation.
3. Should the tests show that any piece of equipment or cable or wiring connection, in the judgment of the Engineer, is defective or functions improperly, such adjustments and/or replacements shall be made by the Contractor as to make the installation satisfactory to the Engineer and at no extra cost.
4. The bridge field tests are intended to confirm each major sub-component acceptance factory tests, and that the subsystem is operational prior to the conditional acceptance functional checkout. Confirmation of correct operation of sub-components will be demonstrated through successful operation of the particular component. However, the Contractor is still responsible for the factory acceptance tests as required per contract specifications. Examples of subsystems are the span drive systems, control and power wiring, limit switches, starters, relay systems, etc.

BB. Stage 1 – Contractors Field Testing

1. Adjust, calibrate and test all equipment, place the integrated system in service, and test the integrated system. Provide verification that all inputs and outputs and all signals have been properly installed and tested.
2. Demonstrate that the completed system functions properly by performing at least 10 consecutive complete bridge operations for each location including both PLC A and B control, each without failure or any adjustments to the satisfaction of the Engineer. (A complete bridge operation shall be defined as starting from turning control power on, operating all equipment up to completely opening the span, operating all equipment up to completely closing the span, and ending by turning control power off.) Demonstrations should be completed with both the physical switches and the HMI touchscreen controls. Demonstrate the operation of all bypass functions. Demonstrate the operation of the ATS and generator and provide at least 3 complete operations under generator power. Deliver a report describing results of the contractor's field tests, diagnostics, and calibrations including written certification to the Contracting Agency that the installed complete system has been calibrated, tested, and is ready to begin Stage 2 – Conditional Acceptance Functional Checkout. The report shall also include a copy of the approved Stage 1 – Contractor's Field Testing procedure.

CC. Stage 2 - Acceptance Testing Functional Checkout

1. During this stage, perform a step-by-step demonstration of the bridge operating systems as specified. The demonstration shall not be performed until all construction (including all trades) is completed, all punch list items has been resolved, and the "Technical Manuals" and other documents are submitted and approved by the Engineer.
2. Prepare a test procedure, which shall be submitted at a minimum of 30 days prior to the test date for review and approval. The test procedure shall list in numbered steps each device to be demonstrated, the action required by the operator and the expected results. The bridge operation shall be performed using the main utility source and the stand-by generator in conjunction with any back-up systems and the main control system. Operation of all interlocks and bypass switches shall be demonstrated. Each step shall be provided with a pass/fail blank.
3. The conditional acceptance functional checkout test, as specified, shall not commence until receipt by the Contractor of written permission from the Contracting Agency and approved by DelDOT, based on the Contractor's Stage 1 written report. This shall include certification of successful completion of Stage 1- Contractor's Field Testing, as specified above. The Contracting Agency may terminate this portion of the testing at any time when the system fails to perform as specified.
4. Upon a failure resulting in termination of testing by the Contracting Agency or by the Contractor an assessment period shall commence. Identify all failures, determine the cause of all failures, repair all failures, and deliver a written report to the Contracting Agency. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which the testing should be resumed. After delivering the written report, convene a test review meeting at the job site to present the results and recommendations to the Contracting Agency. As part of this test review meeting, demonstrate that all failures have been corrected by performing the appropriate portions of the conditional acceptance functional checkout test. Based on the Contractor's report and test review meeting, the Contracting Agency will determine the retest date.
5. Upon successful completion of the conditional functional checkout testing, deliver test reports and other documentation specified to the Contracting Agency for approval prior to commencing the endurance test.

DD. Stage 3 - Endurance Period

1. After successful completion of the field testing and acceptance testing (Stages 1 and 2) including correction of all deficiencies, the Contractor submit a request to DelDOT to start the endurance period. The letter shall include dates of final acceptance testing as well as a signed field test procedure. The start of the endurance period shall not occur until the approval of the record as-built drawings and O&M manuals.
2. Approval of the letter by DelDOT will start the endurance period in which a minimum of 3 days, 8 bridge openings per day, shall be witnessed by DelDOT. At any point during the endurance period should a fault occur DelDOT will be notified of the fault and cause as well as actions to be taken to repair or further troubleshoot.
3. After documentation of the fault is submitted to DelDOT the contractor will enter a conditional testing period not to exceed two weeks. During this period the Contractor will be required to perform additional testing to prove the fault has been repaired. Once conditional testing is accepted by DelDOT the endurance period can continue at which point the Contractor will witness the remaining bridge openings or 8 additional bridge openings whichever is greater.
4. Following successful completion of the endurance period submit a letter with the endurance period results. Acceptance of this letter by DelDOT will start the warranty period.

EE. Factory Inspection and Testing of the Bridge Control System

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1. The motor control enclosures, PLC cabinets, back panels, control desk, ATS and other apparatus supplied, assembled or fabricated by the vendor of the electrical control system shall be subjected to shop inspections to demonstrate compliance with all specified requirements. The inspection is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the Contractor of responsibility for imperfect material or workmanship.
2. The control cabinets, PLC cabinets, back panels and control desk shall be completely assembled, wired and connected at the factory, and shall be subjected to the manufacturer's standard inspections and testing. The manufacturer's standard testing for the equipment may comprise at least the following:
 - a. Wire continuity tests, either visual or verified with continuity tester.
 - b. Operational check of circuits to determine proper interlocking of circuits and operator's devices.
 - c. Simulated operational testing to verify proper operation in accordance with the plans and specifications using all modes of operation.
 - d. Polarity of connections to instruments and other polarity-sensitive devices.
 - e. Inspection of materials, fit of parts, finishes, adjustments, and conformance with catalog cuts.
3. The enclosed control cabinets, back panels, drives cabinets and control desk shall be completely interconnected and shall be subjected to electrical and operational testing to ensure accuracy of connections and to demonstrate proper functioning of equipment. Limit switch contacts shall be simulated using the actual limit switches if available or by using toggle or knife switches.
4. The toggle switch or knife switches shall be setup and installed on a fabricated test station. The test station shall be labelled with the limit switch designation being simulated. Actual limit switches can be used in place of the toggle switches provided they can be easily simulated or actuated.
5. The entire PLC system shall be interconnected as part of these tests including touchscreens. The PLC I/O shall be monitored from a separate laptop computer with the associated programming and monitoring software for the PLC system. As the touchscreen, pilot devices, limit switches, sensors, etc. are activated the associated PLC I/O will be monitored. Alarms and indicators will be tested and monitored during simulated operation. All back-up systems will also be tested.
6. During the testing, the control system vendor shall be required to adjust the PLC/HMI ladder logic and programming to the satisfaction of the Engineer. After each adjustment the testing shall be repeated as may be required to test all associated equipment.
7. The factory testing shall also include a complete sequenced, simulated operation of the bridge auxiliaries and span drive, and shall include complete adjustment, verification and testing of the control logic, control relays PLC, and contactors to demonstrate operation in accordance with specified requirements. Testing of the various interlocks as specified herein and shall also be included during the factory tests.
8. The Engineer or his authorized representative shall witness the factory inspection and special testing required herein, and no equipment shall be shipped from the factory until it has been released for shipment by the Engineer. Provide thirty (30) days notification in advance of the date of tests so that arrangements can be made for DelDOT and the Engineer to be present at the tests. Submit to the Engineer for review, thirty (30) days prior to the testing date, a copy of all standard and all special tests to be performed, as well as actual test forms to be approved by the Engineer.
9. During the witnessed inspections, nameplate legends, conductor identifications, instrument scales, escutcheon plate engraving and all other details of construction shall be checked for conformity with specified requirements and approved shop drawings.
10. Factory tests for equipment other than the bridge control system shall be as specified in the various materials sections throughout these specifications.

11. The complete control system as specified herein shall not be shipped to the bridge site or other facility until the written approval from DelDOT.

FF. HMI Display Screen, Alarms and Network Testing

1. The complete network including HMI and PLC's shall be connected and tested with the HMI screen for proper operation. The testing shall include emergency stop testing and local operation testing of the drive systems. A list of alarms shall be generated on each HMI and modified per the direction of the Engineer or DelDOT. A final list of alarms shall be submitted prior to the start of factory acceptance testing.
2. The test date for HMI and network testing shall be 30 days or more from the date of the factory testing of the completed control system. During the testing an opportunity shall be provided to review the HMI screen layout with the control system vendor and make adjustments to design of each screen and the overall layout. As part these tests the on-going fabrication of the control system will be visual inspected by the Engineer.

GG. Field Acceptance Test Data

1. All test results, parameters; data specified herein to be recorded shall reference the appropriate paragraph number and shall be presented in legible, tabular format, listing associated parameters and conditions. For example, pump motor current shall the reference speed (ft/min) of the hydraulic cylinders, span leaf angle (degrees), raise or lower mode, etc.
2. The results of the main and ancillary systems tests shall be presented in a matrix form on an Inspection Report Data Sheet. The proposed format of these sheets shall be submitted to the Engineer for acceptance prior to the actual testing. Any parameter value, which falls beyond the recommended range, would require the re-adjustment or replacement of the defective device.
3. The table of the test results shall have references to the specific sections of the testing procedure. The precision of the results will depend on the accuracy of recording equipment, the observer and weather conditions. For each stage of testing of the bridge control equipment, the name of the person who will perform the test, instruments used with calibration data if required, the exact date, time and weather conditions shall be recorded.
4. Some devices such as the transfer switch, lamps, console indicator lights, console-controlled lighting, horn, can be easily tested without performing any bridge opening operation.
5. The bridge main parameters shall also be observed on the drive keypad and a laptop screen, and visually compared to the control console touchscreen and indicators. Any discrepancy between results should be recorded. A discrepancy between critical measurements like span angle indication shall be resolved prior to continuing the tests.
6. The testing shall be accomplished sequentially, following the bridge operation instructions for normal operation and emergency operation. The major bridge systems shall be monitored while the bridge operates. All safety interlocking shall be verified such that each components can only be operated in the correct sequence. All bypass switch operations shall be verified.
7. The printout originals of all tests shall be kept for future reference, and a printout copy shall be attached to the Technical Manuals for reference. Another printout copy shall be provided to the Engineer.

HH. Arc Flash/Coordination Study and Labeling

1. A coordination study shall be performed in conjunction with the fabrication of the motor controls and power distribution equipment. The coordination study shall be made available prior to shipment of the control system from the fabricators facility.
2. In addition, once construction of the electrical system is complete but prior to final acceptance, provide adhesive vinyl arc flash labeling on all new equipment in accordance with applicable codes and requirements. Equipment requiring labels include components that are likely to be opened for

maintenance including motor control equipment, drive enclosures, panel boards, disconnect switches, etc. Labeling shall include the arc flash hazard at the location clearly indicating the appropriate level of protection required.

3. In order to prepare and affix the arc flash labels, retain the services of a professional engineer registered in the state of Delaware to perform a survey of the newly installed electrical equipment and perform an analysis of the arc flash hazards using industry standard software. Prior to procuring and installing the arc flash labels, submit the results of the arc flash analysis, including calculations and label schedules, and submit for review. The final report shall be stamped by the Delaware licensed Professional Engineer.

II. Removal of Existing Equipment

1. The removal work of the existing equipment under this subsection shall be done in conformance with all requirements governing the sequencing and scheduling of construction. Removal of electrical equipment covered under this item shall include all electrical equipment not designated to be salvaged.
2. Removal of electrical equipment on the movable span is covered under another item and will be removed as part of Item 211000 Removal of Structures and Obstructions.
3. Any existing conduit encased in concrete, which are to be abandoned, shall be cut back to the concrete surface, threaded and capped with steel pipe caps.
4. Existing conduit that interferes with new conduit, wire and equipment shall be removed as part of this items and may require saw cutting, chipping, blasting, etc.
5. Removal of roadway lighting and traffic signals shall be included under this item and performed by the Contractor.
6. In general, all apparatus to be removed shall be disconnected by removing existing bolts, nuts and screws. The work shall include removal of all brackets, hangers, clamps, fittings and other hardware no longer needed.
7. All existing holes in concrete created from the removal of existing equipment including conduit, supports, boxes, water lines, etc. shall be sealed.
8. All existing facilities, apparatus, cables, wiring and other equipment which are to remain in place on the bridge, shall be protected at all times from damage or defacement caused by the Contractor's operations. Any such damage or defacement shall be promptly repaired or cleaned to the satisfaction of the Engineer at no extra cost. If, in the opinion of the Engineer, the Contractor's operations require the temporary removal of existing equipment for proper protection, such removal and remounting shall be done at no extra cost.
9. Upon completion of the work, repair all damaged or defaced areas exposed by the removal of equipment, or caused by his operations, in a workmanlike manner satisfactory to the engineer. Small bolt holes in concrete surfaces shall be filled with epoxy mortar. Holes in the walls ceilings or floors of the houses shall be filled with grout and finished to match the existing surfaces. Any damage to windows, window framing, sash, sills, frames or any other architectural trim shall be repaired, and painted surfaces shall be repainted after being repaired. Any holes in the ground shall be filled with earth top soil and suitably landscaped to match the surrounding areas.
10. All existing materials and equipment removed under this item shall become the property of the Contractor unless otherwise specified, and shall be removed from the site and disposed of properly.
11. The following items shall be salvaged and delivered to DelDOT by the contractor:
 - a. Warning gates including housing, arms, gongs and internal parts. The arms shall be separated from the gate for transportation and delivery.
 - b. Traffic signals heads and poles.

c. Aerial cable support poles.

JJ. Lightning Protection System

1. The movable span balance frame and counterweight tower and all electrical equipment and its associated supports (poles, etc.) shall be protected by a lightning protection system installed in accordance with NFPA 780, latest edition.
2. Special attention shall be paid to routing the lightning ground conductors from the lightning system so as to maintain a minimum 6 feet spacing from the control equipment and equipment bonding down leads to eliminate any metal body of inductance bonding. The system shall be installed in a manner to assure long-term reliability. Connections to the span structure and other fixed metal parts, cable splices, and connections to ground terminal components shall be welded. Drilling of the bridge structure is not permitted unless specifically approved by the Construction Manager.
3. The lightning protection system shall be tested for continuity on all cables and connections. Lightning protection system is to be inspected by an independent authorized source and provided with a master label.

KK. Bonding and Grounding

1. In general, bonding and grounding shall be made by molded fusion exothermic welds unless specified otherwise. Exothermic welds for bonding of equipment shall be molded fusion-type, with molds as required, as manufactured by Cadweld, Thermoweld, Metalweld or approved equal. Where physical limitations prevent exothermic welding, approved mechanical, solderless bonding lugs shall be installed.
2. Ground system conductors shall be continuous unspliced connections between welds and terminal lugs. Paint, rust, and scale shall be removed over the entire contact area. All connections shall be made up as tightly as possible, and any bare metal or paint undercoat remaining exposed shall be spot painted to restore the surface with the same coating and number of coats as applied to the adjacent metal.
3. Structural steel, all metal framing, cases, and enclosures of the electrical equipment, such as control cabinets, limit switches, conduits, boxes, and all other metal parts in the proximity of current carrying conductors or equipment installed on the bridge shall be bonded and solidly connected together via equipment ground conductors. Equipment ground conductors shall be provided in each conduit and flexible cable or cord.
4. For the flexible droop cable installation at the bridge, one conductor shall be utilized as the equipment ground and be bonded. The equipment ground conductors in all cables shall be bonded to the respective terminal boxes. In addition, bonding between the fixed and movable span shall be achieved by using an external visible bonding strap composed of welding cable in a location as shown on the plans or as approved by the Project Engineer.
5. Ground system conductors shall be continuous unspliced connections between terminal lugs. Paint, rust, and scale shall be removed over the contact area. All connections shall be made up as tightly as possible, and any bare metal or paint undercoat remaining exposed shall be spot painted to restore the surface with the same coating and number of coats as applied to the adjacent metal. Bolted connections shall be restricted to removable items (e.g., motors).
6. A minimum of two ground rods per pier, shall be installed to establish the bridge grounding system. Where lightning protection is required, the bridge ground system shall be connected to the lightning protection ground electrodes.
7. The utility service neutral conductor shall be grounded in accordance with the utility company's standard requirements.
8. Upon completion of installation of electrical grounding and bonding system's test ground resistance with ground resistance tester. Where tests show resistance-to-ground is over twenty-five (25) ohms, reduce

resistance to twenty-five (25) ohms or less, by installing additional grounding connections to the pier. The test shall be repeated to demonstrate compliance.

LL. Painting of Electrical Equipment

1. All new electrical equipment (unless otherwise noted), such as conduits, non-stainless boxes/enclosures, device enclosures, supporting clips and brackets, and other devices, shall be given two coats of paint as specified under the requirements for painting structural steel. Before applying the two coats, all surfaces shall be cleaned free of all grease, oil, dirt, and foreign material. Galvanized surfaced shall be etched with copper sulfate solution, after which two coats of paint shall be applied. In lieu of etching, the Contractor may use galvanizing primer as a first coat for galvanized surfaces followed by two coats of paint. The final coat of paint on equipment mounted on the steel work shall be of a color and type of paint to match the structural steel. The final coat of paint on equipment shall be of a color and type of paint to match the bridge.
2. Stainless steel enclosures, stainless steel conduit, liquid tight conduit, and fittings and die cast zinc limit switch enclosures shall not be field painted. These devices shall be adequately protected from all field-painting operations. Equipment not to be painted shall be carefully masked with polyethylene to prevent accidental paint coverage. If any coating material is applied to the surfaces indicated, as not to be painted, the paint shall be completely removed.

Method of Measurement:

Item 615504, BRIDGE ELECTRICAL SYSTEM, will not be measured.

Basis of Payment:

The work will be paid for at the contract bid price for lump sum for Item 615504, BRIDGE ELECTRICAL SYSTEM. This price shall include all labor, tools, equipment, material and incidentals necessary to satisfactorily complete the work in accordance with the Contract Plans and Special Provisions.

The lump sum bid for Item 615504 shall be the sum of the costs associated with the work performed. The completed Breakout Sheets must be submitted with Bid Proposal.

11/03/2023

615512 - BRIDGE SCUPPERS

DESCRIPTION:

This work consists of fabricating, providing, and installing new bridge scuppers and downspouts in the precast concrete end spans 1 and 3.

MATERIALS:

A. Scuppers	AASHTO M270 (ASTM A709) Grade 50
B. Downspouts	ASTM A53 Schedule 40 Black Seamless Steel Pipe
C. Bar Pipe Straps	ASTM A36
D. Threaded Inserts	Flared Thin Slab Ferrule Insert, Galvanized
E. Hot Dip Galvanized Zinc	ASTM A123
F. High Strength Fasteners:	
1. Bolts	ASTM F3125 Grade A325 Type 1
2. Hex Nuts	Section 1039.3
3. Galvanize	ASTM F2329

CONSTRUCTION METHODS:

A. Install proposed scuppers and downspouts as shown on the contract plans and in accordance with Section 615.

METHOD OF MEASUREMENT:

A. The Department will measure the quantity of bridge scuppers provided and acceptably installed per each.

BASIS OF PAYMENT:

A. The Department will pay for bridge scuppers at the contract unit price per each. Price and payment will constitute full compensation for providing and installing all materials and incidentals to complete the Work.

07/17/2023

617515 - HEADWALL

Description:

This work consists of providing and placing a concrete drainage headwall and check valve.

Materials:

A. GABC	Section 1005
B. Coarse Aggregate, Delaware No. 3 Stone	Section 1004
C. Reinforced Concrete Pipe	Section 1031
D. PCC, Class B	Section 1022
E. Bar Reinforcement	Section 1037
F. Borrow	Sections 209 and 1001
G. 18" Inline Check Valve	In accordance with the Plans

Construction:

- A. Submit shop drawings in accordance with Section 105.4, for the headwall and inline check valve at least 30 days before installation for review by the Department.
- B. Excavate for the headwall in accordance with Section 207.
 1. Remove unsuitable material as determined by the engineer and replace with approved bedding material.
- C. Place bedding material.
 1. Place DE No. 3 stone in accordance with Section 302.3 at the location and to the depth shown in the Plans.
 2. Place and compact GABC in accordance with Section 301.3 at the location and to the depth shown in the Plans.
- D. Place premanufactured concrete drainage headwall as shown on the Plans.
- E. Install 18-inch Inline Check Valve at headwall in accordance with the Plans.

Method of Measurement:

The Department will measure the quantity of headwalls per each placed and accepted.

Basis of Payment:

- A. The Department will pay for headwalls at the contract unit price per each. Price and payment will constitute full compensation for:
1. providing and placing materials;
 2. excavating within the template of the item;
 3. foundation preparation and compaction;
 4. removal and disposal of existing materials;
 5. installation of the check valve.
- B. The Department will pay for:
1. Excavation and embankment outside the template of the item in accordance with Section 207.
 2. Rock excavation in accordance with Section 207.
 3. Undercut excavation in accordance with Section 202.

11/07/23

626501 – THREE STRAND TUBE RAIL PARAPET

DESCRIPTION:

This work consists of fabricating, providing, and installing three strand tube rail parapets as shown on the Plans.

MATERIALS:

A. Anchor Bolts, Nuts and Washers:	
1. Anchor bolts	ASTM F1554 Grade 105 S1. Galvanize the full thread and 3-inch below.
2. Nuts, heavy hex	Section 1039.4
3. Flat washers	Section 1039.4
4. Galvanize	ASTM F2329
B. Structural Tubing for Rail Elements	ASTM A500 Grade C
C. Steel Posts	ASTM A769
D. Plates and Angles	ASTM A36
E. Steel Curb	AASHTO M270 (ASTM A709) Grade 50
F. Hot Dip Galvanized Zinc	ASTM A123
G. High Strength Fasteners:	
1. Bolts	ASTM F3125 Grade A325 Type 1
2. Nuts, heavy hex	Section 1039.3
3. Washers	Section 1039.3
4. Galvanize	ASTM F2329
H. Bolts, Nuts, and Washers for General Use	Section 1093.2
I. Reduced Weld Base Studs	Low Carbon Steel ASTM A29 Grade 1020
J. PCC Masonry, Superstructure, Class D	Section 1022
K. Bar Reinforcement, Epoxy Coated	AASHTO M31 (ASTM A615) Grade 60

CONSTRUCTION METHODS:

A. Submittals

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1. Prepare and submit Shop Drawings and Working Drawings for the tube railings in accordance with Section 105. Show all details of the railings and of the materials proposed for use. Obtain the engineer's approval before fabrication.

B. Fabrication

1. Completely fabricate each component of the railing system including all required holes.
2. Blast clean or grind all welds of the railing smooth and remove all weld splatter. Ensure all components are free of oil and any mill coating, burrs, pits, rust or other foreign matter or surface blemishes.
3. Hot-dip galvanize components after fabrication. Do not punch, drill, cut or weld steel railing components after galvanizing.

C. Packaging, Handling, and Storage

1. Handle, pack, ship, and store the materials in a manner that will not damage the component or the applied coating.
2. Store components at least 4 inches above the ground and surrounding surfaces by use of blocks, racks, or platforms. Wrap the components while stored to protect from corrosion or damage, and to keep free of all dirt, oil, grease, or other foreign matter. Wrapping will remain while the component is stored and will remain until the component is to be incorporated into the work.
3. Repair or replace damaged material, as directed by the engineer.

D. Installation

1. Clean all anchor bolts free of dirt, grease, oil, or other deleterious substances prior to roughening with a wire brush or other approved method. Once anchor bolts are clean, set all rail anchor plates and rail anchor bolts in accordance with the contract and approved shop drawings before casting the embedment concrete. Cast the embedment concrete where a concrete curb is shown on the Plans.
2. Where the rail parapet is mounted on a steel curb, install the plate washers and anchor bolts as shown on the Plans.
3. Install base plate, posts, and any required rail anchor assembly components. Bolt base plate in accordance with contract and tighten nuts by means of the turn of the nut installation method in accordance with Section 615. Attach metal rail and adjust railing as needed before bolting connections to ensure abutting joints match and align throughout the length of the rail. Provide a continuous railing system and splice at each rail joint as required by the contract plans.
4. After installation of the railing is complete, touch up exposed portions of the anchor bolt threads, and any portions of the nuts, washers, or railing components. Perform work in accordance with manufacturer's recommendations. Remove, discard, and replace any damaged area considered beyond repair as determined by the engineer.

METHOD OF MEASUREMENT:

- A. The Department will measure the Three Strand Tube Rail Parapet as the number of linear feet fabricated, placed, and accepted.
- B. The Department will measure:
 - 1. PCC Masonry, Superstructure, Class D in accordance with Section 610.
 - 2. Bar Reinforcement, Epoxy Coated in accordance with Section 611.
 - 3. Steel Curb in accordance with Section 615.

BASIS OF PAYMENT:

- A. The Department will pay for Three Strand Tube Rail Parapet at the contract unit price per linear foot.
- B. Price and payment will constitute full compensation for providing, fabricating, hauling, storing, and installing all materials, and for replacing any damaged components.
- C. The Department will pay for:
 - 1. PCC Masonry, Superstructure, Class D in accordance with Section 610.
 - 2. Bar Reinforcement, Epoxy Coated in accordance with Section 611.
 - 3. Steel Curb in accordance with Section 615.

07/25/2023

763501 - CONSTRUCTION ENGINEERING

763597 – UTILITY CONSTRUCTION ENGINEERING

DESCRIPTION:

- A. This work consists of construction lay out. Subsection 105.10 Construction Stakes, Lines and Grades will be replaced by this spec.
- B. The Department will only establish the following:
 - 1. Original and final cross-sections for borrow pits.
 - 2. Final cross-sections:
 - a. Top and bottom pay limit elevations for all excavation bid items that are not field measured by construction inspection personnel.
 - b. The contractor shall notify the engineer when these pay limit elevations are ready and allow for a minimum of two calendar days for the engineer to obtain the information.
 - 3. Line and grade for extra work added on to the project plans.
- C. When applicable, this work will also consists of providing construction and right-of-way/easement information to utility companies performing work (as defined in the Utility Statement) within the LOC.

MATERIALS:

Not applicable.

CONSTRUCTION METHODS:

- A. Equipment
 - 1. Use and provide written certification that the equipment/instrument has been calibrated and is within manufacturer's tolerance. The certification shall be dated a maximum of 9 months before the start of construction. Renew the certification a minimum of every 9 months. The equipment/instrument shall have a minimum measuring accuracy of [3mm+2ppmxD] and an angle accuracy of up to 2.0 arc seconds or 0.6 milligons.
 - 2. If the use of GPS technology in construction stakeout is chosen, provide the engineer with a GPS rover and automatic level for the duration of the contract. The GPS rover must be in good working condition and of similar make and model. Provide formal training on the GPS system being used to a maximum of 4, of the engineer's appointees. The formal training must be up to 8 hours or to the satisfaction of the engineer. At

the end of the contract, the engineer will return the GPS rover. If any of the equipment/instruments are found to be out of adjustment or inadequate to perform its function they shall be immediately replaced to the satisfaction of the engineer.

3. Choosing to use GPS technology does not give the authority to use machine control. Construction Engineering (GPS) Machine Control Grading shall only be used if noted in the contract outlining the available files that will be provided and "the Release for delivery of documents in electronic form to a contractor" are signed by all parties prior to delivery of any electronic files. Only files designated in the contract shall be provided. If machine control grading is allowed on the project, see the machine control section of this specification. GPS technology and machine control technology shall not be used in the construction of bridges.

B. Engineering/Survey Staff

1. Provide and have available an adequate engineering staff that is competent and experienced to set lines, grades, and compatibility with the scope of the project. Additionally, employ an engineer or surveyor, licensed in the State of Delaware, to be responsible for the quality and accuracy of the work done by the engineering staff. When individuals or firms other than the contractor perform any professional services under this item, that work shall not be subject to the subcontracting requirements of Subsection 108.1. Assume full responsibility for any errors and/or omissions in the work of the engineering staff.

C. Performance Requirements

1. Construction Engineering shall include establishing:
 - a. the survey points and survey centerlines;
 - b. finding, referencing, offsetting the project control points;
 - c. running a horizontal and vertical circuit to verify the precision of given control points.
2. Establishing plan coordinates and elevation marks for:
 - a. culverts
 - b. slopes
 - c. subbase
 - d. subsurface drains
 - e. paving
 - f. subgrade
 - g. retaining walls
 - h. any other stakes required for control lines and grades.
3. Setting vertical control elevations for:
 - a. footings
 - b. caps
 - c. bridge seats and deck screed.

4. Preserve the Department's project control points and benchmarks. Establish and preserve any temporary control points (traverse points or benchmarks) needed for construction. Any project control points (traverse points) or benchmarks conflicting with construction of the project shall be relocated. Replace any or all stakes that are destroyed at any time during the life of the contract as directed by the engineer. Re-establish centerline points and stationing prior to final cross-sections by the engineer. The vertical control error of closure shall not exceed 0.035 feet times. The horizontal control precision ratio shall have a minimum precision of 1:20,000 feet of distance traversed prior to adjustment.
5. Perform construction centerline layout of all roadways, ramps, connections, and driveways from project control points set by the engineer. Use the profiles and typical sections provided in the plans shall calculate proposed grades at the edge of pavement or verify information shown on the Grades and Geometric sheets.
6. Advise the engineer of any horizontal or vertical alignment revisions needed to establish smooth transitions to existing facilities. Immediately bring to the attention of the engineer any potential drainage problem within the project limits. The engineer must approve any proposed variation in profile, width, or cross slope.
7. Establish the working points at centerlines of bearings on bridge abutments and on piers, mark the location of anchor bolts to be installed, check the elevation of bearing surfaces before and after they are ground, and set anchor bolts at their exact elevation and alignment in accordance with the contract. Before completion of the fabrication of beams for bridge superstructures, verify the locations, both vertically and horizontally, of all bearings and assume full responsibility for fabricated beams fitting and bearing as constructed. After beam erection and concurrently with the Department project surveyors or their designated representative, survey top of beam elevations at a maximum of 10-foot stations and compute screed grades. Submit the beam elevations to the engineer for review and approval before the stay-in-place forms are set. Construction stakes and other reference control marks shall be set at intervals as established by the engineer to assure that all components of the structure are constructed in accordance with the lines and grades shown on the plans. Take full responsibility for all structure alignment control, grade control and all necessary calculations to establish and set these controls.
8. Investigate proposed construction for possible conflicts with existing and proposed utilities. Report any conflicts to the engineer for resolution.
9. Stake all sidewalk and curb ramp grades in accordance with the contract. Review the stakeout with the engineer prior to construction. The engineer must approve any deviation from the contract in writing.
10. Stake all drainage inlets in accordance with the contract. The offsets and top of grate elevations need to be calculated for each type of drainage inlet specified in the contract in order to line up the drainage inlet's flow line with the specified curb or ditch flow line as shown in the contract. The engineer must approve any deviations from the contract in writing.
11. If wetland areas are involved and specifically defined on the plans the following shall apply:

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- a. Do not enter, damage, or destroy wetland areas, which exist beyond the LOC. These provisions will be strictly enforced, and all personnel shall understand the importance of these provisions.
 - b. Delineate wetlands at the LOC throughout the entire project, before any clearing operations commence as shown on the plans to the satisfaction of the engineer.
 - c. Use orange vinyl flagging material with "Wetland Boundary" printed on the flagging. In wooded areas, tie the flagging on the trees, at approximate 20-foot intervals through wetland areas. In open field and yard areas that have been identified as wetlands, drive 6-foot posts into the ground at approximate 50-foot intervals and tie with the flagging. The flagging shall extend approximately 12-inches in length beyond the post. Use oak posts with cross sectional dimensions of 1 1/2-inches to 2-inches by 1 1/2-inches to 2-inches or 1/4-inch rebar.
 - d. If the flagging has been destroyed and the engineer determines that its use is still required, reflag the area. Flagging shall be replaced within 48 hours of notification that replacement is needed. After 48 hours the engineer may proceed to have the area reflagged.
 - e. Remove all posts and flagging at project acceptance.
 - f. Assume any responsibility for any damages to wetlands located beyond the LOC, which occurs from his/her operations during the life of the contract. Restore all temporarily disturbed wetland areas to their preconstruction conditions.
12. Whenever the engineer will be recording data for establishment of pay limits, the contractor will be invited to obtain the data jointly with the engineer's survey crew(s) in order to agree with the information. If the contractor's representative is not able to obtain the same data, then the information obtained by the engineer shall be considered the information to be used in computing the quantities in question.

D. Submittals

1. All computations, survey notes, electronic files, and other records necessary to accomplish the work shall be preserved and made available to the Department in a neat and organized manner at any time as directed by the engineer. The engineer may check all or any portion of the stakeout survey work or notes and any necessary correction to the work shall be made as soon as possible. Provide the engineer with such assistance as may be required for checking all lines, grades, and measurements necessary for the execution of the work. Checking by the engineer shall not relieve responsibility for the accuracy or completeness of the work. Copies of all notes must be provided to the engineer at the completion of the project.
2. Submit any of the following at the engineer's request:
 - a. Proposed method of recording information in field books to ensure clarity and adequacy.
 - b. A printout of horizontal control verification, as well as coordinates, differences, and error of closure for all reestablished or temporary control points.
 - c. A printout of vertical control verification, with benchmark location elevation and differences from plan elevation.

- d. Sketch of location of newly referenced horizontal control, with text printout of coordinates, method of reference and field notes associated with referencing control - traverse closure report.
- e. Description of newly established benchmarks with location, elevation, and closed loop survey field notes - bench closure report
- f. All updated electronic and manuscript survey records.
- g. Stakeout plan for each structure and culvert.
- h. Computations for buildups over beams, screed grades, and overhang form elevations.
- i. A report showing differences between supplied baseline coordinates and field obtained coordinates, including a list of preliminary input data.
- j. Any proposed plan alteration to rectify a construction stakeout error, including design calculations, narrative and sealed drawings.
- k. Baseline for each borrows pit location.
- l. Detailed sketch of proposed overhead ground mounted signs or signals showing obstructions that may interfere with their installation.
- m. Copies of cut sheets.

E. Machine Control Grading

- 1. Machine control grading to be used on the project if authorized by the engineer.
- 2. Use of this procedure and equipment is intended for grading the subgrade surface; it is not intended for the use in constructing final surface grades.
- 3. Materials:
 - a. Provide all equipment required to perform GPS machine control grading, including equipment needed by to verify the work to the engineer.
 - b. Use manufacturer's GPS machine control equipment and system to achieve the grading requirements in accordance with the contract.
- 4. Construction
 - a. Convert the electronic data provided by the Department into the format required for the equipment.
 - b. The Department will provide no additional electronic data.
 - c. Perform at least one 500 foot test section with the selected GPS system to demonstrate the capabilities, knowledge, equipment, and experience to properly operate the system and meet acceptable tolerances. The engineer will evaluate and make the determination as to whether additional 500 foot test sections are required. Failure to demonstrate this ability to the satisfaction of the engineer, construct the project using conventional surveying and staking methods.
 - d. DelDOT Responsibilities:
 - i. The Department will set initial vertical and horizontal control points in the field for the project as indicated in the contract.

- ii. The Department will provide the project specific localized coordinate system.
 - iii. The Department may provide data in an electronic format as indicated in the general notes.
 - (1.) The information provided shall not be considered a representation of actual conditions to be encountered during construction. Providing this information does not relieve the responsibility of making an investigation of conditions to be encountered. This includes site visits, and basing the bid on information obtained from these investigations, and the professional interpretations and judgments of the contractor.
 - (2.) The Department will develop and provide electronic data for use as part of the contract in the format as indicated in the general notes.
 - iv. The Department will provide the following electronic files:
 - (1.) ASCII data files with coordinates and elevations for proposed points as selected by the engineer.
 - (2.) Existing digital terrain model in .dtm file format compatible with software currently used by the Department.
 - (3.) Proposed digital terrain model in .dtm file format compatible with software currently used by the Department.
 - (4.) Design file in .dgn file format, that contains 3D features lines for the proposed design, 3D feature lines are for the proposed top surface elevation only.
 - v. The engineer will perform spot checks of the machine control grading results, surveying calculations, records, field procedures, and actual staking. If the work is not being performed in a manner that will assure accurate results, the engineer may order the work to be redone to the requirements of the contract. The engineer may also require the use of conventional surveying and staking.
- e. Contractor's responsibilities:
- i. No less than 2 weeks before the scheduled preconstruction meeting, submit to the engineer for review a written machine control grading work plan which shall include the equipment type, control software manufacturer and version, and proposed location of the local GPS base station used for broadcasting differential correction data to rover units.
 - ii. If the need to establish new control points, traverse from existing control points and verify to be accurate by conventional surveying techniques.
 - iii. Assume all risks and liabilities of any assumptions or manipulations marked from the electronic information provided or if chosen to develop a separate digital terrain model.
 - iv. Ensure that the electronic data provided will function in their machine control grading system.
 - v. Provide the engineer with a GPS rover and Automatic Level, for use during the duration of the contract. At the end of the contract, the GPS rover and Automatic Level will be returned. Provide a

total of 8 hours of formal training on the GPS machine control system to the engineer and up to three additional Department appointees per rover.

- vi. Review and apply the data provided by the Department to perform GPS machine control grading.
- vii. Convert the electronic data provided by the Department into a format compatible with their system.
- viii. At the beginning of each work day check and if necessary, recalibrate the GPS machine control system in accordance with the manufacturer's recommendations, or more frequently as needed to meet the requirements of the project.
- ix. Meet the accuracy requirements as detailed per the Department's standards.
- x. Establish secondary control points at appropriate intervals and at locations along the length of the project. These points shall be outside the project limits and/or where work is performed. These points shall not to exceed 1000 feet intervals. The horizontal position of these points shall be determined by conventional survey traverse and adjustments from the original baseline control points. The conventional traverse shall meet or exceed the Department's Standards. The elevation of these control points shall be established using differential leveling from the project benchmarks, forming a closed loop. A copy of all new control point information including closure report shall be provided and approved by the engineer prior to construction activities. Assume responsibility for all errors resulting from these efforts and correct deficiencies to the satisfaction of the engineer.
- xi. Provide stakes at all alignment control points, at every 500 foot stationing, and where required for coordination activities involving environmental agencies and utility companies.
- xii. Set hubs, at a minimum of 500 foot intervals, at the top of finished grade at all hinge points on the cross section on the main line and at least 4 cross sections on side roads and ramps as directed by the engineer or as shown on the plans. Placement of a minimum of 4 control points outside the limits of disturbance for the excavation of borrow pits, Stormwater Management Ponds, and wetland mitigation sites. These control points shall be established using conventional survey methods for use by the engineer to check the accuracy of the construction.
- xiii. Preserve all reference points and monuments that are identified and established by the engineer for the project.
- xiv. Provide control points and conventional grades stakes at critical points such as, PC's, PT's, superelevation points, and other critical points required for the construction of drainage and roadway structures.
- xv. Follow the guidelines set forth in the "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques" and follow a minimum of Second Order Class 1, (2-I) classification standards.
- xvi. Automated equipment operations have a high reliance on accurate control networks from which to take measurements, establish positions, and verify locations and features. Therefore, a strong

contract control network in the field which is the same or is strongly integrated with the project control used during the design of the contract is essential to the successful use of this technology with the proposed Digital Terrain Model (DTM). Consistent and well designed site calibration for all machine control operations are required to ensure the quality of the contract deliverables. The Contract Control Plan is intended to document which horizontal and vertical control will be held for these operations. Continued incorporation of the Base Station(s) as identified in the Contract Control Plan is essential to maintaining the integrity of positional locations and elevations of features. The Contract Control Plan shall be submitted to the Department for review and approval by the Departments Survey Section 3 weeks prior to the start of any machine control work. Operate and maintain all elements of the Machine Grade Control continuously once the operations begin until otherwise approved by the engineer.

5. Contract Control Plan:

- a. Develop and submit a Contract Control Plan for use of Machine Control Grading. Contract control includes all primary and secondary horizontal and vertical control which will be used for the construction contract. Upon the completion of the initial survey reconnaissance and control verification, but prior to beginning primary field operations, submit a Contract Control Plan document. The Contract Control plan shall be signed and sealed by a Delaware licensed Land Surveyor or Delaware Professional Engineer who oversees its preparation for acceptance by the engineer. The plan shall include the following:
 - i. A control network diagram of all existing horizontal and vertical control recovered in the field as contract control.
 - ii. Include a summary of the calculated closures of the existing control network, and which control has been determined to have been disturbed or out of tolerance from its original positioning.
 - iii. An explanation of which horizontal and vertical control points will be held for construction purposes. If necessary, include all adjustments which may have been made to achieve required closures.
 - iv. An explanation of what horizontal and vertical control (including base stations) was set to accomplish the required stakeout or automated machine operation. Include how the position of these new control points was determined.
 - v. Describe the proposed method and technique (technology and quality control) for utilizing the control to establish the existing and/or proposed feature location and to verify the completed feature location and/or measured quantity.
 - vi. A listing of the horizontal and vertical datums to be used and the combined factor to be used to account for ellipsoidal reduction factor and grid scale factor.
 - vii. If chosen to use machine control as a method of measuring and controlling excavation, fill, material

placement or grading operations as a method of measuring and controlling excavation, fill, material placement or grading operations, the Control Plan shall include the method by which the automated machine guidance system will initially be site calibrated to both the horizontal and vertical contract control, and shall describe the method and frequency of the calibration to ensure consistent positional results.

F. Utility construction methods:

1. The engineer must approve all requests for Utility Construction Engineering before the work begins.
2. Instruct utility companies to submit their requests to the engineer. The engineer will decide if the requested work meets the criteria for Utility Construction Engineering or is normal Construction Engineering and pass the requests along with the decision.
3. The survey crew size shall be adequate to efficiently perform the work required and must be approved by the engineer.
4. Work covered under Utility Construction Engineering will fall into two categories:
 - a. Engineering/surveying work that is not necessary for construction of the project, staking the clear zone line, providing cut/fill grades at proposed utility pole locations, staking back of drainage structures, and staking right-of-way lines where construction of the project (exclusive of utilities) is within the right-of-way.
 - b. Engineering/surveying work that is necessary for construction but must be provided for utility companies well in advance of the need and will likely need to be redone later, as determined by the engineer. This can be any of the Construction Engineering work that when done early cannot be expected to remain undisturbed until needed for construction of the project (non-utility).

METHOD OF MEASUREMENT:

- A. The Department will not measure construction engineering.
- B. The Department will measure the quantity of utility construction engineering as the actual number of hours the survey crew is in the field actively engaged in utility construction engineering work.

BASIS OF PAYMENT:

- A. The Department will pay the lump sum unit bid price for this work. Price and payment constitute full compensation for:
 1. the work associated with construction engineering;
 2. providing all equipment and instruments;
 3. providing and placing stakes;
 4. flagging and any reflagging;
 5. reconstruction of work;
 6. all costs related to the development of separate digital terrain model;

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7. reestablishing reference points; and
 8. wetland restoration.
- B. The Department will pay for utility construction engineering at the contract unit price per hour actively engaged in performing the work. Price and payment will constitute full compensation for:
1. Office work;
 2. providing all labor;
 3. equipment;
 4. instruments;
 5. stakes; and
 6. other materials necessary to complete the work.
- C. The Department will make monthly payment in proportion to the amount of work done as determined by the engineer.
- D. The Department will not make any adjustment in payment for any issues with equipment to operate the GPS machine control system for any construction items or be justification for granting contract time extension.
- E. The Department will not make any consideration for any extension of contract time or additional compensation due to delays, corrective work, or additional work that may result from faulty and erroneous construction stakeout, surveying, and engineering required.
- F. The Department will not make any adjustments for all liability, costs, or delays if the contractor chooses to develop a separate digital terrain model.

4/20/21

763503 - TRAINEE

DESCRIPTION:

The work will consist of providing training in the construction crafts in accordance with the requirements stated in the General Notices of this proposal under the Standard Federal Equal Employment Opportunity Construction Contract Specifications (Executive Order 11246).

METHOD OF MEASUREMENT:

The quantity of trainee hours will be measured as the actual number of hours the trainee is actively engaged in construction activities.

BASIS OF PAYMENT:

The Department will pay for trainee at a fixed rate of \$0.80 per hour toward the hourly rate.

763511 - MAINTENANCE BUILDING

DESCRIPTION:

This work consists of constructing a new Administration Building as indicated in the Contract Drawings and in accordance with Appendix A - Technical Specifications.

MATERIALS AND CONSTRUCTION:

All materials and construction shall conform to the requirements of the Contract Drawings and in accordance with Appendix A - Technical Specifications.

MANDATORY PRE-BID MEETING:

All bidders must be represented at the Mandatory Pre-Bid Meeting(s) for this contract. The meeting information is provided on the first page of this contract (page i). The bidder's representative must sign-in and identify the name of the bidder they represent.

Failure to sign-in with the bidder's company name at the Mandatory Pre-Bid Meeting will result in the bidder being found non-responsible and non-responsive, and their bid will be rejected.

METHOD OF MEASUREMENT:

This item will be made on a lump sum basis wherein no measurement will be made.

BASIS OF PAYMENT:

The Department will pay for this item on a contract unit price per lump sum bid. Price and payment will constitute full compensation for

1. Providing and placing materials;
2. for all labor, tools, equipment, hardware, and necessary incidentals to complete the work;
3. provide a complete, working and usable facility acceptable to the Engineer.

8/10/2021

763520 - ELECTRONIC TICKETING

Description:

This work consists of providing electronic data for material weight tickets delivered to the project. This work also consists of placing an identifying vehicle number on the driver side and the passenger or rear sides of the delivery vehicle. This does not preclude or dismiss any requirement for paper tickets required by the Standard Specifications or other rules and regulations.

General Requirements:

- A. Send electronic tickets (eTicket) to the Department's Electronic Ticketing Portal <https://tickets.deldot.gov> as they are generated. The Department will reject any load that does not have a corresponding eTicket unless the cause is beyond the contractor's control. In such circumstances paper tickets may be permitted at the discretion of the engineer.
- B. Payment for material weight delivered to the project will be based upon the eTickets marked "*Delivered*", less waste, excess material weight as noted in 105.12 of the Standard Specifications, and any audit corrections.
- C. Do not reissue or reprint tickets that have been marked "*Delivered*" or "*Rejected*" without first notifying the engineer. The engineer may reject a reissued or reprinted ticket at their discretion. When a reissued or reprinted ticket is rejected, payment will be based upon the original ticket.

Data Integration:

Request a list of the Department's naming nomenclature. Include in the request an identification of what system the supplier utilizes for its load read-out weighing system. If necessary, create an Application Programming Interface (API) to integrate with the Department's eTicketing Portal. Utilize the API to provide electronic data from the load read-out weighing system at the material source that is readable by the Department's eTicketing Portal. Update the load read-out weighing system and API as necessary to maintain connection the Department's eTicketing Portal.

The data shall be provided as follows:

Reference Field No.	Description	Examples	Data Type	Required
1	Ticket Number	5126349, 101R, 539-19	String	Yes
2	Contract Number	T202011001	String	Yes

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3	Contract Name (Job)	Walnut Street Streetscape Improvements	String	Yes
4	Contractor Name (Customer)	Mumford & Miller, Inc.; A Del Construction	String	Yes
5	Supplier Name	River Asphalt; Allan Myers Materials	String	Yes
6	Supplier Plant	Plant #1 Dagsboro; Dover Asphalt	String	Yes
7	Job Number (Location)	Task 1; Location 5	String	Yes
8	Weigh Master Name	Johnny Scales	String	Yes
9	Weigh Master ID	1234567	String	Yes
10	Left Intentionally Blank			No
11	Mix Design ID (Product)	1628p; AM-WILM-29 76-22	String	Yes
12	Material Type (Product Description)	9.5mm top; 19MM 76-22 NON CARB	String	Yes
13	Item No. (Product Code)	401005; 401016	String	Yes
14	Load Number	75	Number	Yes
15	Identifying Vehicle Number	T-1	String	Yes
16	Hauler	John Doe Trucking	String	Yes
17	Legal Gross Vehicle Weight	73,280	Number	Yes
18	Loading Date & Time	2020-06-15T13:45:30	String	Yes
19	Gross Weight	72,980	Number	Yes
20	Net Weight	27,900	Number	Yes
21	Truck Tare Weight	45,080	Number	Yes
22	Void	280	Number	No
23	Daily Running Total	44.43	Number	Yes

All provided weights shall be accurate to 0.01 tons.

Loads which do not have the required data shall be rejected.

Setup and Calibration:

Conduct a test of each supplier's integration with the Department's eTicketing Portal prior to shipping material. Complete test at least 14 days prior to shipping material unless otherwise approved by the engineer. The test must involve at least four calibration eTickets from each supplier approved for use on the project. The calibration eTickets must accurately reflect the categories 1-7 shown above; all other categories shall be marked "TEST". After the engineer confirms the calibration eTickets have been entered into the Department's eTicket Portal, void the eTickets with the reason "Calibration Testing".

Uptime:

Uptime reliability of the material supplier's ticketing system must be 99.5% over any 30-day rolling period. Uptime is defined as the ability for the Department to receive electronic tickets within a maximum of 10 minutes from when the ticket was created.

Load Identification:

Ensure the identifying vehicle numbers on the delivery vehicle correspond to the ticket. Place the numbers on the delivery vehicles such that at least one can be safely read from within the work area. Delivery vehicles without identifying vehicle numbers shall be rejected.

Method of Measurement:

The Department will not measure electronic ticketing.

Basis of Payment:

- A. The cost associated with creating and maintaining an API, providing electronic ticketing data, and placing identifying vehicle numbers on the delivery vehicles is incidental to the item being placed.
- B. The Department will make no payment for material that is rejected.

01/18/2022

763522 - COAST GUARD SPECIFIC CONDITIONS

DESCRIPTION:

This work consists of coordination with Coast Guard specification on all tidal waterways.

CONSTRUCTION METHODS:

- A. Prepare and provide three copies of a plan and schedule for operations within the waterway, for submission to Commander (AOWB), 5th Coast Guard District, 431 Crawford St., Portsmouth, VA 23704 for approval. Comply with all provisions of the Inland Rules of the Road. Give written notice to the Coast Guard of any planned temporary obstruction to the waterway navigation as well as copies of the plan and schedule of operations at least 30 days in advance of the work.
- B. The plan and schedule of operations within the waterway shall include:
 - 1. A sketch of the waterway indicating:
 - a. Locations of all restrictions that will be placed in the waterway, such as barges, anchors and anchor lines, turbidity curtains, cofferdams and sheeting, etc.
 - b. The location and height above high mean water of any scaffolding or netting.
 - 2. A projected set of dates and length of time each operation will take, hours of each operation and whether or not the equipment will be removed at night.
 - 3. Should the contractor's proposed work require that the channel, or a portion of the channel, be closed to vessel navigation, the plan should specify the length of the requested closure, the work activities to be performed and the proximity to previous or future closures. These work activities may include demolition and removal of the existing bridge, pile removal and installation, pier construction, installation of the bascule leaf, etc. The anticipated maximum closure period is 14 calendar days, subject to the approval of the USCG. The requested date of each closure period may not be within 14 days of any other closure.
 - 4. Contractor is responsible for requesting and receiving approval for all temporary deviations from the normal bridge operation schedule from the USCG.
- C. In the event of any material, machinery or equipment lost, dumped, thrown overboard, sunk or misplaced during work give immediate notice to the Coast Guard and the Department. The notice shall give a description, location, and actions taken to remove and preserve navigation. Properly mark the objects, to preserve navigation, until approval has been given.

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- D. Provide and install temporary obstruction lights as required by operation and permanent construction under the contract. Each temporary light shall consist of battery or power operated slow flashing amber light less than 60 flashes per minutes and visible for a range of 4 nautical miles on 90% of the nights of the year. Install lights on the upstream and downstream if necessary to obtain the coverage required. Mark all bridge piers until construction has been completed and permanent navigational lights have been installed and accepted. Provide four copies of plans showing the proposed temporary lights during construction to the Department for approval before work is commenced. Deviations from the prescribed temporary lights during periods of construction will be permitted only upon written Coast Guard approval.
- E. Maintain the temporary obstruction lights on permanent construction until permanent navigational lights have been installed and made operable in accordance with the Coast Guard requirements.
- F. The Federal government and the Department assume no responsibility for any damage sustained or caused by the contractor's plant, equipment or barges being anchored or moored at the aforementioned location. Approval by either agency shall not act as a waiver of liability for any damage that may result from the contractor's operation.

METHOD OF MEASUREMENT:

The Department will not measure Coast Guard Specific Conditions.

BASIS OF PAYMENT:

The Department will pay for Coast Guard Specific Conditions at the contract lump sum price. Price and payment will constitute full compensation for:

1. Preparing and providing plan and schedule of operations;
2. Properly marking objects;
3. Coast Guard commandant specifications;
4. Providing a temporary navigational lighting plan;
5. Maintenance and removal of temporary obstruction lights;

The Department will pay for the cost for providing and installing permanent navigational lighting in accordance with Item 615504– BRIDGE ELECTRICAL SYSTEM.

Department reserves the right to recover any costs for failures in compliance with any requirements requiring the Federal government to take action for the protection of navigation.

07/25/2023

763525 – ROAD USER COST

Description:

Road User Cost shall be assessed to compensate failure to open the project to unrestricted highway traffic on time in accordance with the contract's General Description.

Method of Measurement:

The Department will not measure Road User Cost.

Basis of Payment:

The assessment will be determined by the Road User Cost documentation in the General Description of the Contract.

8/3/23

763537 – INTEGRAL FENDER SYSTEM

DESCRIPTION:

This work consists of constructing a pier-mounted energy absorbing fender system as shown on the Plans.

MATERIALS:

- A. Reinforced Thermoplastic Structural Shapes (RTSS) for the wales, consisting of a thermoplastic matrix reinforced with chopped fiberglass filaments and continuous fiberglass reinforced polymer reinforcing bars, of the type, size and material properties herein and in the Plans.
- B. Thermoplastic Structural Shapes (TSS) for the spacer blocks and clearance gauge supports, consisting of a thermoplastic matrix reinforced with chopped fiberglass filaments of the type, size and material properties herein and in the Plans.
- C. Energy absorbing elastomeric arch fenders consisting of natural rubber, synthetic based rubber, or a blend of the material properties, type, size, rated energy and rated performance herein and in the Plans.
 - 1. Type 316 stainless steel hardware to splice, fasten, connect and anchor fender system components, of the details, type and size shown in the Plans.
- D. Qualifications:
 - 1. Provide documented experience for the manufacturers of the Reinforced Thermoplastic Structural Shapes (RTSS) and Thermoplastic Structural Shapes (TSS) materials and the energy absorbing elastomeric arch fenders manufacturing these materials, including a minimum of 5 projects in the last 5 years using similar materials in a similar marine fender application. Submit a list of project names, locations, owners, with contact information to the engineer to demonstrate this experience.
- E. RTSS and TSS manufacturing requirements:
 - 1. Use polyethylene made from recycled post-consumer or post-industrial thermoplastics with a minimum of 15 percent (by weight) chopped fiberglass filament reinforcement, with a black outer skin and black core color.
 - 2. For RTSS material only, at the discretion of each manufacturer, different matrix materials may be used for the skin and core, provided both materials meet the requirements in Table 1. Matrix material within 1-inch from the reinforcing bar surface shall not contain voids greater than 3/4-

inch diameter and 2-inches in length. Matrix cross section shall not contain voids exceeding 1-1/4-inches in diameter and the sum of all voids greater than 3/8-inches in diameter shall not exceed 5 percent of the cross-sectional area.

3. Mix polyethylene with the appropriate colorants, UV inhibitors, and antioxidants, as required to meet the properties and requirements listed in Tables 1 and 4.
4. Extrude material as one continuous piece with no joints or splices to the dimensions and tolerances in accordance with Table 5.
5. Manufacture the material with a seamless and smooth outer skin. Minor manufacturing imperfections may be acceptable, provided they do not negatively affect performance. Submit documentation to the engineer of any intended manufacturing imperfections for approval.
6. Components shall be continuous, except at splice locations shown in the Plans.
7. Recess all attachment hardware.
8. Fiberglass bar reinforcement for the RTSS components shall consist of solid, round, thermoset basalt fiber reinforced polymer (BFRP) or glass fiber reinforced polymer (GFRP) bars with vinyl ester or epoxy resin, with properties and requirements in Table 2. The coefficient of variation (COV) for each of the specified test results shall be less than 6 percent. Outliers shall be subject to further investigation per ASTM E178. If the COV exceeds 6 percent, the number of test specimens per production LOT may be doubled, a maximum of two times, to meet the COV requirement. Otherwise, the results shall be rejected.
9. Physical and mechanical properties shall meet the requirements specified in Tables 1 thru 5. Submit to the engineer a certificate of analysis for each production LOT from the producer, confirming compliance with the requirements. Qualification testing shall be conducted by an independent laboratory approved by the engineer. A production LOT is defined as an amount of material produced from start to finish with the same constituent materials used in the same proportions without changing any production parameter.

Table 1 - RTSS Matrix Properties		
Property	Test Method	Requirement
Density	ASTM D792	48-63 pcf
Water Absorption	ASTM D570	2 hrs.: < 1.0 % weight increase 24 hrs.: < 3.0 % weight increase

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Brittleness	ASTM D746	Brittleness Temperature < -40°C
Impact Resistance	ASTM D256, Method A - Izod	> 0.55 ft-lbs./in.
Hardness	ASTM D2240	44-75 (Shore D)
Ultraviolet	ASTM D4329 UVA	500 hours < 10% Change in Shore D Durometer Hardness
Abrasion	ASTM D4060	Weight Loss: < 0.02 oz. Cycles = 10,000 Wheel = CS17 Load = 2.2 lbs.
Chemical Resistance	ASTM D756	Sea Water: < 1.5% weight increase Gasoline: < 9.5% weight increase No. 2 Diesel: < 6.0% weight increase
Tensile Properties	ASTM D638	2,200 psi at break (min.)
Compressive Modulus	ASTM D695	40,000 psi (min.)
Friction Coefficient (Static)	ASTM D1894	0.25 (wet, max.)
Fastener Withdrawal	ASTM D6117	Screw: 400 lbs. (min.)

Table 2 - Fiberglass Reinforcing Properties

Property	Test Method	Requirement	Specimens per LOT
Fiber Mass Fraction	ASTM D2584 or ASTM D3171	≥70%	5
Short-Term Moisture Absorption	ASTM D570 Procedure 7.1 24 hrs. at 122°F	≤0.25%	5
Long-Term Moisture Absorption	ASTM D570 Procedure 7.4 Immersion to full saturation at 122°F	≤1.0%	5
Glass Transition Temperature (T _g)	ASTM D7028 (DMA) or ASTM E1356 (DSC; T _m) /ASTM D3418 (DSC; T _{mg})	≥230°F ≥212°F	3

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Total Enthalpy of Polymerization (Resin)	ASTM E2160	Identify resin system and report average value of three replicates	--
Degree of Cure	ASTM E2160	≥95% of Total polymerization enthalpy	3
Cross-Sectional Area	ASTM D7205 1-1/4" dia. (#10) bar	1.154 to 1.385 in ²	10
Guaranteed Tensile Strength		98.2 kips	
Tensile Modulus		≥6,500 ksi	
Alkali Resistance with Load	ASTM D7705; Procedure B with sustained load of 30% guaranteed tensile strength for 3 months followed by tensile strength test per ASTM D7205	≥ 70% guaranteed tensile strength	5
Transverse Shear Strength	ASTM D7617	>22 ksi	5
Horizontal Shear Strength	ASTM D4475	>5.5 ksi	5

Table 3 - Wale Flexural Strength Properties

Property	Test Method	Requirement
Max Stress in Bending	ASTM D6109 (*)	per Plans (min.)
Bending Stiffness, EI	ASTM D6109 (*)	Per Plans (+/- 10%)
Ultimate Bending Moment	ASTM D6109 (*)	per Plans (min.)
(*) ASTM D6109 modified to single point loading.		

Table 4 - TSS Matrix Properties

Property	Test Method	Requirement
Density	ASTM D792	50-65 pcf
Impact Resistance	ASTM D256, Method A - Izod	> 0.55 ft-lbs./in.
Hardness	ASTM D2240	44-75 (Shore D)
Ultraviolet	ASTM D4329 UVA	500 hours < 10% Change in Shore D Durometer Hardness

Chemical Resistance	ASTM D756 or ASTM D543	Sea Water: < 1.5% weight increase Gasoline: < 9.5% weight increase No. 2 Diesel: < 6.0% weight increase
Tensile Properties	ASTM D638	3,000 psi at break (min.)
Friction Coefficient (Static)	ASTM D2394	0.25 (wet or dry, min.)
Water Absorption	ASTM D570	2 hrs.: < 1.0 % weight increase 24 hrs.: < 3.0 % weight increase
Secant Modulus at 1% Strain	ASTM D6109	150,000 psi (min)
Flexural Strength	ASTM D6109	2,500 psi (min)
Compressive Strength	ASTM D6108	2,200 psi (min)
Compressive Strength Perpendicular to Grain	ASTM D6108	700 psi (min)
Fastener Withdrawal	ASTM D6117	Nail: 250 lbs. (min.) Screw: 400 lbs. (min.)
Coefficient of Thermal Expansion	ASTM D6341	0.000028 in/in/°F (max)

Table 5 – RTSS and TSS Dimensions & Tolerances		
	Dimension	Tolerance
Length	Per order	± 1.0”
Width	9.875 inches	+/- 0.375 inches
Height	9.875 inches	+/- 0.375 inches
Corner radius	1.375 inches	+/- 0.500 inches
Outer Skin Thickness	0.1875 inches	+/- 0.125 inches
Distance from outer surface to rebar center	0.75 inches	+/- 0.500 inches
Straightness (gap, bend or bulge inside while lying on a flat surface)		<1.5 inches per 10 feet of length

F. Energy Absorbing Elastomeric (Rubber) Arch Fenders:

1. Provide energy absorbing elastomeric arch fenders meeting the requirements of the contract.

Arch fenders of similar geometry and/or different manufacturer may be used, provided that the alternative includes published product data based on testing protocols that meet the requirements of the “2002 PIANC Guidelines for the Design of Fender Systems, Appendix A, Procedure to Determine and Report the Performance of Marine Fenders”, published by the International Navigation Association.

2. All supplied arch fenders shall be compressed to its rated deflection limit at least once prior to shipment, to verify performance. Provide this compliance verification to the engineer.
3. The elastomer for the proposed arch fenders shall consist of vulcanized natural or synthetic based rubber or a blend thereof; include carbon black; be resistant to aging, seawater, abrasion, ultraviolet rays; be homogenous in quality and free from foreign materials, bubbles, tears, cracks, and other harmful defects.
4. Do not use recycled, regenerated, or off-specification rubber to manufacture the arch fenders. Submit a manufacturer’s certificate of conformance to the engineer, stating the rubber meets this requirement.
5. Provide hardware for mounting arch fenders to the concrete consisting of Type 316 stainless steel and of a female socket type configuration.
6. Internal steel reinforcing plates for mounting shall be fully encapsulated within the rubber body, such that no steel is exposed, except where female bolting nuts are present, and shall be bonded through vulcanization.
7. Conduct performance testing on all arch fenders in accordance with “PIANC Fender Performance Testing Guidelines” under loading that achieves the design deflection limit, with no correction for velocity, angle, and temperature. Record and compare results to the published load-deflection curve. Apply loading toward the top face at a constant velocity to compress the arch fender and cycle the load a total of three times, from zero to the designed deflection limit and back to zero. After the arch fender rests for a minimum of one-hour, perform a fourth loading-cycle. Use the results of the fourth loading-cycle evaluate the performance. Record the ambient temperature at the time of the tests. Testing results shall match the published load-deflection relationship within +/-10 percent without observed damage. If velocity correction is required for interpretation of performance data, then the application of the correction factor must be demonstrated during the submittal stage of the project. The velocity correction factor must be clearly stated and remain unwavering.
8. Conduct material testing, performed by independent third-party testing laboratory, on rubber samples, measuring approximately 50-grams in size, from two of the arch fenders, selected at

random. Take samples from rubber prepared in the quality control process under the same production conditions.

9. Verify dimensions of each arch fender.
10. Physical and mechanical properties shall meet the requirements specified in Tables 6 and 7.

Table 6 - Rubber Composition		
Property	Test Method	Requirement
Density	ISO 2781	1.20 g/cc (max.)
Polymer (Rubber)	ASTM D6370	45% (min.)
Carbon Black	ASTM D6370	20% (min.)
Ash Content	ASTM D297	5% (max.)
Rubber Filler Ratio = Polymer % / (Ash Content % + Carbon Black Content %)	--	> 1:2

Table 7 - Rubber Properties			
Property		Test Method	Requirement
Before Aging	Hardness	ASTM D2240 Shore A	78° Shore A (max.)
	Tensile Strength	ASTM D412 Die C	2320 psi (min.)
	Ultimate Elongation		350% (min.)
After Aging	Change in Hardness	ASTM D573 96 hrs. @ 70°C	+8° Shore A (max.)
	Change in Tensile Strength		-20% (max.)
	Change in Ultimate Elongation		-70% (max.)
Compression Set		ASTM D395 Method B 22 hours at 70°C	30% (max.)
Bond Strength		ASTM D429 (Rubber to Steel)	7 N/mm (min.)

Ozone Resistance	ASTM D1149	No visible cracks
Dynamic Fatigue	ASTM D430 Method B (15,000 Cycles) Grade 0: no cracks Grade 1: < 10 cracks, < 0.5mm long Grades 2 thru 10: increasing crack size	Grades 0 or 1 (pass) Grades 2 thru 10 (fail)
Abrasion Resistance	BS 903.A9 Method B - 1000 rev	Volume Loss <1500 mm ³
Tear Resistance	ASTM D624 Die B	4,800 lbs/ft (min.)

CONSTRUCTION METHODS:

A. Shop Drawings:

1. Prepare and submit shop drawings of the fender system together with product data sheets, test reports with performance data, and material certifications that demonstrate that the materials meet the specified requirements.

B. RTSS and TSS:

1. Field verify all concrete dimensions, elevations and mounting conditions required for installation prior to cutting wale materials to size. Report any discrepancies from Plan dimensions to the engineer and propose dimensional adjustments for review and approval, prior to making corrections.
2. Cut, bevel, drill, countersink RTSS and TSS material in accordance with the manufacturer's recommendations.
3. Set and align all material to lines and grades in the Plans, such that it is plumb, true and achieves accurate fit-up at connections. Securely attach all materials to concrete substrate and securely connect mating components.

C. Storage, Handling and Installation:

1. Store, handle and install materials in accordance with the manufacturer's published procedures.
2. Protect materials at all times during storage, handling, transportation and installation from damage. Protect materials from exposure to the environment including extreme heat. Lift, handle and support materials in a manner that will avoid damage. Support and secure on dunnage above ground in a manner that avoids excessive deflection and such that the material

may be conveniently inspected. Handle and lift materials using nylon slings or other devices without sharp edges.

D. Identification

Label each component with unique identifier consistent with the shop drawings, material certifications, test records, and reports in order to facilitate traceability and properly locate on the bridge.

E. Installation Guidance

Prepare and submit to the engineer recommendations for installation of the RTSS and TSS materials including instructions on cutting, drilling, patching, protection, handling, and storage of these materials.

METHOD OF MEASUREMENT:

The Department will not measure integral fender system.

BASIS OF PAYMENT:

A. The Department will pay for the complete integral fender system at the contract lump sum price.

Price and payment will constitute full compensation for:

1. Providing and placing all materials;
2. RTSS wales;
3. TSS spacer blocks and clearance gauge sign and supports;
4. energy absorbing elastomeric arch fenders;
5. stainless steel anchors, fastening and connection hardware;
6. shop drawing preparation;
7. manufacturing, testing and documentation;
8. submission of manufacturing imperfections for approval;
9. transportation, storage, and installation;
10. collection, removal and disposal of unused materials, debris and waste;
11. All other incidentals required to complete the Work.

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- B. The Department will make no additional payments for any rejected, miscut, or mis-drilled materials in need of replacement. Materials exhibiting discoloration, deterioration, cracks, splits, scratches, gouges and or other deficiencies, as determined by the engineer, will be rejected.
- C. Supporting piles, reinforced concrete substrate, and navigation lighting will be paid for with other items in the contract.

08/23/2023

763599 - FIELD OFFICE, SPECIAL II

Description:

This work consists of providing, erecting, equipping, maintaining, and removing modular offices and adjacent parking areas. These field office units may be situated in different locations. Each field office and parking area are for the exclusive use for Department personnel, engineers, designers, consultants, and inspectors.

Materials:

- A. Each modular office and adjacent parking lot must meet the requirements in Table 1, Table 2, Table 3 and as described below:
1. Weatherproof construction; tightly floored and roofed with air space above the ceiling for ventilation; and fully skirted with rigid, watertight covering overlapping the bottom of the exterior siding to the existing ground.
 2. Supported above the ground and safely secured to its support if the support is an in-ground anchored foundation or by tie-downs to the ground.
 3. Contain interior and exterior paneling, lighting, and plumbing fixtures.
 4. Provide suitable indoor toilet facilities in accordance with the requirements of state and local Boards of Health, or of other bodies or courts having jurisdiction in the area.
 5. Connect to the local water and sanitary lines. If public utilities are not available, utilize freshwater and wastewater holding tanks to provide with running water.
 6. Provide an adequate positive locking system on the inside of the restroom doorway to ensure privacy.
 7. When separate facilities for men and women are not available or required, place a sign with the wording "Rest Room" (letter height 1-inch minimum) over the doorway.
 8. Equip with heating and cooling capabilities to provide comfortable working conditions; this includes an exhaust fan, heating equipment, and air conditioning connected to an operational power source.
 9. Provide electrical, water, fuel, or other utility necessary to fully power HVAC equipment. If electrical service is not readily available from the utility provider, provide and maintain a temporary generator (including fuel) until power can be established.
 10. Perform or arrange all necessary utility connections and/or their maintenance.
 11. Provide maintenance of the heating, exhaust fan, and air conditioning equipment by validated service contracts for the length of the contract.
 12. Provide maintenance of the potable water supply equipment, refrigerator, and microwave by validated service contracts for the length of the contract. Service contracts must allow a Department-authorized individual to deal directly with the service organization to request repair or maintenance.
 13. Provide and maintain the interior with new furnishings. All furnishings must be approved by the engineer prior to installation in the modular field office. Office furnishings remain the property of the Contractor at the conclusion of the Project. Place the following furnishings as directed by the engineer:

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- a. 12 folding chairs;
 - b. 1 large conference table for a minimum of 12 people;
 - c. 2 trash cans with lids and new plastic liners at each disposal interval – 1, 30+ gallons, 1, 10+ gallons;
 - d. 2 dry erase boards a minimum of 4-foot x 3-foot each with markers and erasers;
 - e. 1 floor mat at each entrance;
 - f. 1 long-handled large-size broom with synthetic bristles and dustpan;
 - g. 2 rough plan racks;
 - h. 2 legal size filing cabinets with 4 drawers;
 - i. 1 legal size fire-resistant filing cabinet with lock and key with 4 drawers and meeting underwriters' approval for not less than one hour test.
14. Provide and maintain the following office equipment for each modular field office; engineer must approve the equipment prior to installation in the field office. Deliver the equipment in new and working condition:
- a. 2 all-in-one print/copy/scan/fax machine capable of producing 35-pages per minute, double-sided, on 8 1/2-inch x 11-inch and 11-inch x 17-inch paper. Machine must be wireless capable and network capable and be able to print/copy/scan in color and in black and white;
 - b. 2 combination electrical surge, spike, and noise protection devices.
15. Provide all consumables required for the office equipment and furnishings for the length of the contract. These consumables must be provided on request and include paper, tape, toner/printer ink, cleaning kits, and batteries. Provide maintenance of all office equipment by a validated service contract for the length of the contract. Service contracts must allow a Department-authorized individual to deal directly with the service organization to request repair.
16. Provide an alarm system in each field office for security with electronic, direct connection to a security service provider. The security systems shall have interior motion, window, and entrance detectors and built in manual fire alarms. The Contractor shall provide validated monitoring and service contracts for the length of the Contract for each field office. These contracts shall allow a Department authorized project person to deal directly with the security service provider to request service and/or repair.
17. Provide and maintain a new telephone equipment system meeting the following requirements:
- a. 3 lines with a call forward busy feature with 1 line being dedicated to communication with the general public;
 - b. 1 telephone answering machine having all-digital recording, 14-minute message capacity, selectable message time, voice prompt assistance, day/time stamp, call screening, two-digit LED message indicator, toll saver, power failure memory back-up, and message interrupt from any station;
 - c. Locate telephone lines as directed by the engineer;
 - d. Allow a Department-authorized project person to deal directly with the telephone company to report outages and/or request repair;
 - e. Install and perform initial setup of the specified telephone system. Initial installation and setup costs shall be the responsibility of the Contractor. All subsequent monthly billings, after initial installation and setup, for each field office telephone system shall be received and paid by the Contractor. A copy of each of these subsequent bills shall be forwarded to the Project Resident for reimbursement on the contract pay estimate and the reimbursement will be for the amount of the bill only and shall not include any additional mark-up or profit.
- B. Construct a field office parking lot for each modular field office in accordance with all applicable city, county, state, and federal codes.
1. The parking area and entrance pathways shall be a minimum of 6-inch graded aggregate subbase.

2. Provide a stabilized construction entrance in accordance with Section 908 adjacent to the parking area within 25-feet of the water service connection.
- C. Construct a stair and deck platform at each exterior door with hand and safety rails designed to last the life of the contract. Rails must conform to the requirements of the Architectural Accessibility Board and other federal, state, and local boards, bodies, and/or courts having jurisdiction in the contract limits.
- D. Maintenance of the modular field office and its adjacent parking area includes the following:
 1. Remove snow and/or ice from the parking area and from the entrance pathways to the field office within 12-hours of each occurrence.
 2. Maintain and replace all provided items, furnishings, and equipment.
 3. Provide bottled water and drinking cups for the water cooler.
 4. Provide lavatory supplies, trash bags, and janitorial supplies.
 5. Provide replacement items for all lighting fixtures.
 6. Maintain all utilities including telephone system.
 7. Provide janitorial and waste disposal services twice a week.
 8. Clean up trash and debris from the parking lot once a week.
 9. Maintain the facilities in clean and good working condition; keep rest room stocked with adequate lavatory and sanitary supplies at all times during the period of the Contract.
- E. Field Office, Special Type I consists of 1 single wide trailer measuring 50-foot length by 12-foot width.
- F. Field Office, Special Type II consists of 1 single wide trailer measuring 50-foot length by 12-foot width and 1 double wide trailer measuring 50-foot length by 24-foot width.
- G. Remove the field office from the premises when directed by the Department.

TABLE 1. General Field Office Requirements for Each Modular Office

Doors Leading to Exterior	Minimum of 2 insulated doors; equip each with a keyed passage lock and a keyed deadbolt lock.
Electrical Outlets	Located a minimum of every 10 ft along each wall with a minimum of 2 outlets per room.
Exit Sign	1 lighted "EXIT" sign for each exterior passage door.
Fire Extinguisher	1 per exterior door; may be chemical or dry powder and be UL Classification 10-B:C (min.) and be suitable for Types A:B:C fires.
First Aid Kit	Commercial- or industrial-type first aid and safety kit suitable for Project conditions and hazards, including snakebites.
Height (Floor to Ceiling)	8'-0" nominal.

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Insulation	Exterior walls, ceiling, and floor must be insulated.
Internet Access	Via a broadband connection with WiFi access utilizing WPA2 security. Options include cable modem, DSL, or similar service; dial-up is not acceptable. Position the WiFi router to provide sufficient coverage in the field office with a minimum 50-ft radius. Provide 2 data jacks in locations indicated on the approved office plan accepted by the Department. Provide usernames and passwords for authorized wireless users as determined by the Department Construction Project Manager. Ascertain the means by which the Internet source will be provided. Provide Internet download and upload speeds of at least 100 Mbps at all times. Coordinate the Internet source with the Department Construction Project Manager to assure compatibility with the Department's hardware/software requirements. Provide and maintain an operational wireless access point. At the Department's sole discretion, a 4G LTE wireless hotspot may be acceptable.
Keys	Minimum of 2 complete sets; give to the engineer's representative.
Lighting	One 4,000-lumen overhead light centrally located and evenly spaced every 10 ft along the interior ceiling, with a minimum of 1 overhead light per room.
Microwave	New; minimum 900 watts.
Other Material Requirements	Free of asbestos and all other hazardous materials.
Parking Spaces	12 functional spaces, each measuring 9'-0" x 20'-0".
Refrigerator	New; minimum 2.6 cubic ft.
Smoke Detector	New; minimum 1 working combination smoke and carbon dioxide detector per room.
Water Cooler	New potable water cooler with hot and cold taps; minimum 5-gallon capacity; maintain a supply of at least 5 gallons of extra water at all times.
Windows	Minimum of 6 insulated windows total; minimum glass area of 1,150 sq inches per window. Equip each window with a horizontal mini-blind covering the full glass area, a screen, and a locking device. Cover exterior of each window with steel bar grids.
Water Service Connections	At least 1 outside water service connection shall be provided at each field office. Each water connection shall have a 3/4" frost proof hose bib with vacuum breaker and shall include 100 linear feet of 5/8" minimum diameter reinforced, industrial or commercial grade, soft rubber hose per connection.

TABLE 2. Field Office Requirements for Single Wide Modular Field Office

Exterior Dimensions	The single-wide field office shall have minimum exterior dimensions of 50'-0" length by 12'-0" width.
Floor Space	The single-wide field office shall be new and have a minimum floor space of 600 square feet.
Furnishing Requirements	2 full-size office desks. Each with filing drawer and fully adjustable ergonomic design swivel chair with armrests and 5-leg base having wheel casters.

TABLE 3. Field Office Requirements for Double Wide Modular Field Office

Exterior Dimensions	The double-wide field office shall have minimum exterior dimensions of 50'-0" length by 24'-0" width.
Floor Space	The double-wide field office shall be new and have a minimum floor space of 1,200 square feet.
Furnishing Requirements	6 full-size office desks. Each with filing drawer and fully adjustable ergonomic design swivel chair with armrests and 5-leg base having wheel casters.

Construction:

A. General Requirements:

1. The field office must be ready for use no later than 30-calendar days after the date of the fully executed contract and before construction begins unless site mobilization is delayed for Department-approved reasons. In the event of approved delay, the field office must be ready for use no later than 10-calendar days after initial mobilization.
2. The Contractor is responsible for obtaining all required licenses and permits for installation, and placement of the field office and its parking area.
3. The field office must be available for use by the Department continuously throughout the duration of the Project.

B. Submittals:

1. Submit a specific location layout drawing and construction details for the proposed field office and its parking area for approval by the engineer.
2. Submit a copy of all validated field office, equipment, and maintenance service assistance and/or monitoring agreements and/or contracts as mentioned herein to the Department's administrative office on or before the first day the field office is ready for use.

Method of Measurement:

The Department will not measure field offices.

Basis of Payment:

- A. The Department will pay for field office at the contract unit price per each month. Partial months will be paid at the rate of 0.033-months per day. Price and payment will constitute full compensation for:
1. Providing, placing, and maintaining all materials;
 2. installation of stabilized construction entrance;
 3. submittals and all drawings;
 4. removal and restoration to original conditions;
 5. removing hazardous material and/or underground tanks;
 6. obtaining licenses and permits.

2/22/2023

763626 - DIESEL FUEL COST PRICE ADJUSTMENT

Description:

This section defines the criteria for payments to the Contractor to reflect increases or decreases in the cost of diesel fuel consumed in the performance of applicable construction work.

Contract Applicability:

To have the Diesel Fuel Cost Price Adjustment provisions apply to this project, a properly completed Diesel Fuel Cost Price Adjustment Option form must be submitted to the Department with the Bidder's bid proposal. If a properly completed Diesel Fuel Cost Price Adjustment Option form is not provided by the bidder, the Department will consider the option to apply the Diesel Fuel Cost Price Adjustment provisions for the project to be declined. No further opportunity to elect Diesel Fuel Cost Price Adjustment for the project will be made available.

Price Adjustment Provisions:

A. These price adjustment provisions apply to contract items in the contract schedule of prices as grouped by category. Specific pay items to be adjusted are attached as an appendix to this Special Provision. General category descriptions and the fuel usage factors which are applicable to each are as follows:

1. Categories:

Category	Description	Applicability
A	Earthwork	The combined total of applicable item plan quantities must exceed 5,000 CY.
B	Subbase and Aggregate Base Courses	The combined total of applicable item plan quantities must exceed 500 tons.
C	Bituminous Materials (Bases and Pavements)	The combined total of applicable item plan quantities must exceed 500 tons.
D	Rigid Materials (Bases and Pavements)	The combined total of applicable plan quantities must exceed 5,000 CY.
E	Structures	Contract items will be based upon the total value of work performed for each structure including any associated work, i.e. items not grouped under Categories A thru D.

2. Diesel Fuel Usage Factors:

Category	Description	Factor	Units
A	Earthwork	0.34	Gallons per CY
B	Subbase and Aggregate Base Course	0.64	Gallons per Ton
C	Flexible Bases & Pavements	2.98	Gallons per Ton
D	Rigid Bases & Pavements	0.98	Gallons per CY
E	Structures	6.76	Gallons per \$1,000 of work performed

Category	Conversion	Factor
B	SY to ton	90 lbs/sy-in
C	SY to ton	112.5 lbs/sy-in
D	SY to CY	Inches of depth/36

3. Delaware Posted Diesel Fuel Price will be issued monthly by the Department at https://deldot.gov/Business/bids/index.shtml?dc=diesel_fuel.

- a. The Project Base Price Index (FB) is the index price posted by the Department on the project advertisement date in \$/gallon.
- b. The Fuel Price Index for adjustment (FP), will be the index price posted by the department monthly in \$/gallon.

Price Adjustment Determination:

- A. The following criteria and conditions will be considered in determining a price adjustment for diesel fuel cost fluctuations on a monthly basis.

1. Unit Price Adjustment Calculation.

- a. When the ratio FP/FB is calculated to be less than 0.95 or calculated to be greater than 1.05, the Department will adjust unit bid price prices in accordance with the following formula:

$$AUP = (FP-FB)(F)+(UBP)$$

where:

AUP = Adjusted Unit Price

FP = Fuel Price Index for the month in which prices are adjusted for applicable construction work.

FB = Project Base Price Index

F = Diesel Fuel Usage Factor (See above chart in section 1.2 for usage factors.)

UBP = Unit Bid Price specified in the Contractor's Bid Proposal

Payment of Adjusted Unit Prices:

- A. The unit bid prices of work items affected by the fuel escalation will be adjusted by change order, either up or down. The Diesel Fuel Price Index will be used for all the applicable items performed during the monthly period.
- B. If the Contractor exceeds the authorized allotted completion time, the adjusted item prices on the last authorized allotted calendar day or working day shall be the prices used during the time liquidated damages are assessed. However, if the posted price for diesel fuel goes down, the item prices shall be adjusted downward accordingly.
- C. Upon completion of the work and determination of final pay quantities, an adjusting work order will be prepared to reconcile any difference between estimated quantities previously paid and the final quantities. In this situation, the value for FP used in the price adjustment formula will be the average of all FP's previously used for computing price adjustments.
- D. The Department reserves the right to inspect the records of the prime contractor and its subcontractors and material suppliers to ascertain actual pricing and cost information for the diesel fuel used in the performance of applicable items of work.
- E. When applicable items of work, as specified herein, are added to the contract as Extra Work in accordance with the provisions of Section 104.2.E, no price adjustment will be made for fluctuations in the cost of diesel fuel consumed in the performance of the extra work, unless otherwise approved by the Engineer. The current price for diesel fuel is to be used when preparing required backup data for extra work to be performed at a negotiated price. For extra work performed on force account basis, reimbursement for material and equipment along with specified overhead and profit markups will be considered to include full compensation for the current cost of diesel fuel.

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Any Price Increases or Price Rebates that are calculated based on items of work performed by subcontractors will be added to or deducted from payments due to the Contractor in the appropriate pay period. The Contractor shall then accurately record on the appropriate CN-103 form the additions or deductions into adjusted contract value. The Contractor shall make payment to the subcontractor(s) who actually performed the work in accordance with DelCode Title 17, Chapter 8.

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Appendix - Item 763626 Diesel Fuel Cost Adjustment

	<u>Item Numbers</u>
Category A: Earthwork Excavation & Embankment, Borrow (total qty must exceed 5000 CY)	202000, 207000, 207001, 207021, 209006
Category B: Subbase and Agg. GABC, PTB, Soil Cement Base (total qty must exceed 500 T)	301001, 302002, 302005
Category C: Flexible Bases and Pavements Warm Mix Asphalts (total qty must exceed 500 T)	401005, 401014
Category D: Rigid Bases and Pavements Concrete, P.C.C. Patching (total qty must exceed 5000 CY)	
Category E: Structures Bridges, Large P.C.C. Structures	610005, 610008, 610017 610018, 610500

763650 – STEEL COST PRICE ADJUSTMENT

Description:

This section defines the criteria for payments to the contractor to reflect increases or decreases in the cost of steel used on specific items of work identified in the contract in accordance with this provision.

Contract Applicability:

To have the steel cost price adjustment provision apply to this contract, a properly completed steel cost price adjustment option form must be submitted to the Department with the bidder's bid proposal. If a properly completed steel cost price adjustment option form is not provided by the bidder, the Department will consider the option to apply the steel cost price adjustment provisions for the project to be declined. No further opportunity to elect steel cost price adjustment for the contract will be made available.

Price Adjustment Provisions:

- A. This price adjustment provision is eligible for consideration for the following steel items:
 - 1. Structural steel (rolled beams, plate girders, diaphragms, plate bearings, etc.);
 - 2. reinforcing steel (plain, galvanized, and epoxy coated);
 - 3. overhead sign structures;
 - 4. guardrail, posts;
 - 5. standard sign or lighting supports;
 - 6. railing;
 - 7. steel encasement pipe;
 - 8. steel piles (pipe and H-piles);
 - 9. steel strand (used for prestressed or post-tensioned finished elements);
 - 10. sheet piles;
 - 11. ductile iron pipe and fittings (water & sewer); and
 - 12. stay in place forms, building cladding (exterior and interior rolled panels, etc.)
- B. Inventoried materials or fasteners of any kind are not eligible for consideration. Fasteners include bolts, nuts, washers, rivets, and welding rods.
- C. This provision applies only to material cost changes of steel that occur between the date of bid advertisement and the date the material is shipped or invoiced to the contractor, subcontractor, or supplier/fabricator placing the steel into the finished component, whichever occurs first. To be eligible for this price adjustment, place purchase order(s) for eligible steel items for price adjustment identified in the contract within 30 days of the notice to proceed. To apply a steel cost price adjustment to the contract, all eligible items must be submitted. Failure to submit one of the eligible items will result in the steel cost price adjustment for all items being waived.

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- D. Store, label, or tag steel items which are eligible for adjustment such that they are recognizable by color marking, and identifiable by project for inspection and audit verification.
- E. This provision allows for price adjustment for embedded steel used for prestressed or post-tensioned precast components where providing steel is included in the unit price of the finished bid item. Steel used for post-tensioned or prestressed elements shall be evaluated for price adjustment in the same manner as other steel material eligible under the requirements of this provision. price adjustment shall only apply to the tonnage or poundage of steel strand used in the prestressed or post-tensioned element. Submit material price quotes, bid papers, or other documentation to the Department, before executing the contract, for the bid items applicable for price adjustment. Submitted documentation shall support the completion of the form establishing the average price per pound for the eligible steel bid item. The Department will only accept the information in the format provided at the end of this provision. Certify that all items of documentation are original and were used in the computation of the amount bid for the represented eligible pay items for the month bids were advertised. Use the documentation to support the base line material price (base price) of the steel item only. No adjustment will be made for changes in other components of the contract unit bid price, including, fabrication, shipping, storage, handling, and erection.
- F. Failure to submit specifically required information such as purchase order, price data, bill of lading, material information or other requested information as noted herein will result in the contractor not being eligible for price adjustment of steel items.
- G. This provision will not apply to items added after contract is executed. But will apply to quantity added to original contract items.
- H. Steel shortages may be justification for an excusable, non-compensable delay in accordance with section 108.7.B. Such shortages will not constitute grounds for claims for standby equipment, extended office overhead, or other costs associated with such delays.
- I. The need for application of the adjustments herein to non-bid items will be determined by the engineer on an individual basis and, if appropriate, will be specified on the change order.
- J. Any apparent attempt to unbalance bids in favor of items subject to price adjustment may result in rejection of the bid proposal.

Price Adjustment Applicability

- A. Price adjustment of each qualifying item under consideration will be subject to the following conditions:
 - 1. There must be an increase or decrease in the cost of eligible steel materials in excess of 5% from the base price when compared with the latest producers price index (price index) in effect at the time material is shipped or invoiced to the contractor, subcontractor, or supplier/fabricator placing the steel into the finished component, whichever occurs first.

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2. The Price Index the Department is using is based on The U.S. Department of Labor, Bureau of Labor Statistics, Producers Price Index (PPI) which measures the average price change over time of the specific steel eligible item from the perspective of the seller of goods. The specific PPI to be used to adjust the price for the eligible steel items is shown in the table below. The PPI is subject to revision four months after original publication; therefore, price adjustments and payments will not be made until the index numbers are finalized.
3. The following table indicates the PPI steel category index items and the corresponding I.D. numbers to which the steel items will be compared:

Steel Item	Bureau of Labor Statistics PPI Series I. D. Number WPU#
Reinforcing steel (plain, galvanized, and epoxy coated) Steel Strand (Prestressed & Post-tensioning)	WPU101704 (https://data.bls.gov/timeseries/WPU101704)
Plate girders & rolled beams (Standard & High strength, diaphragms, plate bearings, etc.) Steel piling (H-pile, pipe piles & sheet piles)	Average of WPU1017 & WPU101 (https://data.bls.gov/timeseries/WPU1017?data_tool=XGtable & https://data.bls.gov/timeseries/WPU101?data_tool=XGtable)
Steel encasement pipe Overhead sign structures, posts, poles, sign or lighting supports, & railing	WPU101706 (https://data.bls.gov/timeseries/WPU101706)
Guardrail	Average of WPU1017 & WPU101707 (https://data.bls.gov/timeseries/WPU1017?data_tool=XGtable & https://data.bls.gov/timeseries/WPU101707)
Ductile Iron Pipe & Fittings	WPU10150211 (https://data.bls.gov/timeseries/WPU10150211)
Stay-in-place forms, building cladding (exterior and interior rolled panels, etc.)	WPU101707 (https://data.bls.gov/timeseries/WPU101707)

Price Adjustment Determination:

The price adjustment will be determined by computing the percentage of change in index value beyond 5% above or below the index on the advertisement date to the index value on the date the steel material is shipped or invoiced to the contractor, subcontractor, or supplier/fabricator placing the steel into the finished component, whichever occurs first. Weights and date of shipment must be documented by a bill of lading provided to the Department. The final price adjustment dollar value will be determined by multiplying the percent increase or decrease in the index (beyond 5%) by the represented quantity of steel shipped by the base price per pound subject to the limitations herein.

$A = B \times P \times Q$	
Where:	
A =	Steel price adjustment in lump sum dollars
B =	Average weighted price of steel submitted with bid on project in \$/lb
P =	Adjusted percentage change in PPI average from billing date to advertisement minus 5% (0.05) threshold
Q =	Total quantity of steel in pounds shipped to fabricator for the specific project

Price increase/decrease will be computed as follows:

Sample Calculation of a Price Adjustment (increase)		
Project	Tuesday, April 28, 2009	
advertised on		
Project has structural steel in the amount of:	450,000	lbs.
Orders placed in timely manner and according to contract.		
Contractor's Freight on Board (F.O.B.) supplier price for the structural steel in	\$ 0.28	/lb
Adjusted** BLS Producers Price Index most recently published average at time of advertisement:		157.0
** final change after 4 months		
All steel shipped to fabricator in same month: October-09		
October 2009.		
Adjusted BLS Producers Price Index (PPI) most recently published average for month of		173.7
Adjustment formula is $A = B \times P \times Q$		
Where: A =	Steel price adjustment in lump sum dollars	
B = \$ 0.28/lb	Average weighted price of steel submitted with bid on project in \$/lb = \$0.28/lb	
P = 0.0564	Adjusted percentage change in PPI average from billing date to bid date minus 5% threshold = $(173.7 - 157.0) / 157.0 - 0.05 = 0.0564$	
Q = 450,000 lbs.	Total quantity of steel shipped to fabricator in October 2009 for this project in pounds = 450,000 lbs.	
A = \$ 7,102.55	$0.28 \times 0.0564 \times 450,000$	
A = \$ 7,102.55	Lump Sum adjustment paid to Contractor	

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Sample Calculation of a Price Adjustment (decrease)		
Project advertised on April 27, 2009.		
Project has structural steel.	450,000	lbs.
Orders placed in timely manner and according to contract.		
Contractor's F.O.B. supplier price for the structural steel in bid:	\$ 0.28	/lb
Adjusted** BLS Producers Price Index most recently published average at time of	173.7	
** final change after 4 months		
All steel shipped to fabricator in same month, October-09		
Adjusted BLS Producers Price Index (PPI) most recently published average for month of	157.0	
Adjustment formula is $A = B \times P \times Q$		
Where: A =	Steel price adjustment in lump sum dollars	
B = \$ 0.28/lb	Average weighted price of steel submitted with bid on project in \$/lb = \$0.28/lb	
P = -0.0461	Adjusted percentage change in PPI average from billing date to bid date minus 5% threshold = $(157.0-173.7)/173.7+0.05 = -0.0461$	
Q = 450,000 lbs.	Total quantity of steel shipped to fabricator in October 2009 for this project in lb = 450,000 lb	
A = \$ (5,808.60)	$0.28 \times -0.0461 \times 450,000$	
A = \$ (5,808.60)	Lump Sum credit from Contractor	

Basis of Payment:

The Department will adjust monthly progress payments up or down as appropriate for cost changes in steel used on specific items. The price adjustments will be made as a lump sum payment for eligible steel products placed and accepted.

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- 831500 - PROVIDE AND INSTALL UP TO 6" SCHEDULE 80 PVC CONDUIT (OPEN CUT)
 - 831501 - PROVIDE AND INSTALL 4" SCHEDULE 80 PVC CONDUIT (OPEN CUT)
 - 831502 - PROVIDE AND INSTALL 3" SCHEDULE 80 PVC CONDUIT (OPEN CUT)
 - 831503 - PROVIDE AND INSTALL 2-1/2" SCHEDULE 80 PVC CONDUIT (OPEN CUT)
 - 831504 - PROVIDE AND INSTALL 2" SCHEDULE 80 PVC CONDUIT (OPEN CUT)
 - 831505 - PROVIDE AND INSTALL 1" SCHEDULE 80 PVC CONDUIT (OPEN CUT)
- 831506 - PROVIDE AND INSTALL 1" FLEXIBLE METALLIC-LIQUIDTIGHT CONDUIT
- 831507 - PROVIDE AND INSTALL 2" FLEXIBLE METALLIC-LIQUIDTIGHT CONDUIT
- 831508 - PROVIDE AND INSTALL 3" FLEXIBLE METALLIC-LIQUIDTIGHT CONDUIT
- 831509 - PROVIDE AND INSTALL 4" FLEXIBLE METALLIC-LIQUIDTIGHT CONDUIT
 - 831512 - PROVIDE AND INSTALL 1" SCHEDULE 80 PVC CONDUIT (TRENCH)
 - 831513 - PROVIDE AND INSTALL 2" SCHEDULE 80 PVC CONDUIT (TRENCH)
 - 831514 - PROVIDE AND INSTALL 2-1/2" SCHEDULE 80 PVC CONDUIT (TRENCH)
 - 831515 - PROVIDE AND INSTALL 3" SCHEDULE 80 PVC CONDUIT (TRENCH)
 - 831516 - PROVIDE AND INSTALL 4" SCHEDULE 80 PVC CONDUIT (TRENCH)
- 831517 - PROVIDE AND INSTALL 1" SCHEDULE 80 PVC CONDUIT (ON STRUCTURE)
- 831518 - PROVIDE AND INSTALL 2" SCHEDULE 80 PVC CONDUIT (ON STRUCTURE)
- 831519 - PROVIDE AND INSTALL 2-1/2" SCHEDULE 80 PVC CONDUIT (ON STRUCTURE)
- 831520 - PROVIDE AND INSTALL 3" SCHEDULE 80 PVC CONDUIT (ON STRUCTURE)
- 831521 - PROVIDE AND INSTALL 4" SCHEDULE 80 PVC CONDUIT (ON STRUCTURE)
 - 831522 - PROVIDE AND INSTALL 1" GALVANIZED STEEL CONDUIT (TRENCH)
 - 831523 - PROVIDE AND INSTALL 2" GALVANIZED STEEL CONDUIT (TRENCH)
- 831524 - PROVIDE AND INSTALL 2-1/2" GALVANIZED STEEL CONDUIT (TRENCH)
- 831525 - PROVIDE AND INSTALL 3" GALVANIZED STEEL CONDUIT (TRENCH)
- 831526 - PROVIDE AND INSTALL 4" GALVANIZED STEEL CONDUIT (TRENCH)
- 831527 - PROVIDE AND INSTALL 1" GALVANIZED STEEL CONDUIT (BORE)
- 831528 - PROVIDE AND INSTALL 2" GALVANIZED STEEL CONDUIT (BORE)
- 831529 - PROVIDE AND INSTALL 2-1/2" GALVANIZED STEEL CONDUIT (BORE)
- 831530 - PROVIDE AND INSTALL 3" GALVANIZED STEEL CONDUIT (BORE)
- 831531 - PROVIDE AND INSTALL 4" GALVANIZED STEEL CONDUIT (BORE)
- 831532 - PROVIDE AND INSTALL 1" GALVANIZED STEEL CONDUIT (OPEN CUT)
- 831533 - PROVIDE AND INSTALL 2" GALVANIZED STEEL CONDUIT (OPEN CUT)
- 831534 - PROVIDE AND INSTALL 2-1/2" GALVANIZED STEEL CONDUIT (OPEN CUT)

831535 - PROVIDE AND INSTALL 3" GALVANIZED STEEL CONDUIT (OPEN CUT)

831536 - PROVIDE AND INSTALL 4" GALVANIZED STEEL CONDUIT (OPEN CUT)

831537 - PROVIDE AND INSTALL 1" GALVANIZED STEEL CONDUIT (ON STRUCTURE)

831538 - PROVIDE AND INSTALL 2" GALVANIZED STEEL CONDUIT (ON STRUCTURE)

831539 - PROVIDE AND INSTALL 2-1/2" GALVANIZED STEEL CONDUIT (ON STRUCTURE)

831540 - PROVIDE AND INSTALL 3" GALVANIZED STEEL CONDUIT (ON STRUCTURE)

831541 - PROVIDE AND INSTALL 4" GALVANIZED STEEL CONDUIT (ON STRUCTURE)

831542 - PROVIDE AND INSTALL 2" HDPE SDR-13.5 CONDUIT (BORE)

831543 - PROVIDE AND INSTALL 2-1/2" HDPE SDR-13.5 CONDUIT (BORE)

831544 - PROVIDE AND INSTALL 3" HDPE SDR-13.5 CONDUIT (BORE)

831545 - PROVIDE AND INSTALL 4" HDPE SDR-13.5 CONDUIT (BORE)

831560 - PROVIDE AND INSTALL UP TO 4" SCHEDULE 80 PVC CONDUIT (OPEN CUT)

831561 - PROVIDE AND INSTALL 1-1/2" SCHEDULE 80 PVC CONDUIT (TRENCH)

831562 - PROVIDE AND INSTALL 1-1/2" SCHEDULE 80 PVC CONDUIT (ON STRUCTURE)

831563- PROVIDE AND INSTALL 1-1/2" GALVANIZED STEEL CONDUIT (OPEN CUT)

831564 - PROVIDE AND INSTALL 1-1/2" GALVANIZED STEEL CONDUIT (TRENCH)

831565 - PROVIDE AND INSTALL 1-1/2" GALVANIZED STEEL CONDUIT (BORE)

831566 - PROVIDE AND INSTALL 1-1/2" GALVANIZED STEEL CONDUIT (ON STRUCTURE)

831569 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 1" SCHEDULE 80 PVC CONDUITS IN TRENCH OR OPEN CUT

831570 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 1-1/2" SCHEDULE 80 PVC CONDUITS IN TRENCH OR OPEN CUT

831571 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 2" SCHEDULE 80 PVC CONDUITS IN TRENCH OR OPEN CUT

831572 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 2-1/2" SCHEDULE 80 PVC CONDUITS IN TRENCH OR OPEN CUT

831573 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 3" SCHEDULE 80 PVC CONDUITS IN TRENCH OR OPEN CUT

831574 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 4" SCHEDULE 80 PVC CONDUITS IN TRENCH OR OPEN CUT

831575 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 2" HDPE 13.5 SDR CONDUIT IN DIRECTIONAL BORE

831576 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 2-1/2" HDPE 13.5 SDR CONDUIT IN DIRECTIONAL BORE

831577 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 3" HDPE 13.5 SDR CONDUIT IN DIRECTIONAL BORE

831578 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 4" HDPE 13.5 SDR CONDUIT IN DIRECTIONAL BORE

831579 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 1" GALVANIZED STEEL CONDUIT IN TRENCH OR OPEN CUT

831580 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 1-1/2" GALVANIZED STEEL CONDUIT IN TRENCH OR OPEN CUT

831581 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 2" GALVANIZED STEEL CONDUIT IN TRENCH OR OPEN CUT

831582 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 2-1/2" GALVANIZED STEEL CONDUIT IN TRENCH OR OPEN CUT

831583 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 3" GALVANIZED STEEL CONDUIT IN TRENCH OR OPEN CUT

831584 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 4" GALVANIZED STEEL CONDUIT IN TRENCH OR OPEN CUT

831585 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 1" STEEL CONDUIT IN DIRECTIONAL BORE

831586 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 1-1/2" STEEL CONDUIT IN DIRECTIONAL BORE

831587 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 2" STEEL CONDUIT IN DIRECTIONAL BORE

831588 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 2-1/2" STEEL CONDUIT IN DIRECTIONAL BORE

831589 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 3" STEEL CONDUIT IN DIRECTIONAL BORE

831590 - PROVIDE & INSTALL SECOND AND SUBSEQUENT ADDITIONAL 4" STEEL CONDUIT IN DIRECTIONAL BORE

Description:

This work consists of providing and installing a conduit or shield, of the type and size required.

Materials:

Provide materials in accordance with Section 831.2.

Construction:

A. General Installation Requirements -

1. The Department has the right to reject any installation method proposed for a given work site. PVC shall not be installed under existing pavement unless it is on a continuous roll or with the engineer's written approval.
2. Conduit installed underground shall be installed in a straight line between terminal points. In straight runs, junction well spacing shall be no more than 600 feet for fiber optic conduit or no more than 300 feet for copper in conduit, or as directed by the engineer. If bends are required during installation, they must be

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manufactured sweeping bends. The engineer will be consulted before any bends are installed to ensure that the proper arc is provided.

3. Underground conduit shall have a minimum cover as measured from the finished grade of 24 inches and a maximum cover of 48 inches. The opening shall be filled halfway with the cover material and tamped down firmly before filling in the remainder of the opening. Additional lifts shall be used as required to install the metallic warning tape at the specified depth. All cover material shall be free of rocks, debris, vegetation or other deleterious material that may damage the conduit. An underground utility warning tape shall be installed as specified in this section and the remainder of the fill shall be added, tamping down the top layer.
4. Conduit not terminated to a base or in a junction well shall be terminated 2 feet beyond the edge of the pavement unless otherwise directed by the engineer, and properly capped. Tape is not an approved method. Conduit shall not extend more than 3 inches inside a junction well. See Standard Construction Details or applicable Plan Details for typical methods of termination.
5. All underground conduits shall be marked in the ground with a metallic warning tape. The marking tape shall be buried directly above the conduit run that it identifies, at a depth of approximately 12 inches below final grade. The tape identifying all conduits shall be at least 6 inches wide and have a minimum thickness of 3 mils and 500 percent elongation.
6. The color of the metallic warning tape identifying fiber optic cable should be bright orange (preferably AULCC orange) and shall read "WARNING - OPTICAL CABLE" or other wording approved by the engineer that conveys the same message. The color of the tape identifying all other cables shall be bright red and shall read "WARNING -BURIED ELECTRIC BELOW" or other wording approved by the engineer that conveys the same message.
7. Using conduit tools, rigid metallic conduit shall be cut, reamed, and threaded. The thread length shall be as necessary to ensure that the sections of conduits when screwed into a coupling and tightened correctly will butt together and the joint will be watertight. A three-piece threaded union, as approved by the engineer, shall be used to join two threaded lengths of conduit in the case where a standard coupling will not work. A threaded union shall not be used in a conduit run that is to be driven. At no time is a threadless coupling or a split-bolt coupling to be used for direct buried conduit.
8. All lengths of HDPE conduit shall be connected with irreversible fusion couplings. Mechanical and removable couplings will not be accepted.
9. All lengths of PVC conduit shall be connected by one conduit end fitting inside the flared end of the other conduit section. If this is not possible, then a coupling may be used. Regardless of how connection is made, all joints shall be sealed with the appropriate epoxy to ensure that the two conduit pieces bond to one another to form a solid waterproof link. Using conduit tools, the conduit shall be cut and prepared. If approved by the engineer, a coupler module may be used where conduit segments do not align properly to allow the flared end of one conduit segment to mate with the normal end of the other segment.
10. Sealed end caps (with knockouts if empty) shall be placed on the ends of all conduits, after compressed air has been used to clear all foreign matter.
11. If not already pre-installed by the manufacturer, a polyester or polypropylene pulling rope or tape (fish wire) with a minimum rated strength of 1,250 pounds shall be installed in each conduit for future use. In instances where the Contractor installs the cable, the fish wire may be eliminated.
12. All PVC and HDPE conduits shall have a continuous metallic trace wire installed for the entire length of the conduit run for all fiber installations.
13. Stabilize slopes in accordance with section 908 as directed by the engineer.

B. Installation of Conduit Under Existing Pavement, Directional Bore -

1. Directional bore shall be used for installation of conduits under existing pavement with a conduit diameter not less than 1-1/2-inch. The size of a bore shall not exceed the outside diameter of the conduit by more than 1 inch. If it does, cement grout shall be pumped into the void. Only HDPE and/or Galvanized Steel conduit may be installed by Directional Bore methods.

C. Installation of Conduit Under Existing Pavement, Open Cut -

1. Installation by saw cutting the full pavement depth and removing the existing pavement with an excavator or by hand methods, shall be used only for conduits not less than 1-1/2-inch diameter. The engineer must first approve all open cutting of roadways. The width and length of open cut and patch restoration materials shall be as shown on the plan details. The Contractor shall be responsible for the removal of all cut pavement and surplus excavation, and for the replacement and correction of any damaged pavement outside the sawcut limits after the conduit(s) are installed.

D. Installation of Conduit Under Existing Pavement, Unpaved Trench -

1. Trenching or other approved method shall be used for installation of conduit in unpaved trench or under new pavement. Backfill in conduit trenches shall be compacted thoroughly as it is being placed. At the discretion of the engineer, remove sod to place conduit with an approved sod cutter and replace, or place 6 inches of topsoil and seed in accordance with section 908. In areas where new pavement is to be placed or in areas where total reconstruction is taking place, sodding or seeding may not be required by the engineer.

E. Installation of Conduit on Structure -

1. Conduit installed on structure shall consist of drilling anchors into concrete, brick, stone, steel or wood and mounting the conduit with the proper clamps or hangers. The conduit shall be attached to the structure by use of one-hole conduit hangers and approved anchors not more than 36 inches apart. Any 90-degree turns in the conduit run shall be accomplished by placing the proper size and type manufactured sweeping bends for the application needed.

F. Installation of Additional Conduit in Trench or Open Cut Pavement -

1. In the case of slotted or trenched installations, install additional conduits at the same time as the initial installation. The engineer shall indicate the quantity of conduits to be installed during a build. Additional conduits may be stacked one on top of the other, side by side or in a matrix. Conduits shall not twist around one another or be allowed to deviate from straight line paths except in the case of bend installations. Conduits installed at the same time in the same trench or slot shall remain oriented the same in relation to one another throughout the conduit run.

G. Installation of Additional Conduits in Directional Bore -

1. In the case of a directional bore that more than one conduit shall be installed at the same time as the initial installation, install 1 or more additional conduits. The engineer shall indicate the quantity of conduits to be installed during a build. The additional conduits may be stacked one on top of the other, side by side or in a matrix. Conduits shall not twist around one another or be allowed to deviate from straight line paths except in the case of a gentle bend. Conduits installed at the same time, in the same bore shall remain oriented in the same relation to one another throughout the conduit run.

Method of Measurement:

- A. The Department will measure the quantity of conduit in linear feet of conduit provided and installed and accepted.
- B. The Department will measure the quantity of conduit in linear feet of conduit installed under existing pavement by a directional bore or by open cutting the pavement along the path of the bore or open cut, from the point that cannot be trenched to the point that trenching can resume.
- C. The Department will measure the quantity of conduit in linear feet of conduit reduced or divided (with a junction well or conduit body) as part of the larger conduit.

Basis of Payment:

- A. The Department will pay for providing and installing conduit at the contract unit price per linear foot. Price and payment will constitute full compensation for:

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1. Providing and placing all materials; and
 2. labor.
- B. The Department will pay for installing conduit by directional bore at the contract unit price per linear foot. Price and payment will constitute full compensation for:
1. Excavation and backfilling;
 2. placing the conduit;
 3. caps, if required; and
 4. all other requirements.
- C. The Department will pay for installing conduit by open cutting existing pavement at the contract unit price per linear foot. Price and payment will constitute full compensation for:
1. Excavation and backfilling;
 2. placing the conduit;
 3. disposal of excess materials; and
 4. all other requirements.
- D. The Department will pay for installing conduit by unpaved trench at the contract unit price per linear foot. Price and payment will constitute full compensation for:
1. Excavation and backfilling;
 2. removal of sod, if required;
 3. placing the conduit;
 4. disposal of excess materials;
 5. replacing excavated on site sod, if required;
 6. seeding, if required; and
 7. all other requirements.
- E. The Department will pay for:
1. Borrow in accordance with Section 207;
 2. Restoring pavement in accordance with Sections 401 or 502;
 3. Saw cutting in accordance with Section 762; and
 4. Topsoil and seeding or sodding from an outside source in accordance with Section 908.

10/23/23

832511 – PROVIDE AND INSTALL CONDUCTOR #8 STRANDED COPPER, TYPE XHHW

Description:

This work consists of providing and installing Copper Stranded #8 AWG XHHW Electrical Conductors for the lighting system.

Materials:

- A. Materials in accordance with Section 832.2
- B. Conductors are to be #8 AWG stranded copper XHHW in accordance with NFPA 70 National Electrical Code Article 300 and 310.

Construction Method:

Construct in accordance with Section 832.3.

Method of Measurement:

The Department will measure conductor #8 stranded copper, type XHHW by the linear foot installed and accepted.

Basis of Payment:

The Department will pay for conductor #8 stranded copper, type XHHW at the contract unit price per linear foot. Price and payment will constitute full compensation in accordance with Section 832.5.

12/08/2023

Contract No. T202007301

850520 - LUMINAIRE (LED), 150 WATTS HPS EQUIVALENT

850521 - LUMINAIRE (LED), 250 WATTS HPS EQUIVALENT

850522 - LUMINAIRE (LED), 400 WATTS HPS EQUIVALENT

850523 - LUMINAIRE (LED), 640 WATTS HPS EQUIVALENT (HIGH MAST ONLY)

850524 - LED WALL PACK, 250 WATTS HPS EQUIVALENT

850525 - LED WALL PACK, 400 WATTS HPS EQUIVALENT

850526 - LED WALL PACK, 75 WATTS HPS EQUIVALENT

850527 - LED WALL PACK, 150 WATTS HPS EQUIVALENT

Description.

This work consists of providing and installing an LED light fixture (luminaire) on pole (not inclusive in this item) with wattage, lamp type and distribution type.

Materials.

The LED Wattages above are based on the equivalent output to HPS lighting. Refer to maximum LED Wattages below.

Provide a complete fixture with a heavy-duty, cast-aluminum housing, door with extruded aluminum heat sink, tool-less entry, hinged removable power tray door for easy maintenance, and have fastening hardware that is stainless steel or zinc plated steel. The fixture shall meet ANSI 136.31 3.0 G vibration requirements. Fixture shall have a two-bolt slip fitter system for mounting on a 1 1/4-inch to 2 3/8-inch mounting arm connection. A grey powder coat finish shall be applied to the fixture unless otherwise shown on the plans, or as directed by the engineer.

The fixture shall also meet the following criteria:

1. Lamps: LED
2. Wattage:
 - a. 50 Watt Maximum for Item No. 850526
 - b. 90 Watt Maximum for Item No. 850520 and 850527
 - c. 175 Watt Maximum for Item No. 850521 and 850524
 - d. 250 Watt Maximum for Item No. 850522 and 850525
 - e. 450 Watt Maximum for Item No. 850523
3. Voltage: 120V - 277V
4. CRI: 70 Minimum
5. Lumens:

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- a. 3,000 to 5,000 for Item No. 850526
 - b. 8,000 to 12,000 for Item No. 850520 and 850527
 - c. 16,00 to 20,000 for Item No. 850521 and 850524
 - d. 27,000 to 31,000 for Item No. 850522 and 850525
 - e. 40,000 to 50,000 for Item No. 850523
6. Rated L70 Lamp Life: 100,000-hours minimum when operated at 77-degrees F.
 7. Distribution: Type II or Type III (unless otherwise indicated).
 8. Color Temperature: 3,000 K - 4,500 K.
 9. Drive Current: 850-mA maximum.
 10. Driver: 0-10V dimming.
 11. IP66 Rating for optical portion of the housing.
 12. 10kV/10kA minimum internal surge suppression module, meeting UL 1449/ANSI C62.41.2 Category C.
 13. 3 Pin NEMA Photocontrol Receptacle with a Shorting Cap.

Luminaire mounting height shall be as indicated on drawings. Luminaire shall provide point illumination of not less than the given values in the table that follows:

Luminaire	Foot-candle Point Table	
	Point 1	Point 2
Luminaire (LED), 75 Watts HPS Equivalent	0.10	0.11
Luminaire (LED), 150 Watts HPS Equivalent	0.16	0.22
Luminaire (LED), 250 Watts HPS Equivalent	0.27	0.37
Luminaire (LED), 400 Watts HPS Equivalent	0.46	0.55
Luminaire (LED), 640 Watts HPS Equivalent	0.55	0.60

Point 1

coordinates are 90 feet longitudinal distance. Point 2 coordinates are 90-feet longitudinal and 30-feet transverse. The point values given in the table are based on a 30-foot mounting height with a Light Loss Factor of 1. The point values produced by the submitted fixture shall be included with the fixture submittal.

Metal Parts shall be free of burrs and sharp corners and edges. Doors, frames, and other internal access shall be smooth operating and free of light leakage under operating conditions.

Factory applied labels shall comply with UL 1598. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place. Labels shall include the following lamp characteristics:

1. CCT and CRI for all luminaires

Luminaire finish shall be manufacturers standard paint applied to factory-assembled and tested luminaire before shipping.

Construction.

- A. Install luminaires in accordance with the manufacturer's installation instructions and shall follow the following installation requirements:
 1. Comply with NECA 1.
 2. Fasten luminaire to pole.
 3. Install luminaires at height indicated on drawings and level and square with finished grade.
 4. Perform an illumination test.
- B. Luminaire identification decals shall be installed to the luminaire housing in accordance with NEMA conventions. Ensure the decal is readily visible from the ground and meets ANSI C136.15-2015 Roadway and Area Lighting Equipment-Luminaire Field Identification standard.
- C. After installation of luminaires and control devices and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- E. Luminaires will be considered defective if they do not pass tests and inspections. Provide fixture cutsheets, details, and the IESNA LM-79 and LM-80 test reports to the engineer for shop drawing review before purchasing.
- F. Provide documentation that demonstrates that the proposed model of LED luminaire has been tested for electromagnetic compliance following the measurement protocols specified in ANSI standard C63.4-2003 and required by 47 CFR 15.31.
- G. If the Contract require each light fixture to be provided with an independent photoelectric control device, provide a photocell with each lighting fixture in place of the shorting cap. Provide photoelectric control using solid state circuitry, cadmium sulfide type with hermetically sealed silicone rectifier rated 120-volt, 60-cycle AC and 1000-watts maximum load. Provide photoelectric control with "Fail On" functionality such that in the event of a photocell becoming inoperative, the light fixture will remain in a permanent "On" state through day and nighttime hours. Photo control shall be twist lock type, with suitable mounting bracket with locking type receptacle.
- H. The photoelectric control shall be set to operate, by default factory setting or by field adjustment, using the following criteria:
 1. Turn on the light fixture at a minimum vertical illumination value of 3-foot-candles.
 2. Turn off the light fixture at a maximum vertical illumination value of 6-foot-candles.
- I. All electrical materials shall conform to the requirements of the National Electrical Code of the National Fire Protection Association, and to all local and state laws and/or ordinances governing such installations.

Method of Measurement.

The Department will measure the quantity of LED luminaires as the number luminaires provided, installed, and accepted.

Basis of Payment.

- A. The Department will pay for LED luminaires at the contract unit price of each luminaire installed, and accepted. Price and payment will constitute full compensation for:
1. All materials, including the luminaires; and
 2. incidentals required to complete the Work.

2/9/23

Contract No. T202007301

851502 - ALUMINUM LIGHTING SINGLE DAVIT ARM, 8' ARM SPREAD

851503 - ALUMINUM LIGHTING SINGLE DAVIT ARM, 12' ARM SPREAD

851504 - ALUMINUM LIGHTING SINGLE DAVIT ARM, 15' ARM SPREAD

851506 - ALUMINUM LIGHTING STANDARD, 30' POLE

851507 - ALUMINUM LIGHTING STANDARD, 40' POLE

851509 - ALUMINUM LIGHTING STANDARD WITH SINGLE TRUSS ARM, 30' POLE

851520 - ALUMINUM LIGHTING SINGLE DAVIT ARM, 10' ARM SPREAD

851522 - ALUMINUM LIGHTING SINGLE DAVIT ARM, 20' ARM SPREAD

DESCRIPTION:

- A. Aluminum Lighting Standard with Arm & Pole
 - 1. The work consists of providing and installing Aluminum Lighting Standard with Single Davit or Truss Arm and breakaway transformer base, luminaire.
- B. Aluminum Lighting Single Davit Arm
 - 1. The work consists of providing Aluminum Standard Single Davit Arm with the specified arm spread and installing on an already installed pole.
- C. Aluminum Lighting Standard Pole
 - 1. The work is comprised of providing Aluminum Lighting Standard Pole of the specified height, breakaway transformer base, and installing (on an already installed pole base not included in this item).

MATERIALS:

- | | |
|---|---------------------|
| A. Submersible Breakaway Connector Kits | Section 832 or 1074 |
| B. H-taps, C-taps, Butt Splices | Section 832 or 1074 |
| C. Anchor Bolts, Galvanized | Section 1039 |
| D. Hardware, Lighting Standard, Stainless Steel | Section 1044 |
| E. Aluminum Castings, Alloy 356-T6 | Section 1044 |
| F. Anchor Base Plate, Aluminum Alloy 6000 Series | Section 1044 |
| G. Welding, Aluminum | Section 1044 |
| H. Lighting Pole and Davit Arm, Aluminum Alloy 6063-T6 | Section 1062 |
| I. Conduit | Section 1062 |
| J. Pole ID Tag, Clear Anodized 1/16-inch thick Aluminum | |
| K. Transformer Base | |
| L. Lighting Standard | |
| M. Electrical Materials | |

CONSTRUCTION METHODS:

All construction methods shall be in accordance with Section 851 and the following:

- A. New aluminum lighting standards shall consist of a tapered aluminum shaft having a base welded to the lower end. The pole shaft, pole extensions, and davit arms shall each be spun from one piece of seamless tubing, the strut and arm plates shall be extruded, all of which conform to the requirements of ASTM B221 aluminum alloy 6063 T6. The shaft shall have no circumferential welds, except at the lower end joining the shaft to the base and

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shall conform to the dimensions listed in the chart below. The shaft shall contain an internal vibration dampening device positioned approximately $\frac{2}{3}$ the height of the pole. The top of the lighting standard shaft shall be drilled for two 1/2-inch lockbolts to secure the davit bracket to the lighting standard shaft. If the pole is not placed on a transformer base, it will have one 3-inch x 5-inch handhole which after pole is set should face so that maintainer may view oncoming traffic.

- B. The table below presents the davit arm length with corresponding outer diameter and wall thickness for each pole height.

HEIGHT OF POLE	DAVIT ARM LENGTH	OUTER DIAMETER	WALL THICKNESS
30'	8'	10"	0.156"
	12'	10"	0.156"
	15'	10"	0.156"
	20'	10"	0.156"
40'	8'	10"	0.188"
	12'	10"	0.188"
	15'	10"	0.188"
	20'	10"	0.188"

- C. Bracket arms shall be of the davit type consisting of an aluminum shaft having the outer diameter and wall thickness as listed in the table above. The davit arm shall be designed to slip over the top of the lighting standard shaft for a distance of at least 12 inches. The luminaire end of the davit arm shall be fitted with a 2-inch NPS aluminum pipe not less than 6 inches long. Determine the nominal mounting height as shown in the plans. The length of the davit arm will be as shown on the Plans or 12 feet if not specified elsewhere. Davit arm less than 8 feet long shall not be used without written permission from the Chief Traffic Engineer.
- D. Each lighting standard shall be provided with a permanent tag which shall be 2-inch x 4-inch fabricated from clear anodized 1/16-inch thick aluminum. The edge shall be smooth and corners rounded and the tag shall be curved to fit the light standard shaft. Tags shall be secured to shafts by means of four (4) 1/8-inch diameter 18 8 stainless steel round head drive screws of self tapping screws. The embossed identifying letters and/or numerals shall be not less than 3/4-inches high with stroke of not less than 3/16-inches. Identifying letters and/or numerals shall be designated on the Plans.
- E. Transformer Base
1. Transformer bases, shall conform to the latest edition of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaire and Traffic Signals". Before any work, begins submit documents showing that the breakaway device meets the current AASHTO Breakaway Design. For breakaway installations, the standard shall electrically disconnect from the supply wire at the foundation when knocked down by an errant vehicle or from some other cause.

F. Luminaire

1. All HPS luminaire shall be in accordance with Section 850 of the Department's 2016 Standard Specifications. All LED luminaires shall be in accordance with the specifications for LED Luminaire provided elsewhere in this document covering Item Numbers 850520 through 850527.

G. Installations of Lighting Standards

1. Lighting Standards shall be installed and located in accordance with the Plans and as directed by the Engineer. The bracket arms shall be set perpendicular to the edge of the roadway unless otherwise ordered or specified. If necessary, aluminum shims may be used to plumb the pole.

H. Certification:

1. Arrange inspection by a Delaware licensed electrical inspection agency or contractor's licensed staff) for all lighting system work including but not limited to service, branch circuits, junction wells, underground conduit, all grounding and bonding and any electrical work performed on the project. Submit certification for the chosen Delaware licensed electrical inspection agency or contractor's staff to the Project Engineer for approval prior to starting work.

METHOD OF MEASUREMENT:

The Department will measure the quantity of aluminum standards in number of standards installed, certified, and accepted.

BASIS OF PAYMENT:

- A. The Department will pay for aluminum standards with arm and pole, aluminum standard poles, and aluminum Davit arms at the contract unit price of each installed, certified, and accepted. Price and payment will constitute full compensation for:
1. Lighting standard;
 2. single davit arm;
 3. transformer base;
 4. luminaire;
 5. labor;
 6. equipment;
 7. hardware;
 8. pole;
 9. id tags;
 10. flush joint;
 11. gusset plate; and
 12. incidentals necessary to complete the work.

8/10/21