MAINE TURNPIKE AUTHORITY

MAINE TURNPIKE

CONTRACT DOCUMENTS

CONTRACT 2025.15

MAINE TURNPIKE TOLL TUNNEL REPAIRS
NEW GLOUCESTER – MILE 67.0 AND
WEST GARDINER – MILE 100.2

NOTICE TO CONTRACTORS

PROPOSAL

CONTRACT AGREEMENT

CONTRACT BOND

FINAL LIEN AND CLAIM WAIVER AND AFFIDAVIT

SPECIFICATIONS

MAINE TURNPIKE AUTHORITY

SPECIFICATIONS

The Specifications are divided into two parts:
Part I, Supplemental Specifications and Part II, Special Provisions.

The Maine Turnpike Supplemental Specifications are additions and alterations to the 2014 Maine Department of Transportation Standard Specifications. See Subsection 100.1.

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MAINE TURNPIKE AUTHORITY

NOTICE TO CONTRACTORS

Sealed Proposals will be received by the Maine Turnpike Authority for:

CONTRACT 2025.15

MAINE TURNPIKE TOLL TUNNEL REPAIRS
NEW GLOUCESTER – MILE 67.0 AND
WEST GARDINER – MILE 100.2

at the office of the Maine Turnpike Authority, 2360 Congress Street, Portland, ME, until 11:00 a.m., prevailing time as determined by the Authority on November 13, 2025 at which time and place the Proposals will be publicly opened and read. Bids will be accepted from Contractors **prequalified** by the Maine Department of Transportation for Building or Bridge Construction Projects. All other bids may be rejected. This Project includes a wage determination developed by the State of Maine Department of Labor.

The work consists of repairs to and within access tunnels beneath the Turnpike mainline toll plazas in the Towns of New Gloucester and West Gardiner, Maine. The work includes canopy and tunnel drainage repairs, electrical wiring and electrical cabinet replacement, heating, ventilating, and dehumidification reconstruction, lighting, stairwell enclosure reconstruction, coordination with Maine Turnpike toll vendor, maintenance of traffic and all other work incidental thereto in accordance with the Plans and Specifications.

Plans and Contract Documents may be examined by prospective Bidders weekdays between 8:00 a.m. and 4:30 p.m. at the office of the Maine Turnpike Authority, 2360 Congress Street, Portland, Maine. **The half size Plans** and Contract Documents may be obtained from the Authority upon payment of Fifty ($50.00) Dollars for each set, which payment will not be returned. Checks shall be made payable to: Maine Turnpike Authority. The Plans and Contract Documents may also be downloaded from a link on our website at http://www.maineturnpike.com/project-and-planning/Construction-Contracts.aspx.

For general information regarding Bidding and Contracting procedures, contact Nate Carll, Purchasing Manager, at (207)482-8115 or email at ncarll@maineturnpike.com. For information regarding Schedule of Items, plan holders list and bid results, visit our website at **http://www.maineturnpike.com/project-and-planning/Construction-Contracts.aspx** . For Project specific information, email all questions to Nate Carll, Purchasing Manager, at ncarll@maineturnpike.com. Responses will not be prepared for questions received by telephone. Bidders shall not contact any other Authority staff or Consultants for clarification of Contract provisions, and the Authority will not be responsible for any interpretations so obtained.

All work shall be governed by the Specifications entitled "State of Maine, Department of Transportation, Standard Specifications, Revision of November 2014", "Standard Details,

Revision of November 2020" and "Best Management Practices for Erosion and Sediment Control", latest issue. Copies and recent updates to these publications can be downloaded at: http://www.maine.gov/mdot/contractors/publications/ .

Proposals must be accompanied by an original bid bond, certified or cashier's check payable to the Maine Turnpike Authority in an amount not less than Five (5%) Percent of the Total Amount in the Proposal, but not less than $500.00. The Bidder to whom a Contract is awarded will be required to furnish a Surety Corporation Bond, satisfactory to the Authority, on the standard Contract Bond form of the Authority, for a sum not less than the Total Amount of the Proposal.

Proposals must be made upon the Proposal Forms furnished by the Authority separately with the Contract Documents, and must be enclosed in the sealed special addressed envelope provided therefore bearing the name and address of the Bidder, the name of the Contract, and the date and time of Proposal opening on the outside.

A pre-bid conference will be held on October 30, 2025 at 10:00 a.m. at the Maine Turnpike Authority, 2360 Congress Street, Portland, Maine.

The Authority reserves the unqualified right to reject any or all Proposals and to accept that Proposal which in its sole judgment will under all circumstances serve its best interest.

MAINE TURNPIKE AUTHORITY

Nate Carll
Purchasing Manager
Maine Turnpike Authority

Portland, Maine

Maine Turnpike Authority

MAINE TURNPIKE

PROPOSAL

CONTRACT 2025.15

MAINE TURNPIKE TOLL TUNNEL REPAIRS
NEW GLOUCESTER – MILE 67.0 AND
WEST GARDINER – MILE 100.2

MAINE TURNPIKE AUTHORITY

PROPOSAL

CONTRACT 2025.15

MAINE TURNPIKE TOLL TUNNEL REPAIRS
NEW GLOUCESTER – MILE 67.0 AND
WEST GARDINER – MILE 100.2

TO MAINE TURNPIKE AUTHORITY:

The work consists of repairs to and within access tunnels beneath the Turnpike mainline toll plazas in the Towns of New Gloucester and West Gardiner, Maine. The work includes canopy and tunnel drainage repairs, electrical wiring and electrical cabinet replacement, heating, ventilating, and dehumidification reconstruction, lighting, stairwell enclosure reconstruction, coordination with Maine Turnpike toll vendor, maintenance of traffic and all other work incidental thereto in accordance with the Plans and Specifications.

This Work will be done under a Contract known as Contract 2025.15 according to the Plans and Specifications which are on file in the office of the Maine Turnpike Authority, 2360 Congress Street, Portland, Maine.

On the acceptance of this Proposal for said Work, the undersigned will give the required bond with good security conditioned for the faithful performance of said Work, according to said Plans and Specifications, and the doing of all other work required by said Specifications for the consideration herein named and with the further condition that the Maine Turnpike Authority shall be saved harmless from any and all damages that might accrue to any person, persons or property by reason of the carrying out of said Work, or any part thereof, or by reason of negligence of the undersigned, or any person or persons under his employment and engaged in said Work.

The undersigned hereby declares that he/she has carefully examined the Plans, Specifications and other Contract Documents, and that he/she will contract to carry out and complete the said Work as specified and delineated at the price per unit of measure for each scheduled item of Work stated in the Schedule of Prices as follows:

It is understood that the TOTAL AMOUNT stated by the undersigned in the following Schedule of Prices is based on approximate quantities and will be used solely for the comparison of bids, and that the quantities stated in the Schedule of Prices for the various items are estimates only and may be increased or decreased all as provided in the Specifications.

SCHEDULE OF BID PRICES
CONTRACT NO. 2025.15
TOLL TUNNEL REPAIRS
NEW GLOUCESTER (MM 67.0)
WEST GARDINER (102.0)

Item No	Item Description	Units	Approx. Quantities	Unit Prices in Numbers		Bid Amount in Numbers	
				Dollars	Cents	Dollars	Cents
515.203	Broadcast Sealant for Concrete Surfaces	Square Yard	1,910				
518.40	Epoxy Injection Crack Repair	Linear Foot	200				
518.511	Repair of Concrete Surfaces - Stairwell Steps	Lump Sum	1				
518.512	Repair of Concrete Surfaces - Stairwell Grinding	Each	4				
518.513	Repair of Concrete Surfaces - Stairwell Landing	Each	4				
518.514	Tollbooth Blockout Sealing	Each	10				
526.306	Temporary Concrete Barrier, Type I - Supplied by Authority (600 LF)	Lump Sum	1				
527.341	Work Zone Crash Cushions - TL-3	Unit	1				
631.53	Electrician	Hour	80				
631.54	Electrician's Apprentice	Hour	80				
652.361	Maintenance of Traffic Control Devices	Lump Sum	1				

CARRIED FORWARD:

Item No	Item Description	Units	Approx. Quantities	Unit Prices in Numbers		Bid Amount in Numbers	
				Dollars	Cents	Dollars	Cents
			BROUGHT FORWARD:				
655.1004	#4/0 AWG Wire	Linear Foot	130				
655.101	#6 AWG Wire	Linear Foot	700				
655.103	#10 AWG Wire	Linear Foot	200				
655.12	#12 AWG Wire	Linear Foot	1,880				
655.141	4pr/24 (Category 5e) Cable	Linear Foot	1,700				
655.2021	1" Sch 80 PVC Conduit	Linear Foot	150				
655.203	1 1/2" Sch 80 PVC Conduit	Linear Foot	140				
655.2031	2" Sch 80 PVC Conduit	Linear Foot	90				
655.2032	2 1/2" Sch 80 PVC Conduit	Linear Foot	230				
655.2101	1-1/2" Liquid Tight Metallic Flexible Conduit	Linear Foot	300				
655.2102	2" Liquid Tight Metallic Flexible Conduit	Linear Foot	250				
655.2103	1" Liquid Tight Metallic Flexible Conduit	Linear Foot	100				

CARRIED FORWARD:

Item No	Item Description	Units	Approx. Quantities	Unit Prices in Numbers		Bid Amount in Numbers	
				Dollars	Cents	Dollars	Cents
			BROUGHT FORWARD:				
655.225	Type F Pull Box	Each	1				
655.227	Type H Pull Box	Each	3				
655.228	Type I Pull Box	Each	1				
655.431	60 AMP Panel Board and Cabinet	Each	4				
655.432	100 AMP Panel Board and Cabinet	Each	6				
655.433	225 AMP Panel Board and Cabinet	Each	1				
655.501	1" PVC Conduit Condulets	Each	2				
655.502	1 1/2" PVC Conduit Condulets	Each	2				
655.503	2" PVC Conduit Condulets	Each	2				
655.5031	2 1/2" PVC Conduit Condulets	Each	2				
655.63	4"x4" Plastic NEMA 4R Raceway	Linear Foot	55				
655.64	6"x6" Plastic NEMA 4R Raceway	Linear Foot	715				

CARRIED FORWARD:

Item No	Item Description	Units	Approx. Quantities	Unit Prices in Numbers		Bid Amount in Numbers	
				Dollars	Cents	Dollars	Cents
			BROUGHT FORWARD:				
655.82	Duplex Receptacle	Each	1				
655.84	Quadplex Receptacle	Each	3				
659.10	Mobilization	Lump Sum	1				
800.31	Stairwell Enclosure	Lump Sum	1				
800.32	Tollbooth Canopy Drainage Modifications	Lump Sum	1				
800.33	Heating, Ventilation, and Dehumidification	Lump Sum	1				
					TOTAL:		

Acknowledgment is hereby made of the following Addenda received since issuance of the Plans and Specifications: _____

_____

_____

Accompanying this Proposal is an original bid bond, cashiers or certified check on _____ Bank, for _____, payable to the Maine Turnpike Authority. In case this Proposal shall be accepted by the Maine Turnpike Authority and the undersigned should fail to execute a Contract with, and furnish the security required by the Maine Turnpike Authority as set forth in the Specifications, within the time fixed therein, an amount of money equal to Five (5%) Percent of the Total Amount of the Proposal for the Contract awarded to the undersigned, but not less than $500.00, obtained out of the original bid bond, cashier's or certified check, shall become the property of the Maine Turnpike Authority; otherwise the check will be returned to the undersigned.

The performance of said Work under this Contract will be completed during the time specified in Subsection 107.1.

It is agreed that time is of the essence of this Contract and that I (we) will, in the event of my (our) failure to complete the Work within the time limit named above, pay to Maine Turnpike Authority liquidated damages in the amount or amounts stated in the Specifications.

The undersigned is an Individual/Partnership/Corporation under the laws of the State of _____, having principal office at _____, thereunto duly authorized.

_____ *(SEAL)*

_____ *(SEAL)*

Affix Corporate Seal
or Power of Attorney
Where Applicable

_____ *(SEAL)*

By: _____

Its: _____

Information below to be typed or printed where applicable:

INDIVIDUAL:

_____	_____
(Name)	(Address)

PARTNERSHIP - Name and Address of General Partners:

_____	_____
(Name)	(Address)
_____	_____
(Name)	(Address)
_____	_____
(Name)	(Address)
_____	_____
(Name)	(Address)

INCORPORATED COMPANY:

_____	_____
(President)	(Address)
_____	_____
(Vice-President)	(Address)
_____	_____
(Secretary)	(Address)
_____	_____
(Treasurer)	(Address)

MAINE TURNPIKE AUTHORITY

MAINE TURNPIKE

YORK TO AUGUSTA

CONTRACT AGREEMENT

This Agreement made and entered into between the Maine Turnpike Authority, and sometimes termed the "Authority", and _____

_____

herein termed the "Contractor":

WITNESSETH: That the Authority and the Contractor, in consideration of the premises and of the mutual covenants, considerations and agreements herein contained, agree as follows:

FIRST: The parties hereto mutually agree that the documents attached hereto and herein incorporated and made a part hereof collectively evidencing and constituting the entire Contract to the same extent as if herein written in full, are the Notice to Contractors, the Accepted Proposal, the Specifications, the Plans, this Agreement, the Contract Bond and all Addenda to the Contract Documents duly issued and herewith enumerated:

_____

_____

SECOND: The Contractor for and in consideration of certain payments to be made as hereafter specified, hereby covenants and agrees to perform and execute all of the provisions of this Contract and of all documents and parts attached hereto and made a part thereof, and at his own cost and expense to furnish and perform everything necessary and required to construct and complete, ready for its intended purpose, in accordance with the Contract and such instructions as the Engineer may give, acceptable to the Authority, in the times provided, all of the Work covered and included under Contract No. _____ covering _____ as herein described.

THIRD: In consideration of the performance by the Contractor of his covenants and agreements as herein set forth, the Authority hereby covenants and agrees to pay the Contractor according to the Schedule of Prices set forth in the Proposal with additions and deductions as elsewhere herein provided in the times and in the manner stated in the Specifications. This Agreement shall insure to the benefit of, and shall be binding upon the parties hereto, and upon their respective successors and assigns; but neither party hereto shall assign or transfer his interest herein in whole or in part without the consent of the other, except as herein provided.

IN WITNESS WHEREOF the parties to this Agreement have executed the same in quintuplicate.

AUTHORITY -

MAINE TURNPIKE AUTHORITY

By: _____

Title: CHAIRMAN

Date of Signature: _____

ATTEST:

_____
Secretary

CONTRACTOR -

_____
CONTRACTOR

By: _____

Title: _____

Date of Signature: _____

WITNESS:

_____

CONTRACT BOND

KNOW ALL MEN BY THESE PRESENTS that _____

of _____ in the County of _____ and State of _____

as Principal, and _____ a Corporation duly organized under the

laws of the State of _____ and having a usual place of business in _____

_____

As Surety, are held and firmly bound unto the Maine Turnpike Authority in the sum of _____Dollars ($_____.___), to be paid to said Maine Turnpike Authority, or its successors, for which payment, well and truly to be made, we bind ourselves, our heirs, executors, successors and assigns jointly and severally by these presents.

The condition of this obligation is such that the Principal, designated as Contractor in the foregoing Contract No. _____ shall faithfully perform the Contract on his part and satisfy all claims and demands incurred for the same and shall pay all bills for labor, material, equipment and all other items contracted for, or used by him, in connection with the Work contemplated by said Contract, and shall fully reimburse the Obligee for all outlay and expense which the Obligee may incur in making good any default of said Principal, then this Obligation shall be null and void; otherwise it shall remain in full force and effect.

Signed and sealed this _____ day of _____, A.D., 202___

Witnesses: CONTRACTOR

_____ _____ *(SEAL)*

_____ _____ *(SEAL)*

_____ _____ *(SEAL)*

SURETY

_____ _____ *(SEAL)*

_____ _____ *(SEAL)*

_____ _____ *(SEAL)*

(Surety must attach copy of Power of Attorney showing authority of Office or Agent to execute bonds)

FINAL LIEN AND CLAIM WAIVER AND AFFIDAVIT

Upon receipt of the sum of _____, which sum represents the total amount paid, including the current payment for work done and materials supplied for Project No. _____, in _____, Maine, under the undersigned's Contract with the Maine Turnpike Authority.

The undersigned, on oath, states that the Final Payment of _____ is the final payment for all work, labor, materials, services and miscellaneous (all of which are hereinafter referred to as "Work Items") supplied to the said Project through _____and that no additional sum is claimed by the undersigned respecting said Project.

The undersigned, on oath, states that all persons and firms who supplied Work Items to the undersigned in connection with said Project have been fully paid by the undersigned for such Work Items or that such payment will be fully effected immediately upon receipt of this payment.

In consideration of the payment herewith made, the undersigned does fully and finally release and hold harmless the Maine Turnpike Authority, and its Surety, if any, from any and all claims, liens or right to claim or lien, arising out of this Project under any applicable bond, law or statute.

It is understood that this Affidavit is submitted to assure the Owner and others that all liens and claims relating to the Work Items furnished by the undersigned are paid.

_____
(Contractor)

By: _____

Title: _____

State of MAINE

County of _____

I, _____, hereby certify on behalf of _____
(Company Officer) *(Company Name)*

its _____, being first duly sworn and stated that the foregoing representations are
(Title)

are true and correct upon his own knowledge and that the foregoing is his free act and deed in said capacity and the free act and deed of the above-named

_____

.

(Company Name)

The above-named, _____, personally appeared before me this ____ day of _____ and swears that this is his free act and deed.

(SEAL)

_____
Notary Public

My Commission Expires: _____

MAINE TURNPIKE AUTHORITY

SPECIFICATIONS

PART I – SUPPLEMENTAL SPECIFICATIONS

(Rev. November 10, 2016)

MAINE TURNPIKE AUTHORITY

SPECIFICATIONS

PART II – SPECIAL PROVISIONS

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PART II - SPECIAL PROVISIONS

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MAINE TURNPIKE AUTHORITY

SPECIFICATIONS

PART II - SPECIAL PROVISIONS

All work shall be governed by the Maine Department of Transportation Standard Specifications, Revision of November 2014, except for that work which applies to sections of the Maine Department of Transportation Standard Specifications which are amended by the Maine Turnpike Supplemental Specifications and the following modifications, additions and deletions.

General Description of Work

The work consists of repairs to and within access tunnels beneath the Turnpike mainline toll plazas in the Towns of New Gloucester and West Gardiner, Maine. The work includes canopy and tunnel drainage repairs, electrical wiring and electrical cabinet replacement, heating, ventilating, and dehumidification reconstruction, lighting, stairwell enclosure reconstruction, coordination with Maine Turnpike toll vendor, maintenance of traffic and all other work incidental thereto in accordance with the Plans and Specifications.

Plans

The drawings included in these Contract Documents, and referred to as the Plans, show the general character of the work to be done under this Contract. They bear the general title "Maine Turnpike – Contract 2025.15 – Toll Tunnel Repairs – New Gloucester, Mile 67.0 and West Gardiner, Mile 100.2".The right is reserved by the Resident to make such minor corrections or alterations in the Plans as he deems necessary without change in the unit prices on the Schedule of Prices of the Proposal.

101.2 Definition

Holidays

The following is added after Memorial Day in the Supplemental Specifications:

Christmas 2025	12:01 p.m. (Noon) preceding Wednesday to 6:00 a.m. the following Monday
New Years 2026	12:01 p.m. (Noon) preceding Wednesday to 6:00 a.m. the following Friday

103.4 Notice of Award

The following sentence is added:

The Maine Turnpike Authority Board is scheduled to consider the Contract Award on November 20, 2025.

104.3.8 Wage Rates and Labor Laws

Section 104.3.8 Wage Rates and Labor Laws has been amended as follows:

The fair minimum hourly rates determined by the State of Maine Department of Labor for this Contract are as follows:

THIS DOCUMENT MUST BE CLEARLY POSTED AT ALL CONSTRUCTION SITES FUNDED IN PART WITH STATE FUNDS

State of Maine
Department of Labor
Bureau of Labor Standards
Augusta, Maine 04333-0045
Telephone (207) 623-7906

Wage Determination - In accordance with 26 MRS §1301 et. seq., this is a determination by the Bureau of Labor Standards, of the fair minimum wage rate to be paid to laborers and workers employed on the below titled project.

2025 Fair Minimum Wage Rates – Heavy & Bridge Cumberland County

Occupational Title	Minimum Wage	Minimum Benefit	Total
Brickmasons And Blockmasons	$31.00	$6.52	$37.52
Bulldozer Operator	$32.68	$5.28	$37.96
Carpenter	$30.78	$4.43	$35.21
Cement Masons And Concrete Finisher	$24.35	$15.65	$40.00
Construction And Maintenance Painters	$45.01	$26.14	$71.15
Construction Laborer	$27.00	$4.94	$31.94
Crane And Tower Operators	$44.07	$6.92	$50.99
Crushing Grinding And Polishing Machine Operators	$27.50	$5.64	$33.14
Earth Drillers - Except Oil And Gas	$22.42	$4.18	$26.60
Electrical Power - Line Installer And Repairers	$53.13	$21.58	$74.71
Electricians	$32.00	$8.91	$40.91
Elevator Installers And Repairers	$71.21	$43.75	$114.96
Excavator Operator	$37.88	$6.67	$44.55
Fence Erectors	$22.00	$2.06	$24.06
Flaggers	$21.50	$0.54	$22.04
Floor Layers - Except Carpet/Wood/Hard Tiles	$26.50	$3.83	$30.33
Glaziers	$46.26	$22.61	$68.87
Grader/Scraper Operator	$31.00	$6.86	$37.86
Hazardous Materials Removal Workers	$21.13	$1.14	$22.27
Heating And Air Conditioning And Refrigeration Mechanics And Installers	$35.00	$5.49	$40.49
Heavy And Tractor - Trailer Truck Drivers	$29.75	$2.52	$32.27
Highway Maintenance Workers	$22.85	$4.79	$27.64
Industrial Machinery Mechanics	$29.50	$3.83	$33.33
Industrial Truck And Tractor Operators	$26.17	$3.49	$29.66
Insulation Worker - Mechanical	$25.50	$6.07	$31.57
Ironworker - Ornamental	$31.37	$25.82	$57.19
Light Truck Or Delivery Services Drivers	$28.00	$3.95	$31.95
Loading Machine And Dragline Operators	$34.63	$4.94	$39.57
Millwrights	$34.50	$7.70	$42.20
Mobile Heavy Equipment Mechanics - Except Engines	$42.50	$4.04	$46.54
Operating Engineers And Other Equipment Operators	$41.25	$8.91	$50.16
Paving Surfacing And Tamping Equipment Operators	$28.00	$5.04	$33.04
Pile-Driver Operators	$36.00	$2.87	$38.87
Pipe/Steam/Sprinkler Fitter	$33.25	$8.37	$41.62
Pipelayers	$27.48	$4.72	$32.20
Plumbers	$35.00	$4.47	$39.47
Pump Operators - Except Wellhead Pumpers	$56.03	$34.76	$90.79
Radio Cellular And Tower Equipment Installers	$30.00	$4.85	$34.85
Reinforcing Iron And Rebar Workers	$31.95	$25.00	$56.95
Riggers	$30.50	$8.25	$38.75
Roofers	$24.67	$4.23	$28.90
Sheet Metal Workers	$27.00	$6.21	$33.21
Structural Iron And Steel Workers	$31.50	$20.09	$51.59
Tapers	$28.50	$3.93	$32.43
Telecommunications Equipment Installers And Repairers - Except Line Installers	$29.00	$5.43	$34.43
Telecommunications Line Installers And Repairers	$28.00	$1.84	$29.84

Welders are classified as the trade to which welding is incidental (e.g. welding structural steel is Structural Iron and Steel Worker)

Apprentices – The minimum wage rates for registered apprentices are the rates recognized in the sponsorship agreement for registered apprentices working in the pertinent classification.

For any other specific trade on this project not listed above, contact the Bureau of Labor Standards for further clarification.

Title 26 §1310 requires that a clearly legible statement of all fair minimum wage and benefits rates to be paid the several classes of laborers, workers and mechanics employed on the construction on the public work must be kept posted in a prominent and easily accessible place at the site by each contractor and subcontractor subject to sections 1304 to 1313.

Appeal – Any person affected by the determination of these rates may appeal to the Commissioner of Labor by filing a written notice with the Commissioner stating the specific grounds of the objection within ten (10) days from the filing of these rates.

A true copy

Attest: Scott R. Cotnoir
Scott R. Cotnoir
Wage & Hour Director
Bureau of Labor Standards

Expiration Date: 12-31-2025
Revision Date: 2-3-2025

THIS DOCUMENT MUST BE CLEARLY POSTED AT ALL CONSTRUCTION SITES FUNDED IN PART WITH STATE FUNDS

State of Maine
Department of Labor
Bureau of Labor Standards
Augusta, Maine 04333-0045
Telephone (207) 623-7906

Wage Determination - In accordance with 26 MRS §1301 et. seq., this is a determination by the Bureau of Labor Standards, of the fair minimum wage rate to be paid to laborers and workers employed on the below titled project.

2025 Fair Minimum Wage Rates – Heavy & Bridge Kennebec County

Occupational Title	Minimum Wage	Minimum Benefit	Total
Brickmasons And Blockmasons	$31.00	$6.52	$37.52
Bulldozer Operator	$40.90	$32.21	$73.11
Carpenter	$29.85	$6.59	$36.44
Cement Masons And Concrete Finisher	$26.50	$0.00	$26.50
Construction And Maintenance Painters	$26.50	$6.00	$32.50
Construction Laborer	$25.40	$21.28	$46.68
Crane And Tower Operators	$37.25	$8.33	$45.58
Crushing Grinding And Polishing Machine Operators	$27.50	$5.64	$33.14
Earth Drillers - Except Oil And Gas	$22.42	$4.18	$26.60
Electrical Power - Line Installer And Repairers	$40.10	$9.88	$49.98
Electricians	$37.50	$7.10	$44.60
Elevator Installers And Repairers	$71.21	$43.75	$114.96
Loading Machine And Dragline Operators	$41.13	$32.21	$73.34
Excavator Operator	$41.13	$32.21	$73.34
Fence Erectors	$22.00	$2.06	$24.06
Flaggers	$25.40	$21.28	$46.68
Floor Layers - Except Carpet/Wood/Hard Tiles	$26.50	$3.83	$30.33
Glaziers	$46.26	$22.61	$68.87
Grader/Scraper Operator	$31.00	$6.86	$37.86
Hazardous Materials Removal Workers	$21.13	$1.14	$22.27
Heating And Air Conditioning And Refrigeration Mechanics And Installers	$35.00	$5.49	$40.49
Heavy And Tractor - Trailer Truck Drivers	$26.25	$5.55	$31.80
Highway Maintenance Workers	$22.85	$4.79	$27.64
Industrial Machinery Mechanics	$29.50	$3.83	$33.33
Industrial Truck And Tractor Operators	$26.17	$3.49	$29.66
Insulation Worker - Mechanical	$25.50	$6.07	$31.57
Ironworker - Ornamental	$31.37	$25.82	$57.19
Light Truck Or Delivery Services Drivers	$28.00	$3.95	$31.95
Millwrights	$34.96	$8.61	$43.57
Mobile Heavy Equipment Mechanics - Except Engines	$33.50	$8.10	$41.60
Operating Engineers And Other Equipment Operators	$45.94	$32.21	$78.15
Paving Surfacing And Tamping Equipment Operators	$29.25	$4.61	$33.86
Pile-Driver Operators	$36.00	$2.87	$38.87
Pipe/Steam/Sprinkler Fitter	$33.25	$8.37	$41.62
Pipelayers	$27.48	$4.72	$32.20
Plumbers	$35.00	$4.47	$39.47
Pump Operators - Except Wellhead Pumpers	$56.03	$34.76	$90.79
Radio Cellular And Tower Equipment Installers	$30.00	$4.85	$34.85
Reinforcing Iron And Rebar Workers	$32.00	$4.68	$36.68
Riggers	$30.50	$8.25	$38.75
Roofers	$24.67	$4.23	$28.90
Sheet Metal Workers	$27.00	$6.21	$33.21
Structural Iron And Steel Workers	$32.00	$8.43	$40.43
Tapers	$28.50	$3.93	$32.43
Telecommunications Equipment Installers And Repairers - Except Line Installers	$29.00	$5.43	$34.43
Telecommunications Line Installers And Repairers	$16.50	$4.28	$20.78

Welders are classified as the trade to which welding is incidental (e.g. welding structural steel is Structural Iron and Steel Worker)

Apprentices – The minimum wage rates for registered apprentices are the rates recognized in the sponsorship agreement for registered apprentices working in the pertinent classification.

For any other specific trade on this project not listed above, contact the Bureau of Labor Standards for further clarification.

Title 26 §1310 requires that a clearly legible statement of all fair minimum wage and benefits rates to be paid the several classes of laborers, workers and mechanics employed on the construction on the public work must be kept posted in a prominent and easily accessible place at the site by each contractor and subcontractor subject to sections 1304 to 1313.

Appeal – Any person affected by the determination of these rates may appeal to the Commissioner of Labor by filing a written notice with the Commissioner stating the specific grounds of the objection within ten (10) days from the filing of these rates.

A true copy

Attest: Scott R. Cotnoir
Scott R. Cotnoir
Wage & Hour Director
Bureau of Labor Standards

Expiration Date: 12-31-2025

105.8.2 Permit Requirements

The Project is subject to the Stormwater Memorandum of Agreement for Stormwater Management Between the Maine Department of Transportation, Maine Turnpike Authority, and Maine Department of Environmental Protection (Stormwater MOA). Under the Stormwater MOA, all MTA construction, operation, and maintenance activities are subject to Maine Stormwater Law Basic Standards through implementation of MaineDOT's Best Management Practices for Erosion and Sedimentation Control (MaineDOT BMP Manual), which are the Contractor's responsibility to implement. Under the Stormwater MOA, certain projects may also require the construction of permanent post-construction stormwater management BMPs, as specified in the plan set to this project where applicable.

The Contractor shall prepare a LOD plan illustrating the Contractor's proposed limit of earthwork disturbance. The LOD plan shall show all construction access locations, field office locations, material and temporary waste storage locations, as well as include the Contract limits of earthwork disturbance. All applicable erosion and sedimentation control devices needed shall be detailed on the Contractor's LOD plan and are not limited to those devices shown on the Contract LOD plan. **This Plan shall be submitted for review and approval, to the Resident within 14 days of Contract award.** Payment for creating, revising, and completing this plan shall be incidental to Item 659.10, Mobilization.

The LOD for this Contract has been estimated to be **0.1** acres.

If, at any time during the Contract, the Limit of Disturbance needs to be adjusted to accommodate construction activities, the Contractor shall resubmit the LOD plan (including any additional erosion and sedimentation control measures needed) to the Resident for review and approval prior to any additional disturbance taking place:

- The Resident shall have a minimum of five (5) working days to approve the revised LOD plan.
- For contracts with a project-specific NOI, if the cumulative area of disturbance exceeds the estimated LOD noted above, the Resident shall first approve of the plan and then possibly resubmit the NOI to Maine DEP for approval. The approval may take a minimum of 14 working days from the date of submittal to Maine DEP.

Compliance with the erosion and sedimentation control requirements outlined in this Contract is required by the Contractor.

105.11 As-Built Plans

The Contractor shall provide the Authority with as-built plans in PDF and MicroStation or AutoCAD. The as-built plans shall note changes to the bid documents, including, but not limited to pavement, concrete, barrier, guardrail, culverts, drainage, foundations, wiring, signs, etc. The as-builts plans shall also provide GPS accurate locations of all underground work. Submittal of Draft, Final Draft, and 100% as-built plans to the Resident shall be conditions of Mobilization Payment, Retainage Reduction,

and Final Payment as noted in Special Provision 108.

105.11.1 As-Built Plan Submittals

The Contractor shall make the following submittals of as-built plans to the Resident as part of the conditions of Mobilization Payment, Retainage Reduction, and Final Payment as noted in Special Provision 108:

a. Draft As-built Plans containing any underground work completed within the prior 30 day period once 50% of the Work is complete.
b. Final Draft As-Built Plans containing all underground work
c. 100% As-Built Plans containing all underground work and changes

105.11.2 As Built Plan Requirements

As-built plans and CADD files shall conform to the following requirements:

a. Include legend of line weights and styles
b. Project stationing shall be on its own layer and be color white
c. Changes to pavement, concrete, barrier, guardrail, foundations, signs etc. shall be on their own layer and be color brown
d. Electric power lines, cable, conduit, and lighting cables shall be on their own layer and be color red
e. Gas, oil, steam, petroleum, or gaseous materials shall be on their own layer and be color yellow
f. Communication, alarm or signal lines, cables, or conduit shall be on their own level and be color orange
g. Potable water shall be on its own layer and be color blue
h. Sewers and drain lines shall be on their own layer and be color green
i. Reclaimed water, irrigation, and slurry lines shall be on their own level and be color purple

107.1 Contract Time and Contract Completion Date

This Subsection is amended by the addition of the following:

All work shall be completed on or before October 30, 2026. Tunnel rehabilitation at both locations shall be substantially complete by October 09, 2026.

107.1.1 Substantial Completion

This Subsection is amended by the addition of the following:

Substantially complete shall be defined by the Authority as the following:

- All tunnel repairs, drainage modifications, heating, ventilating, and dehumidification, all electrical infrastructure replacement, all stairwell enclosures, all lighting, and all connections to emergency backup power complete, tested, and functioning.

- All toll plaza lanes fully opened to traffic including shoulders.
- All disturbed slopes loamed, seeded and mulched, temporary erosion control mix and/or blanket installed where necessary.

Supplemental Liquidated damages on a calendar day basis in accordance with Subsection 107.8 shall be assessed for each calendar day that substantial completion is not achieved.

107.1.1 Limitations of Operations

Construction of the Toll Plaza Tunnel Repairs shall not, in the opinion of the Resident, prohibit the safe and reasonable operations of MTA toll staff. The Contractor shall provide clear access to all toll booths and emergency egress from tunnels at all times during construction.

The Contractor shall not block existing MTA parking at the toll plazas. At daily shift changes, 6 AM, 2 PM, and 10 PM, the Contractor shall provide clear access to and egress from a minimum of two parking spaces within the closed EZ-Pass Only lane within the northbound Cash Lanes portion of the New Gloucester toll plaza, and shall provide clear access to and egress from a minimum of two parking spaces on the right shoulder of the southbound West Gardiner toll plaza. The Contractor shall also provide safe parking for MTA Maintenance vehicles as may be needed for service and repair activities.

The Contractor shall provide one standard porta-potty, for exclusive MTA staff use, at each Toll Plaza for the duration of the Contract. The porta-potties shall be cleaned a minimum of once per week. Final location of the porta-potties shall be determined in the field as directed by the Resident. Supplying, cleaning, moving, and maintaining access to the porta-potties shall not be measured for payment but shall be incidental to Pay Item 659.10 Mobilization.

The Contractor shall submit their proposed staging, storage and construction areas for approval to the Resident. The Contractor shall be responsible for minimizing the footprint of the project, and resulting impacts to the MTA, to the extent practical. The Authority will not allow the Contractor to store materials on site prior to starting work. Site access and final area used for storage shall be coordinated and approved by the Resident.

The Contractor shall be responsible for maintaining all utility services, including backup power at all times during construction, except as noted herein. Toll systems, EZ Pass and Cash, shall not be interrupted except as follows. The Contractor shall coordinate through the MTA, with the MTA Toll vendor to schedule all required power and communication interruptions. Such interruptions shall be scheduled a minimum of 14 calendar days prior to the interruption. The following system outages are allowed and shall be scheduled and approved by the MTA at least two weeks prior to the beginning of any outage: Backup power: Not to exceed four hours. Limited to between June 1st and October 15th; Domestic water service: Not to exceed one week.

The Contractor is responsible to keep all temporarily closed toll lanes free of snow and ice at all times for the duration of the approved closure. This includes maintaining snow-free access to the porta-potty. Snow and ice removal shall be coordinated with MTA Maintenance. Snow and ice shall not be moved into open travel lanes or shoulders. Maintaining snow and ice-free conditions shall not be measured for payment but shall be incidental to Pay Item 659.10 Mobilization.

107.4.6 Prosecution of Work

The following activities shall have the time limitations as specified:

- Demolition and reconstruction of the stairwell enclosures shall be scheduled as early in the contract as possible to minimize requirements for temporary lane closures during cold weather.
- The Contractor will be allowed a seven-day period to close the tunnel stairwell, restricting toll staff passage, for constructing the stairwell enclosure and other repairs that would normally impede passage.
- Outside of the seven-day period, the Contractor shall provide, at a minimum, during daily shift changes at 6 AM, 2 PM, and 10 PM, safe passage for MTA staff.
- Installation of sump pit discharge pipe shall be scheduled for non-frost conditions.
- Foundation support for the make-up air unit shall not be installed with frost in the ground.
- A minimum of one cash lane shall remain open at all times. All lane closures shall be approved by MTA before closure. All lane closures are subject to reopening within a two-hour period as may be requested by MTA. See Special Provision 652 for more information.

The Contractor shall submit to the Authority a construction schedule which shall document that the Contractor has the necessary labor and equipment to work immediately and continuously at the project site once the left-most EZ-Pass lane in the Cash Lanes is closed. The intent of this specification is to minimize the amount of time for lane closure, while providing the Contractor sufficient time to complete the work in a diligent manner and reopen the full toll plaza as prescribed by the project's Substantial Completion date.

108.2.1 Generation of Progress Payments

The Authority will estimate the amount of Work performed at least monthly and make payment based upon such estimates. Estimates may be paid bimonthly (twice-a-month) if the bimonthly (twice-a-month) invoices exceed $100,000. No such estimates or payment will be made if, in the judgment of the Authority, the Work is not proceeding in accordance with the provisions of the Contract. The Contractor agrees to waive all claims related to the timing and amount of such estimates.

108.2.3 Mobilization Payment

The second paragraph is deleted in its entirety and replaced with the following:

Upon approval of all pre-construction submittals required for approval by this Contract, including those listed in Section 104.4.2 – Preconstruction Conference, the Contractor will receive payment of 50% of the Lump Sum price for Mobilization, not to exceed 5% of the Bid less the amount bid for Mobilization. After the Authority determines that the Work is 50% complete and the Contractor has submitted a Draft (50%) as-built

submittal of all underground work to date (within the prior 30 day pay period) as defined in Special Provision 105., the Contractor will receive the other 50% of the Lump Sum price for Mobilization, not to exceed 5% of the Bid less the amount bid for Mobilization. Any remaining Mobilization will be at the completion of physical work.

108.3 Retainage

The seventh paragraph is deleted in its entirety and replaced with the following:

When requested by the Contractor, an 80 percent reduction of retainage will be considered by the Authority when the Project is substantially complete and the Contractor has submitted a Final Draft (98%) as-built submittal of all underground work, in accordance with Special Provision 105. When requesting a reduction, the Contractor shall include an explanation of the outstanding Work, an estimate of the cost to complete the Work, and a schedule for completing the Work. Seasonal limitations as well as warranty and establishment periods (for vegetation) shall be addressed.

SPECIAL PROVISION

SECTION 515

PROTECTIVE COATING FOR CONCRETE SURFACES

(Broadcast Sealant for Concrete Surfaces)

Section 515, Protective Coating for Concrete Surfaces, is deleted in its entirety and replaced with the following:

515.01 Description

The work shall include the surface preparation and application of a broadcast sealant on concrete surfaces to repair the concrete cash lane roadway slabs at the West Gardinier and New Gloucester Toll Plazas. The coating system shall be applied to the concrete roadway slabs, toll booth islands and ORT equipment islands as shown on the plans in accordance with these Specifications and the manufacturer's published recommendations.

The repair of cracks greater than or equal to 0.06 inches, or the manufacturer's recommendation for maximum crack width, and the longitudinal construction joint shall be completed in accordance with Special Provision 518 Epoxy Injection Crack Repair and Special Provision 518 Longitudinal Joint Repair, respectively, before applying the broadcast sealant.

515.02 Materials

The broadcast sealer shall be one of the following three products or an approved equal.

- T-78 Methyl Methacrylate Crack Sealer, as manufactured by Transpo Industries, Inc.
- KBP 204 P Seal, as manufactured by Kwik Bond Polymers
- MasterSeal 630, as manufactured by BASF

The product shall comply with regulations limiting the Volatile Organic Compound (VOC) content of architectural and industrial maintenance coatings.

The Contractor shall submit the product data sheets, material safety data sheets and recommended instructions for application of the proposed sealer.

Materials shall be delivered to the site in original packages or containers bearing the manufacturer's labels and identification.

515.03 Surface Preparation

Concrete surfaces shall be cleaned free of dust, surface dirt, oil, efflorescence and contaminants to ensure penetration of the sealer. Additional surface preparation shall be performed in strict conformance with the manufacturer's published recommendations.

The Contractor may use, when required, appropriate cleaning materials recommended by the sealer manufacturer in conjunction with high pressure water for cleaning the concrete or masonry. Collect all debris and other material removed from the surface and cracks and dispose of in accordance with applicable federal, state, and local regulations.

Cover deck drains, expansion joints, or all other surfaces which are not to be coated with the broadcast sealer.

The Resident shall approve the prepared surface prior to applying the sealer.

515.04 Application

The Contractor shall apply the sealer in strict accordance with the manufacturer's published recommendations. If there is a conflict between the manufacturer's recommendations and the restrictions below, the stricter of the two criteria shall apply.

The application shall not be conducted when surface and air temperatures are outside the range recommended by the manufacturer. The work shall not be conducted when there is a chance of the surface and air temperature falling outside of the recommended temperature range during the appropriate cure time for the air temperature plus 4 hours; nor should it be applied on hot, windy days.

The treatment shall not be applied during rain to wet surfaces or when there is a chance of rain within 24-hours after application. Following any rain fall, allow the concrete surface to air dry a minimum of 48 hours before applying broadcast sealant. After treatment, surfaces should be protected from rain for not less than 48-hours. It shall not be applied when winds are sufficient to carry airborne chemicals to unprotected surfaces.

Prior to applying the sealer, the Contractor shall protect all surrounding non-masonry/non-concrete surfaces, landscape and lawn areas, and surfaces not designated for treatment, from contact with the penetrating sealer, and prevent overspray of the penetrating sealer caused by wind drift. Provide shielding as necessary to prevent dust, debris, and overspray from striking vehicular traffic.

The Contractor shall ensure that all safety equipment, facilities and precautions recommended by the product manufacturer are furnished and/or strictly adhered to.

The sealer material shall be applied in the manner and with the equipment recommended by the product manufacturer. Coverage will vary depending on condition, texture and porosity of the surfaces. A second coat may be required on very porous substrates. Pre-testing is required.

Sealer shall be applied as packaged without dilution or alteration. Sufficient material shall be applied to thoroughly saturate the surface making sure to brush out excess material that does not penetrate.

When the sealer is applied to horizontal surfaces, it shall be applied in a single saturating application with sufficient material and applied so the surface remains wet for one to two minutes

before penetration into the concrete. Surface residues, pools and puddles shall be broomed-out thoroughly until they completely penetrate into the surface.

Broadcast sand shall be applied either by hand or mechanical means on the entire treated area of concrete surfaces prior to cure to achieve a uniform coverage. Follow the Manufacturer's requirements for the amount of sand per square area. Place the sand as the sealant begins to gel. Placing of the sand before the gelling of the sealant may cause settlement, excessive coating of the sand, and loss of friction characteristics. Additional sand that does not adhere to the sealant shall be brushed off. The surface shall be inspected and approved by the Resident before allowing traffic to resume. An alternative to sand, if the manufacturer's requirements allow, is providing a brushed finish for skid resistance.

515.05 Storage

Store in factory sealed containers of unmixed material at temperatures within the range recommended by the manufacturer away from direct sunlight and sources of heat. Once the container is opened for product use the manufacturers requirements shall be followed for storage and the product shall not be used if the recommended shelf life is exceeded.

515.06 Method of Measurement

Broadcast Sealant for Concrete Surfaces will be measured for payment by the square yard, satisfactorily applied and accepted.

515.07 Basis of Payment

Broadcast Sealant for Concrete Surfaces will be paid at the Contract unit price per square yard which price shall be full compensation for all labor, materials, equipment and incidentals required for furnishing and applying the sealer, in accordance with these Specifications or as approved by the Resident.

Surface preparation and protection of surfaces not designated for treatment will not be measured separately for payment, but shall be incidental to the Broadcast Sealant for Concrete Surfaces item.

Payment will be made under:

Pay Item		Pay Unit
515.203	Broadcast Sealant for Concrete Surfaces	Square Yard

SPECIAL PROVISION

SECTION 518

STRUCTURAL CONCRETE REPAIR

(Epoxy Injection Crack Repair)

518.01 Description

The following paragraphs are added:

The work includes Epoxy Injection Crack Repair of concrete cracks with widths equal to or greater than 1/8 inches as shown on the Plans, or identified by the Resident. Epoxy Injection Crack Repair shall be completed for entire length of tunnel and stairwells.

518.02 Repair Materials.

The following paragraphs are added:

Epoxy Injection Crack Repair shall be completed using a high strength, low viscosity moisture tolerant epoxy resin meeting the minimum requirements in the table below and recommended by the manufacturer for the required application. The proposed repair materials shall be submitted to the Resident for approval.

Tensile Strength (@ 7 days)	5,000 psi	ASTM D638
Bond Strength (@ 14 days)	1,000 psi	ASTM C882
Compressive Strength (@ 3 days, 73 °F)	5,000 psi	ASTM D695
Compressive Modulus (@ 7 days)	250 ksi	ASTM D695
Flexural Strength (@14 days)	8,000 psi	ASTM D790

518.07 Placing Repair Materials

The following Subsection is added:

518.071 Placing Epoxy Injection Materials

a) Mix epoxy components per manufacturer's instructions. Review pot life characteristics of combined materials and prepare quantities accordingly;

b) Open all injection ports along the crack and ensure that all injection ports are securely fastened to the concrete substrate;

c) Attach injection device to the lowest port on vertical cracks, or the first port in the series on horizontal cracks;

d) Slowly and under constant pressure, inject the epoxy material into the first port until the epoxy flows out of the next port in the series. While maintaining constant pressure and

flow at the first port, close the adjacent port and continue injection process until epoxy flows from the subsequent port in the series, or until no additional epoxy can be injected into the first port.

e) Repeat the above procedure until all ports have been injected.

518.10 Method of Measurement

The quantity of Epoxy Injection Crack Repair will be measured by the linear foot.

518.11 Basis of Payment

The following paragraphs are added:

Epoxy Injection Crack Repair will be paid at the Contract unit price per linear foot, which price shall include, but not necessarily be limited to: cleaning and preparation of existing concrete, drilling of port holes, placing, curing and finishing epoxy and all materials, labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
518.40	Epoxy Injection Crack Repair	Linear Foot

SPECIAL PROVISION

SECTION 518

STRUCTURAL CONCRETE REPAIR

(Repair of Concrete Surfaces - Stairwells)

518.01 Description

The work shall include removing existing aluminum stair tread nosing and all deteriorated concrete followed by placement of new concrete as shown on the Plans and described herein. Concrete for stair treads shall receive a broom finish. Repairs are only required in the stairwells that are to remain in service:

- New Gloucester Southbound Stairwell – Removed from service
- New Gloucester Northbound Stairwell – Remain in service
- West Gardiner Southbound Stairwell – Removed from service
- West Gardiner Northbound Stairwell – Remain in service

The work shall also include grinding the top surface of the island concrete in front of each stairwell doorway as shown on the plans. Grinding shall produce a clean, uniform surface with a maximum surface roughness of ±1/8 inch in amplitude, or as otherwise approved by the Resident.

In West Gardiner, the work shall also include removing and capping the existing floor drain and sloping the base stairwell landing floor slab towards the tunnel drain trough in both stairwells, as shown in the Plans.

In New Gloucester, both stairwells, base landing floor drain should be tested for functionality. If drain is functional, no modifications are required and the drain and floor shall remain as is. If the drain is not functional, the existing floor drain shall be removed and capped with the floor slab being modified to slope towards the tunnel drain trough similar, to the West Gardiner repair, as shown in the Plans.

At stairwell landing floor slab repairs, the Contractor shall apply a bonding agent to the existing concrete prior to placing the new concrete. Bonding agent shall be selected from the MaineDOT qualified products list for bonding agents. The Contractor shall also provide a broom finish to the new concrete surface.

518.02 Repair Materials.

Concrete:

Concrete shall meet the requirements of MTA Supplemental Specification 502 and shall be concrete class AA. Concrete removal and placement shall be in accordance with MTA Supplemental Specification 518.

518.10 Method of Measurement

The Repair of Concrete Surfaces – Stairwell Steps will be measured by Lump Sum.

The Repair of Concrete Surfaces – Stairwell Grinding will be measured by each unit.

The Repair of Concrete Surfaces – Stairwell Landing will be measured by each unit.

518.11 Basis of Payment

The following paragraphs are added:

Repair of Concrete Surfaces – Stairwell Steps will be paid at Contract Lump Sum, which price shall include, but not necessarily limited to: removal of aluminum nosings and deteriorated concrete, placing new concrete, and all materials, labor, equipment, tools and incidentals necessary to complete the work.

Repair of Concrete Surfaces – Stairwell Grinding will be paid at the unit price each, which price shall include, but not necessarily limited to: grinding island concrete to drain away from stairwell entrance, and all materials, labor, equipment, tools and incidentals necessary to complete the work.

Repair of Concrete Surfaces – Stairwell Landing will be paid at the unit price each, which price shall include, but not necessarily limited to: modifying slab and drain system in the stairwell at the tunnel level to drain into existing tunnel drain trough, and all materials, labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
518.511	Repair of Concrete Surfaces – Stairwell Steps	LS
518.512	Repair of Concrete Surfaces – Stairwell Grinding	EA
518.513	Repair of Concrete Surfaces – Stairwell Landing	EA

SPECIAL PROVISION

SECTION 518

STRUCTURAL CONCRETE REPAIR

(Tollbooth Blockout Sealing)

518.01 Description

At all existing toll booth enclosures, the work shall include removing the existing aluminum flashing angle, sealant, and backer rod at the joint between the toll booth structure and the concrete parapet wall. Once we removed and completely cleaned, new backer rod, sealant, and aluminum angle shall be installed to create a watertight seal as shown on the Plans and described herein.

518.02 Repair Materials.

Tollbooth Blockout Sealant:

Backer rod and Sikasil 728 NS or approved equal shall be installed around the entire perimeter of the toll booth opening as shown in the Plans.

Install 1-1/2" x 1-1/2" x ¼" aluminum angle over the caulked gap; apply a bead of silicone caulking prior to installing the aluminum angle. 1-1/2" aluminum angle shall be attached using self-drilling hex head stainless steel screws. Tool the silicone clean at the edge of the aluminum angle after install. All corners shall be mitered. Dimensions of aluminum angle shall be field verified and upsized as necessary based on field verified dimensions, as shown in the Plans.

The re-use of existing screw holes shall not be permitted. All existing holes shall be sealed with silicone sealant as approved by the Resident prior to the installation of the aluminum angle.

518.10 Method of Measurement

The Tollbooth Blockout Sealing will be measured by each unit.

518.11 Basis of Payment

The following paragraphs are added:

Tollbooth Blockout Sealing will be paid at the Contract unit price each, which price shall include, but not necessarily be limited to: removing existing backer rod, sealant, and flashing, installing new backer rod and sealant, installing aluminum angle and caulking, and all materials, labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
518.514	Tollbooth Blockout Sealing	EA

SPECIAL PROVISION

SECTION 526

CONCRETE BARRIER

(Temporary Concrete Barrier Type I - Supplied by Authority)

526.01 Description

The following paragraphs are added:

This work shall consist of loading, transporting, setting, resetting, removing, transporting and stacking Temporary Concrete Barrier Type I – Supplied by Authority. The barrier shall have attachments allowing individual sections to be connected into a continuous barrier.

The work also includes supplying connecting pins and furnishing and mounting retro-reflective delineators, per Subsection 526.02 and 526.03.

Concrete barriers supplied by Authority shall be available at the following location(s):

Maintenance Area	Linear Feet of Barrier
Litchfield Storage Area Mile 98.2 Northbound	600

Upon substantial completion of work, the Contractor shall remove and transport the barrier back to its maintenance area of origin. All barrier shall be returned, sorted and stacked according to type in locations directed by the project Resident or maintenance area foreman.

526.02 Materials

The following paragraphs are added:

e. Delineators shall be bi-directional with a minimum effective reflective area of eight square inches as approved by the Resident. The reflectors shall be methyl methacrylate and the housing of acrylonitrile butadiene styrene. Color shall be in accordance with the MUTCD.

526.021 Acceptance

The Resident shall have the authority to accept or reject all Temporary Concrete Barrier Type I – Supplied by Authority used on the Project that does not meet the requirements of this specification

526.03 Construction Requirements

The following paragraphs are added:

The Contractor shall notify the Resident prior to the scheduled pick-up and delivery of concrete barrier. No barrier shall be removed from or stacked at the Turnpike Maintenance Area without approval of the Resident.

The Contractor shall move and place barrier-utilizing methods that will not damage the barrier. Barrier that is damaged by the Contractor by failing to use proper methods shall be replaced by the Contractor at no additional cost to the Maine Turnpike Authority.

Concrete barrier supplied by the Authority consists of several different styles. Not all barriers may be compatible. The Contractor shall utilize caution when setting barrier to use identical barrier types as adjacent barrier. Non-compatible barrier that cannot be attached together shall be overlapped by a minimum of 10 feet with the blunt end on the non-traffic side of the barrier. This work will not be measured separately for payment, but shall be incidental to the concrete barrier.

Concrete barrier placed at roadway low points shall be shimmed on 1" by 2" by 2' long wood planks to allow drainage to pass under the barrier. In addition, the Resident may direct the Contractor to shim the concrete barrier at other locations to provide for proper roadway drainage. All labor, material, and equipment necessary to shim the barrier will not be measured separately for payment, but shall be incidental to the Concrete Barrier.

The removal of concrete barrier from adjacent to the travel lane may be conducted without a lane closure if it is accomplished in accordance with the following requirements:

1. Barrier is removed from the trailing end and the workmen and equipment involved in the operation are always behind the barrier. No workmen or equipment shall enter the travel lane.
2. Barrier shall be dragged away from the travel lane to at least a 30-degree angle by the use of a cable.
3. Barrier shall be lifted no more than six inches while within 10 feet of the travel lane.

Retro-Reflective Delineators shall be mounted as follows:

4. One on top of each barrier.
5. One on the traffic side of every barrier used in a taper.
6. One on the traffic side of every other barrier at regularly spaced intervals and locations.
7. Delineators shall be installed on both sides of the barrier if barrier is used to separate opposing traffic.
8. Delineators shall be physically adhered so as to withstand the force of throw from a snow plow.
9. If more than 25% of delineators in any 50 foot section of barrier fall off for any reason, the Contractor will be responsible for reinstalling all the delineators in that run at that their own cost.
10. Contractor is required to submit the installation method for review and approval to the Resident.

526.04 Method of Measurement

The following paragraphs are added:

Temporary Concrete Barrier Type I – Supplied by Authority shall be measured for payment by the lump sum.

The loading, transporting, setting, resetting, removing, transporting, sorting and stacking of the barrier, the furnishing, installation and maintenance of the barrier delineators, and furnishing and installing connector pins will not be measured separately for payment, but shall be incidental to the cost of the Barrier. Temporary storage of Concrete Barrier between construction phases, if required, will not be measured separately for payment, but shall be incidental to the cost of the Barrier. All equipment required to load, unload, transport and stack Concrete Barrier shall be supplied by the Contractor.

Any Barrier lost or damaged by the Contractor shall be replaced by the Contractor at no additional cost to the Authority.

526.05 Basis of Payment

The fifth paragraph is deleted and not replaced.

The following paragraphs are added:

Temporary Concrete Barrier Type I – Supplied by Authority will be paid for at the Contract lump sum price, complete in place. Such payment shall be full compensation for loading, transporting, setting, resetting, temporary storage, removing, transporting and stacking at the area designated, furnishing all materials, and all other incidentals necessary to complete the work. Temporary Concrete Barrier Type I – Supplied by Authority and all connecting pins shall remain the property of the Authority, and shall be returned to the Turnpike Maintenance Area as designated in Subsection 526.01.

Payment of Concrete Barrier shall be based on a percentage of the work accomplished during that pay period.

Payment will be made under:

Pay Item		Pay Unit
526.306	Temporary Concrete Barrier, Type I – Supplied by Authority	Lump Sum

SPECIAL PROVISION

SECTION 527

ENERGY ABSORBING UNIT

(Work Zone Crash Cushion)
(Resetting Existing Work Zone Crash Cushions)

527.01 Description

The first paragraph is deleted in its entirety and replaced with the following:

The Contractor shall furnish and install, or reset work zone crash cushions where shown on the Plans, as specified herein, in Special Provision 652, or as approved by the Resident. Work zone crash cushions are required at each exposed end of temporary concrete barrier or guardrail.

The exposed end of the concrete barrier within 30 feet of the mainline travel lane shall be protected at all times. Barrier shall not be reset until after the work zone crash cushion(s) has been set to protect the exposed end of the barrier.

527.02 Materials

The following paragraph is added:

Work zone crash cushions fabricated prior to December 31, 2019 in serviceable condition shall meet the requirements of NCHRP 350 TL-3 crash test requirements and work zone crash cushions fabricated after December 31, 2019 shall meet the MASH TL-3 crash test requirements for use on the turnpike and local roadways with posted speeds of 45 MPH or greater. Work zone crash cushions fabricated prior to December 31, 2019 shall meet in serviceable condition shall meet the requirements of NCHRP 350 TL-2 crash test requirements and work zone crash cushions fabricated after December 31, 2019 shall meet the MASH TL-2 crash test requirements for use on local roadways with posted speeds of 40 MPH or less. The Contractor shall provide the Resident with documentation of the proposed work zone crash cushion's MASH Crash Test Results prior to installation at the jobsite.

527.03 Construction Requirements

The following is added to the end of the first paragraph:

The design speeds for work zone crash cushions shall be 45 mph for local road and 70 mph for turnpike roadways unless otherwise noted on the Plans.

527.04 Method of Measurement

Work Zone Crash Cushions used to protect exposed ends of guardrail for steel girder erection will not be measured separately for payment but shall be included under the Maintenance of Traffic for Steel Girder Erection item.

Replacement barrels, after collisions, will be paid for as a percentage of the individual barrels damaged to the total barrels in the complete system. The removal of impacted barrels and debris will be considered incidental to the replacement barrels. Barrels on hand, but unused will not be paid for directly.

Resetting Existing Work Zone Crash Cushion will be measured by the Unit, complete in place and accepted.

527.05 Basis of Payment

Resetting Existing Work Zone Crash Cushion will be measured by the Unit, complete in place and accepted.

Payment will be made under:

Pay Item		Pay Unit
527.341	Work Zone Crash Cushions – TL-3	Unit
527.342	Work Zone Crash Cushions – TL-2	Unit
527.343	Resetting Existing Work Zone Crash Cushion	Unit

SPECIAL PROVISION

SECTION 652

MAINTENANCE OF TRAFFIC

MaineDOT Standard Specification 2014 Edition Section 652 – Maintenance of Traffic and the Maine Turnpike Authority 2016 Supplemental Specification Section 652 – Maintenance of Traffic are deleted in their entirety and replaced with the following:

652.1 Description

This work shall consist of furnishing, installing, maintaining and removing traffic control devices necessary to provide reasonable protection for motorists, pedestrians and construction workers in accordance with these Specifications, the applicable provisions of Section 105.4.5 - Special Detours, and the plans.

Traffic control devices include signs, signals, lighting devices, markings, barricades, channelizing, and hand signaling devices, portable light towers, truck mounted impact attenuators, portable rumble strips, portable speed trailers, sequential warning lights, traffic officers, and flaggers.

652.2 Materials

All maintenance of traffic control devices shall conform to the requirements of the latest edition of the MUTCD, NCHRP 350 guidelines and all Traffic control devices shall meet Manual for Assessing Safety Hardware (MASH) 16 guidelines if date of manufacture was after December 31, 2019.

All signs shall be fabricated with high intensity fluorescent retroreflective sheeting conforming to ASTM D 4956 - Type VIII, or Type IX (prismatic). All barricades, drums, and vertical panel markers shall be fabricated with high intensity orange and white fluorescent retroreflective sheeting conforming ASTM D 4956 - Type VII, Type VIII, or Type IX (prismatic).

Construction signs shall be fabricated from materials that are flat, free from defects, retro-reflectorized, and of sufficient strength to withstand deflections using a wind speed of 80 miles/hr.

652.2.2 Signs

Only signs with symbol messages conforming to the design of the Manual of Uniform Traffic Control Devices (MUTCD) shall be used unless the Resident approves the substitution of word messages.

Any proposed use of temporary plaques to cover text or to change text shall be approved by the resident. All signs or proposed plaques shall have a uniform face and be constructed from similar sheeting.

All signs shall be new, or in like new condition and maintained in like new condition throughout the project duration. Signs shall be cleaned just prior to installation and throughout the project utilizing a method that will not damage the reflective sign sheeting.

652.2.3 Flashing Arrow Board

Flashing Arrow Boards must be of a type that has been submitted to AASHTO's National Transportation Product Evaluation Program (NTPEP) for evaluation and placed on the Maine Department of Transportations' Approved Products List of Portable Changeable Message Signs & Flashing Arrow Boards.

Flashing Arrow Boards units shall meet requirements of the current Manual on Uniform Traffic Control Devices (MUTCD) for Type "C" panels as described in Section 6F.56 - Temporary Traffic Control Devices. Flashing Arrow Boards shall have matrix of a minimum of 15 low-glare, sealed beam, Par 46 elements capable of either flashing or sequential displays as well as the various operating modes as described in the MUTCD, Chapter 6-F. If a Flashing Arrow Board consisting of a bulb matrix is used, each element should be recess-mounted or equipped with an upper hood of not less than 180 degrees. The color presented by the elements shall be yellow.

Flashing Arrow Board elements shall be capable of at least a 50 percent dimming from full brilliance. Full brilliance should be used for daytime operation and the dimmed mode shall be used for nighttime operation. Flashing Arrow Board shall be at least 96 inches x 48 inches and finished in non-reflective black. The Flashing Arrow Board shall be interpretable for a distance not less than 1 mile.

Operating modes shall include, flashing arrow, sequential arrow, sequential chevron, flashing double arrow, and flashing caution. In the three arrow signals, the second light from the arrow point shall not operate.

The minimum element on-time shall be 50 percent for the flashing mode, with equal intervals of 25 percent for each sequential phase. The flashing rate shall be not less than 25 nor more than 40 flashes per minute. All on-board circuitry shall be solid state.

Primary power source shall be 12 volt solar with a battery back-up to provide continuous operation when failure of the primary power source occurs, up to 30 days with fully charged batteries. Batteries must be capable of being charged from an onboard 110 volt AC power source and the unit shall be equipped with a cable for this purpose.

Controller and battery compartments shall be enclosed in lockable, weather-tight boxes.

The Flashing Arrow Board shall be mounted on a pneumatic-tired trailer or other suitable support for hauling to various locations, as directed. The minimum mounting height of an arrow panel should be 7 feet from the roadway to the bottom of the panel.

The face of the trailer shall be delineated on a permanent basis by affixing retro-reflective material, known as conspicuity material, in a continuous line as seen by oncoming drivers.

A portable changeable message sign may be used to simulate an arrow panel display.

652.2.4 Other Devices

Vertical panel markers shall be orange and white striped, 8 inches wide by 24 inches high. On the Interstate System, vertical panel markers shall be orange and white striped, 12 inches wide by 36 inches high.

Cones shall be orange in color, a minimum of 28 inches high, and retro-reflectorized. Retro- reflection shall be provided by a white bands of retro-reflective sheeting conforming to the MUTCD. All cones utilized on the project shall be new or in like new condition and shall have a consistent design/appearance.

Drums shall be of plastic or other yielding material and shall be a minimum of 36 inches high and a minimum of 18 inches in diameter. There shall be at least two retro-reflectorized orange and at least two retro-reflectorized white stripes a minimum of 4 inches wide on each drum. All drums utilized on the project shall be new or in like new condition and shall have a consistent design/appearance.

Flaggers shall use a STOP / SLOW handheld paddle as the primary and preferred hand signaling device. Flags shall only be limited to emergencies. STOP / SLOW paddles shall have high intensity prismatic retro reflective sheeting, have an octagonal shape on a rigid handle and shall be at least 18 inches wide with letters at least 6 inches high and shall be constructed from light semi-rigid material. The STOP (R1-1) face shall have white letters and a white border on a red background. The SLOW (W20-8) face shall have black letters and a black border on an orange background.

STOP / SLOW paddles shall also incorporate either white or red flashing lights on the STOP face and white or yellow flashing lights on the SLOW face of the paddle and always be in use.

Paddles must conform to one of the following patterns:

A. Two white or red lights (colors shall be all white or all red), one centered vertically above and one centered vertically below the STOP legend; and/or two white or yellow lights (colors shall be all white or all yellow), one centered vertically above and one centered vertically below the SLOW legend.

B. Two white or red lights (colors shall be all white or all red), one centered horizontally on each side of the STOP legend; and/or two white or yellow lights (colors shall be all white or all yellow), one centered horizontally on each side of the SLOW legend.

C. One white or red light centered below the STOP legend; and/or one white or yellow light centered below the SLOW legend.

D. A series of eight or more small all white or all red lights no larger than 1/4 inch in diameter along the outer edge of the paddle, arranged in an octagonal pattern at the eight corners of the border of the STOP face; and/or a series of eight or more small

all white or all yellow lights no larger than 1/4 inch in diameter along the outer edge of the paddle, arranged in a diamond pattern along the border of the SLOW face; or

E. A series of white lights forming the shapes of the letters in the legend. Flashing light patterns shall be compliant with Section 6E.03 Hand Signaling Devices in the most current version of the Manual on Uniform Traffic Control Devices.

All flashing light patterns on the STOP / SLOW paddle shall be visible from a minimum distance of 1000 feet.

Type I barricades shall be 2 feet minimum, 8 feet maximum in length with an 8 inch wide rail mounted 3 feet minimum above the ground. Type II barricades shall be 2 feet in length with two 8 inch wide rails, and the top rail shall be mounted 3 feet minimum above the roadway. Type III barricades shall be 8 feet in length with three 8 inch wide rails, and the top rail shall be mounted 5 feet minimum above the roadway. The cross members of all barricades shall be of ½ or ⅝ inch thick plywood or other lightweight rigid material such as plastic, fiberglass or fiber wood as approved by the Resident. The predominant color for supports and other barricade components shall be white, except that unpainted galvanized metal or aluminum components may be used.

652.2.5 Portable Changeable Message Sign

Portable-Changeable Message Signs (PCMS) will be furnished by the Contractor and shall be Ver-Mac PCMS-1210 or an approved equal. The face of the PCMS trailer shall be delineated on a permanent basis by affixing retro-reflective material, known as conspicuity material, in a continuous line as seen by oncoming drivers. PCMS's shall be located and relocated to locations approved by the Resident within the Project limits for the duration of the Project.

Features to the Ver-Mac PCMS shall include:

- An all-LED display.
- Be legible from a distance of 1,000 feet.
- Have three (3) lines available for messages.
- Be NTCIP compliant (NTCIP 1203 & 1204).
- Be capable of being programmed by a remote computer via a data (IP over Cell) cellular modem connection.
- Have GPS location capability by adding on a GPS device capable of providing GPS location remotely to the MTA Communications' Center.
- Be programmable by Vanguard Software by Daktronics.

The Contractor shall complete and/or provide the following:

- Submit a catalog cut shop drawing to the Resident of all proposed equipment for review and approval.

- Establish and pay for a data cellular account so that PCMS may be remotely programmed and operated from the MTA Communications' Center.

- Provide to the Authority technical support from the PCMS manufacturer that may be necessary to integrate the PCMS into the MTA software platform (Vanguard Software by Daktronics).

- Provide the manufacturer's software necessary to change the PCMS messages remotely from the MTA Communications' Center and the Resident's computer if necessary or requested.

- Provide training on the operation of the PCMS to the Resident and the MTA Communications' Center representative.

- Make all PCMS on the Project work site available to the MTA for any/all emergency situations as defined by the MTA. This shall include the preemption of any messages running at the time of need as approved by the MTA and the Resident.

The Contractor shall also:

- Furnish, operate, relocate and maintain the PCMS as approved or requested by the Resident.

- Be responsible for the day-to-day programming and operation of the PCMS for Project purposes.

The PCMS(s) shall be on-site, with data cellular account established, GPS location capable, and all training required complete within one month after mobilization or seven days prior to implementing traffic shifts, detours or stoppages, whichever is sooner. Implementation of traffic shifts, detours, or stoppages of traffic will not be allowed without PCMS boards on-site with the specified MTA Communications' Center Software Platform integration and training.

652.2.5 Truck Mounted Attenuator

The truck mounted attenuator system shall conform to the following requirements:

- Truck and attached attenuator shall conform to the NCHRP Report 350, Test Level 3 criteria or MASH if manufactured after 2019.

- Amber, Green, white or any variation of those colors strobe lights with 360-degree visibility.

- An arrow light bar fixed to the vehicle.

- The attenuator shall be mounted to a vehicle with a minimum weight of 24,000 lbs. unless otherwise specified.

Installation: **The TMA shall be located in the closed lane adjacent to active traffic; for double lane closures, only the outer closed lane requires the TMA**. If a buffer zone is required the TMA shall not be located in the buffer zone. The shadow vehicle shall have its front wheels turned away from the work area and from traffic, have parking brake set, and be put in park if an automatic transmission; or if a manual transmission it shall have its front wheels turned away from the work area and from traffic, have parking brake set and should be placed in gear and shut off if possible while still maintaining warning lights. If length of time or weather are a concern for the battery since the warning lights must be maintained the engine should be started and run periodically for battery recharging. No other vehicles or equipment shall park in front of the shadow vehicle or within the buffer space behind the shadow vehicle. For placement details, reference the Manual on Uniform Traffic Control Devices (MUTCD).

A Truck Mounted Attenuator **shall** be utilized in all lane closures, and shoulder closures, where workers are not protected by other positive means (i.e., closures that do not include temporary concrete barrier). If work is being completed behind guardrail a TMA shall be required for all work that is being completed within the deflection zone of the guardrail (minimum of four feet behind the guardrail post).

The placement and positioning of the vehicle shall be in accordance with the Manual on Uniform Traffic Control Devices and the manufacturer's recommendation. TMAs used on the Turnpike mainline shall have a minimum weight of 24,000 lbs and shall provide a 200 foot shadow distance from vehicles or the work zone. **For lane and shoulder closures in excess of 3,000 feet containing multiple work zones a TMA shall be used at each work zone.**

If a Truck Mounted Attenuator is not used as described above, then it will be considered a Traffic Control Plan violation and result in a reduction of payment as outlined in Section 652.

652.2.6 Sequential Flashing Warning Lights

When included in contracts as a bid item Sequential Flashing Warning Lights on drums used for merging tapers and shifting tapers during nighttime operation for project use. The purpose of these lights is to assist the motorist in determining which direction to merge or shift and to reduce the number of late merges resulting in devices being struck and having to be reset to maintain positive guidance at the merge point. The successive flashing of the lights shall occur from the upstream end of the taper to the downstream end of the taper in order to identify the desired vehicle path.

The Sequential Flashing Warning Lights shall meet all of the requirements for warning lights within the current edition of the MUTCD. Each light unit shall be capable of operating fully and continuously for a minimum of 500 hours when equipped with a standard battery set. Each light in sequence shall be flashed at a rate of not less than 55 times per minutes and not more than 75 times per minute. The flash rate and flash duration shall be consistent throughout the sequence. Sequential Flashing Warning Lights shall be "Pi-Lit" Sequential Barricade Warning Lamps or an

approved equal.

Sequential Flashing Warning lights are to be used for merging and shifting tapers that are in place during the nighttime hours (12-hours when ambient light is dimmed). These lights shall flash sequentially beginning with the first light and continuing until the final light at the beginning of a tangent section.

The Sequential Flashing Warning Lights shall automatically flash in sequence when placed on the drums that form the merging or shifting tapers.

The number of lights used in the drum taper shall equal one half the number of drums used in the taper.

Drums are the only channelizing device permitted for mounting the Sequential Flashing Warning Lights.

The Sequential Flashing Warning Lights shall be weather independent and visual obstruction shall not interfere with the operation of the lights.

The Sequential Flashing Warning Lights shall automatically sequence when placed in line in an open area with a distance between lights of 25 to 150 feet. A 10-foot stagger in the line of lights shall have no adverse effect on the operation of the lights.

If one light fails, the flashing sequence shall continue. Non-sequential flashing is prohibited.

652.2.7 Automated Trailer Mounted Speed Sign

The Contract will furnish, operate, and maintain Automated Trailer Mounted Speed Limit Sign(s) for project use. The automated speed sign shall be required when there is a Work Zone Speed Limit in place. The Contractor shall furnish, operate, and maintain the Automated Trailer Mounted Radar Speed Limit Signs during the project operations

Trailer mounted speed limit signs shall be self-contained units including sign assembly, flashing lights, directional radar to measure speed limits, a regulatory speed limit sign, and power supply specifically constructed to operate as a trailer-mounted sign. The preferred color of the unit shall be “construction orange”.

Base material for the regulatory speed limit signs shall be weatherproof, rigid substrate specifically manufactured for highway signing and meet the retro-reflective sheeting application requirements of the sheeting manufacturer.

Sign text shall consist of the letters, digits and symbols either applied by stick-on or silk screen, to conform to the dimensions and designs indicated in the Contract, MUTCD and/or FHWA Standard Highway Signs. The materials and methods shall be in accordance with standard commercial processes.
“Work Zone” construction signs shall be mounted on the trailer unit above the regulatory speed limit sign. (see attached graphic details).

Signs and secondary signs shall follow the MUTCD for minimum mounting heights.

The power supply shall be either full battery power with solar panel charging (capable of maintaining a charged battery level) and 135 amperes, 12-volt deep cycle batteries, or diesel powered generator with a fuel capacity sufficient for 10 hours of continuous operation.

Each unit shall be equipped with two mono-directional flashing lights, placed in accordance with the MUTCD, with amber lenses and reflectors, which are visible through a range of 120 degrees when viewed facing the sign. The lights shall be a minimum of 8-inch diameter, either LED, halogen, or incandescent lamps, and shall be visible for a minimum distance of one mile under daylight conditions and shall have a minimum flash rate of 40 flashes per minute. An "On" indicator light shall be mounted on the back of the signs, which is visible for at least 500 feet to provide confirmation that the flashing lights are operating.

The directional radar shall monitor approaching traffic only. The radar shall be capable of measuring speeds from 5 to 70 MPH at a distance of up to 1500 feet and shall have a high speed cut off thresh hold. Speed data shall be recorded and stored on the sign and must be made available to the Authority as requested.

All existing speed limit signs, which conflict with the construction zone trailer mounted speed limit signs shall be covered completely when the work zone speed limit is in place.

Automated Trailer Mounted Speed Limit Signs shall only be used when a work zone speed limit is in place **and shall be required when the work zone speed limit is active**. The Contractor shall manage the utilization and operation of the Automated Trailer Mounted Speed Limit Signs and if at least one is not used when work zone speed limits are in place then it will be considered a Traffic Control Plan violation and result in a reduction of payment as outlined in Section 652.

The Resident will record the actual time and location for the signs on a daily basis when the Automated Trailer Mounted Speed Limit Signs are in use.

The Automated Trailer Mounted Radar Speed Limit Sign may be placed as shown on the plans, or may replace the posted regulatory speed limit signs, or may be placed at a location within the closed lane that has a reduced speed limit.

Automated Trailer Mounted Speed Limit Signs shall be delineated with retro-reflective temporary traffic control devices while in use and shall also be delineated by affixing a retro-reflective material directly on the trailer.

Upon delivery of the Automated Trailer Mounted Speed Limit Sign and before acceptance by the Authority, the Contractor shall have a representative of the manufacturer review the condition and notify the Resident in writing, of all deficiencies noted.

The Contractor shall arrange to have all necessary repairs performed at no cost to the Authority.

To avoid impairing driver vision, the Contractor shall dim the lighted speed limit

readings by 50 percent during nighttime use and restore full power lighting during daytime operation.

652.2.8 Temporary Portable Rumble Strips

If a pay item is included in the contract or the Contract desires to utilize Temporary Portable Rumble Strips this work consists of furnishing and placing temporary portable rumble strips RoadQuake 2F TPRS or an approved equal. Furnishing a temporary portable rumble strip system includes a method to transport and move these to on-site locations where they will be used. The Contractor shall submit for approval, literature and all necessary certifications to the Maine Turnpike prior to procurement of the product.

If used, Temporary Portable Rumble Strips may not be practicable in areas where the roadway has more than two travel lanes, where volume windows do not allow for breaks in traffic to set up and monitor and adjust, or during nighttime lane closures.

Provide rumble strips where the plans show or as directed by the Resident as follows:

Prior to placing rumble strips, clean the roadway of sand and other materials, that may cause slippage.

Place one end of the rumble strips 6 inches from the roadway centerline. Extend the strips perpendicular to the direction of travel. Ensure strips lay flat on the roadway surface.

Only one series of rumble strips, placed before the first work zone, is required per direction of travel for multiple work zones spaced 1 mile or less apart. Work zones spaced greater than 1 mile apart require a separate series of rumble strips. Each lane shall use one group of temporary rumble strips.

Bracketed “Rumble Strip Ahead” and “Bump” signs shall be utilized and will be paid for under the respective construction sign pay items.

Maintain rumble strips as follows:

If rumble strips slide, become out of alignment, or are no longer in the wheel path of approaching vehicles during the work period, thoroughly clean both sides of the rumble strips and reset on a clean roadway.

Repair or replace damaged rumble strips immediately.

652.3.1 Responsibility of the Authority

The Authority will provide Project specific traffic control requirements and traffic control plans for use by the Contractor. The specific traffic control requirements for the Project are identified in Special Provision Section 652, Maintenance of Traffic (Specific Project Maintenance of Traffic Requirements). No revisions to these requirements or Plans will be permitted unless the
Contractor can thoroughly demonstrate an overall benefit to the public and a Contract

Modification is approved.

The Maine Turnpike Authority may erect lane closures on the mainline within the Project area to collect survey, provide layout, and for any other reasons deemed necessary by the Authority.

652.3.2 Responsibility of the Contractor

The Contractor shall provide continuous and effective traffic control and management for the Project that is appropriate to the construction means, methods, and sequencing allowed by the Contract and selected by the Contractor:

The Contractor shall ensure all jobsite personnel shall wear a safety vest labeled as ANSI 107-2004 standard performance for Class 3 risk exposures at all times. This requirement also applies to truck drivers and equipment operators when out of an enclosed cab.

652.3.3 Submittal of Traffic Control Plan

The Contractor shall provide continuous and effective traffic control and management for the Project that is appropriate to the means, methods and sequencing allowed by the Contract; and consistent with the Traffic Control Plans and Maintenance of Traffic Specifications. The Contractor is responsible for ensuring a safe environment for the Contract workforce, local road users, and turnpike users; and maintaining the safe efficient flow of traffic through the construction zone at all times during the Contract. The protocols and requirements outlined in the Contract shall be strictly enforced. The Contractor shall submit, at or before the Preconstruction Meeting, a Traffic Control Plan (TCP) that provides the following information to the Authority:

a. The name, telephone number, and other contact numbers (cellular phone, pager, if any) of the Contractor's Traffic Control Supervisor (TCS). The TCS is the person with overall responsibility for ensuring the contractor follows the TCP, and who has received Work Zone Traffic Control Training commensurate with the level of responsibility shown in the requirements of the Contract, and who is empowered to immediately resolve any work zone traffic control deficiencies or issues. Provide documentation that the Traffic Control Supervisor has completed a Work Zone Traffic Control Training Course (AGC, ATSSA, or other industry- recognized training), and a Supervisory refresher training every 5 years thereafter. Submit training certificates or attendance roster that includes the course name, training entity, and date of training. **State how the traffic control devices will be maintained including a frequency of inspection for both temporary and permanent traffic control devices.**

Traffic Control Training Course curriculum must be based on the standards and guidelines of the MUTCD and must include, at a minimum, the following:

1. Parts of Temporary Traffic Control Zone

2. Appropriate use and spacing of signs

3. Use and spacing of channelizing devices

4. Flagging basics

5. Typical examples and applications

The Traffic Control Supervisor, or designee directly overseeing physical installation, adjustment, and dismantling of work zone traffic control, will ensure all personnel performing those activities are trained to execute the work in a safe and proper manner, in accordance with their level of decision-making and responsibility. The emergency contact list shall contain a listing of individuals who may be contacted during non-work hours and shall adequately respond to the request.

b. Proposed revisions to the construction phasing or sequencing that reasonably minimizes traffic impacts.

c. A written narrative and/or plan explaining how traffic and pedestrians will be moved through the Project Limits, including transitions during the change from one phase of construction to the next, as applicable.

d. Temporary traffic control treatments at all intersections with roads, rail crossings, businesses, parking lots, pedestrian ways, bike paths, trails, residences, garages, farms, and other access points, as applicable.

e. A list of all Contractor or Subcontractor certified flaggers to be used on the Project, together with the number of flaggers which will be used for each type of operation that flagging is needed. If the Contractor is using a flagging Subcontractor, then the name and address of the Subcontractor may be provided instead of a list of flaggers.

f. A procedure for notifying the Resident of the need to change the traffic control plan or the need to remove a lane restriction.

g. A description of any special detours including provisions for constructing, maintaining, signing, and removing the detour or detours, including all temporary bridges and accessory features and complete restoration of the impacted land.

h. The maximum length of requested contiguous lane closure. The Contractor shall not close excessive lengths of traffic lane to avoid moving traffic control devices.

i. The proposed temporary roadway surface conditions and treatments. The Contractor shall provide an adequate roadway surface at all times; taking into account traffic speed, volume, and duration.

j. The coordination of appropriate temporary items (drainage, concrete barriers, barrier end treatments, impact attenuators, and traffic signals) with the TCP.

k. The plan for unexpected nighttime work, the contractor shall provide a list of

emergency nighttime lighting equipment and safety personnel available on-site or have the ability to have them on site within an hour of the time of need.

l. The plan for meeting any project specific requirements contained in special provision 105 and/or 107, and/or Section 656

m. The lighting plan if night work is anticipated.

The Authority will review the TCP for completeness and conformity with Contract provisions, the current edition of the MUTCD, and Authority policy and procedures. The Authority will review and provide comments to the Contractor within 14 days of receipt of the TCP. No review or comment by the Authority, or any failure to review or comment, shall operate to absolve the contractor of its responsibility to design and implement the plan in accordance with the Contract, or to shift any responsibility to the Authority. If the TCP is determined by the Authority to be operationally ineffective, the Contractor shall submit modifications of the TCP to the Authority for review and shall implement these changes at no additional cost to the Contract. Nothing in this Section shall negate the Contractor's obligations set forth in Section 110 - Indemnification, Bonding, and Insurance. The creation and modification of the TCP will be considered incidental to the related 652 items.

652.3.4 General

Prior to starting any work on any part of the project adjacent to or being used by the traveling public, the Contractor shall install the appropriate traffic control devices in accordance with the plans, specifications and the latest edition of Manual of Uniform Traffic Control Devices, Part VI. The Contractor shall continuously maintain the traffic control devices in their proper position, and they shall be kept clean, legible and in good repair throughout the duration of the work. If notified that the traffic control devices are not in place or not properly maintained, the Contractor may be ordered to immediately suspend work until all deficiencies are corrected.

No equipment or vehicles of the Contractor, their subcontractors, or employees engaged in work on this contract shall be parked or stopped on lanes carrying traffic, or on lanes or shoulders adjacent to lanes carrying traffic, at any time, except as required by ongoing work operations. Contractor equipment or vehicles shall never be used to stop, block, or channelize traffic.

Vehicles parked on the shoulder shall be located so all portions of the vehicle(s) are a minimum of one foot from the traveled way. No operation shall be conducted on or near the traveled lanes or shoulders without first setting up the proper lane closure and traffic control devices. These precautions shall be maintained at all times while this Work is being performed. The Contractor shall keep all paved areas of the highway as clear as possible at all times. No materials shall be stored on any paved area of the highway or within 30 feet of the traveled way (unless protected by concrete barriers and specifically approved by the Resident). Private vehicles owned by Contractor's employees shall be parked close together in a group no closer than 30 feet from the traveled way in pre-approved areas.

Channelization devices shall include Vertical Panel Markers, Barricades, Cones, and Drums shall be in accordance with the MUTCD. These devices shall be installed and maintained at the spacing determined by the MUTCD through the work area.

The Contractor shall maintain existing guardrails and/or barriers until removal is necessary for construction. The Contractor shall use a temporary barrier or appropriate channelizing devices,
as approved by the Resident, while the guardrails and/or barriers are absent. Permanent guardrails and barriers shall be installed as soon as possible to minimize risk to the public.

When Contractor operations or shoulder grading leave a continuous 3 inch or less exposed vertical face at the edge of the traveled way, including the shoulder, or when traffic is shifted into the shoulder adjacent to the edge of pavement where an existing 3 inch or less exposed vertical face creates a safety hazard, channelization devices should be placed 2 feet outside the edge of the pavement at intervals not exceeding 600 feet and, depending on type and location of the exposed vertical face, a 48 inch by 48 inch W8-9 Low Shoulder, or W8-11 Uneven Lane, and/or a W8-17P Shoulder Drop-Off sign should be placed at a maximum spacing of ½ mile. When Contractor operations or shoulder grading leave greater than a 3-inch exposed continuous vertical face at the edge of the traveled way, including the shoulder, or when an existing condition of an exposed vertical face of 3 inches or more is adjacent to active traffic shifted into shoulder, the Contractor shall place shoulder material at a slope not exceeding 3 horizontal to 1 vertical to meet the pavement grade, before the lane is opened to traffic.

Special Detours and temporary structures, if used, shall meet applicable AASHTO standards, including curve radii and grade.

Maine Turnpike Traffic Control Requirements

This Section outlines the minimum requirements that shall be maintained for working on, over, or adjacent to the Maine Turnpike roadway.

General

Two travel lanes in each direction (each direction being 24 feet wide including/excluding shoulder) in the two lane portion of the turnpike, and three travel lanes in each direction (each direction being 36 feet wide including/excluding shoulder) in the three lane portion of the turnpike (Mile 0.0 to mile 44.3) shall be maintained at all times except while performing work in a designated lane, directly over or adjacent to traffic, and during the placement and removal of traffic control devices.

Unless otherwise specified in the contract documents the minimum main line width for a single travel lane shall be 14 ft and minimum ramp widths of 16 ft which must be maintained at all times, from ½ hour before sunrise and ½ hour after sunset as indicated on the Sunrise/Sunset Table at: http://www.sunrisesunset.com/usa/Maine.asp . If the Project town is not listed, the closest town on the list will be used as agreed at the Preconstruction Meeting.

Shoulder closures, lane closures, and lane shifts meeting the MUTCD guidelines, other than those shown in the plans, must be submitted for approval from the MTA prior to use in the construction operations.

No lane closures will be allowed during non-working hours, weekends and/or holiday periods unless included in the Contract as long-term traffic control requirement as outlined in Section 652 – Specific Project Maintenance of Traffic Requirements **unless written permission is obtained from the Authority.**

Any special signs, barricades or other devices deemed necessary by the Resident shall be furnished and maintained by the Contractor. Extra care shall be taken so that the traffic flow will not be disturbed. The use of construction signs and warning devices not shown on the Plans or in the MUTCD is prohibited unless approved by the Resident

The Contractor's personnel and equipment shall avoid crossing traffic whenever possible. No Contractor's vehicle may slow down or stop in a traffic lane unless said lane has previously been made safe with signs and barricades as required by the Resident.

No vehicle will move onto the traveled way at such a time or in such a manner so as to cause undue concern or danger to traffic approaching from either direction. The Contractor or his employees are not empowered to stop traffic.

The Contractor shall take necessary care at all times, in all operations and use of his equipment, to protect and facilitate traffic. During periods of idleness, the equipment shall not be left in a way to obstruct the traffic artery or to interfere with traffic.

The Contractor shall furnish approved signs reading “Construction Vehicle - Keep Back” to be used on trucks hauling to the Project. The signs shall be a minimum of 30-inch by 60-inch, Black and Orange, and meet construction sign retro reflectivity requirements

All vehicles used on the Project shall be equipped with amber flashing lights, by means of a single or multiple, flashing LED or strobe lights mounted so as to be visible 360 degrees. **In addition, vehicles operating under direction of the Maine Turnpike Authority may be equipped with auxiliary lights that are green, white or amber or any combination of green, white or amber.** Auxiliary lighting shall have sufficient intensity to be visible at 500 feet in normal daylight and a flash rate between 1Hz and 4Hz. The vehicle flashing system shall be in continuous operation while the vehicle is on any part of the project and positioned or mounted in such a way to not be obstructed by vehicle mounted or other equipment. Dump trucks, **concrete trucks** and utility trucks **at a minimum** shall have a strobe light mounted on each side of the vehicle. **The use of motorcycles is not permitted within a construction site or as a means to arrive at or leave a work zone**.

Where space is available pavement striping for all tapers shall create a minimum buffer of 250 feet to the point where the temporary concrete barrier taper ends and becomes parallel to the travelway. Temporary concrete barrier shall be tapered at a minimum 8:1 unless space is available and then it should be tapered at 15:1 or 100 feet whichever is longest.

Milling and paving of interchange ramps shall be done between 9:00 p.m. and 5:00 AM, unless otherwise shown on the Maintenance of Traffic Phasing Plans or as directed by the MTA. Only a single ramp at an interchange may be closed at once. Ramp closures will not be permitted the day before or after holidays, on holidays, or on Saturdays or Sundays. The Contractor shall request approval from the Resident/Authority two weeks

prior for all ramp closures. Portable changeable message signs shall be used to provide advance notice and warning of the ramp closure. PCMS's shall be operational a minimum of 1 week prior to ramp closure to notify Patrons. The contractor shall coordinate PCMS locations with the Resident and the MTA.

Access to, and egress from, the construction area shall be with the direction of travel without crossing traffic. Construction vehicles are prohibited from merging with mainline traffic during the AM and PM peak traffic hours unless approved in writing from the MTA. The contractor shall develop work zone access/egress with acceleration and deacceleration areas and should utilize interchange ramp areas whenever feasible.

Temporary Mainline Lane Closures

A lane closure may be required whenever personnel will be actively working within four feet of a travel lane.

Loading/unloading trucks shall not be closer than six feet from an open travel lane. Temporary lane closures will only be allowed at the times outlined in Special Provision, Section 652, Specific Project Maintenance of Traffic Requirements. These hours may be adjusted based on the traffic volume each day by the Resident.

A lane closure is required when a danger to the traveling public may exist. The following is a partial list of activities requiring lane closures. Lane closures may be required for other activities as well:

- Milling and Paving Operations
- Bridge work
- Drainage Installation and/or Adjustment
- Clear Zone Improvements
- Pavement Markings Layout and Placement
- **Work directly over traffic within six feet of a travel lane as measured from the painted pavement marking line or traffic control device will require a lane closure. This work includes but is not limited to the following:**

    1. **Unbolting structural steel**
    2. **Removing structural steel**
    3. **Erecting structural steel**
    4. **Erecting or moving sign panels on bridges or sign structures**
    5. **Bolting structural steel**
    6. **Loading and unloading trucks**
    7. **Light pole removal or installation**
    8. **Snow fence installation**

Lane closures shall be removed if work requiring the lane closure is not ongoing unless included in the Contract as a long-term traffic control requirement or approved by the Resident.

During adverse weather condition when the speed limit on the Maine Turnpike has been reduced to 45 MPH, or during fog or when there is less than ½ mile of visibility, shoulder/lane closures cannot be set up and any currently in place shall be removed. Only work on the turnpike mainline that is behind temporary concrete barrier will be allowed when speed is reduced to 45 MPH or fog/visibility conditions exist.

Daytime lane closures shall be a maximum of three (3) miles. Only one daytime lane closure will be permitted per direction. Nighttime lane closures may extend through the entire length of the Project.

Temporary single lane closures are allowed upon approval of the Resident. **Lane and/or ramp** closure setup may not begin until the beginning time specified. Closures that are setup early or that remain in place outside of the approved time period shall be subject to a lane rental fee of **$1,000** per five minutes for every five minutes outside of the approved time. The installation of the construction signs will be considered setting up the lane closure. Removal of the last construction sign will be considered removal of the closure. Construction signs shall be installed immediately prior to the start of the closure and shall be promptly removed when no longer required. The installation and removal of a closure, including signs, channelizing devices, and arrow boards shall be a continuous operation. The Authority reserves the right to order the removal of an approved closure.

The Authority desires to minimize the number of daytime lane closures and the number of times that a complete stoppage of traffic is required. The Contractor is encouraged to schedule work so that the interference with the flow of traffic will be minimized. Lane closures will not be allowed until traffic associated with complete stoppages of traffic has cleared. Complete stoppages of traffic or lane closures may not be allowed on a particular day if another complete stoppage of traffic has been previously approved for another project.

The Resident is required to receive approval from the Maine Turnpike Authority for all lane closures. **The Resident is required to submit a request for lane closures by noon on Thursday for any lane closures needed for the following week.** The Contractor shall plan the work accordingly.

<u>Temporary Mainline Shoulder Closures</u>

Shoulder closures are anticipated at locations where Contractor access to the mainline is required.

Shoulder closures with plastic drums shall be removed at the end of the workday. Temporary shoulder closures with plastic drums will not be allowed during periods of inclement weather as determined by the Authority.

The location (limits) of shoulder closures with concrete barrier are shown on the Plans.

The barrier must be placed prior to the start of the work requiring concrete barrier and shall remain in place until the work activity is complete.

Equipment Moves

The complete stoppage of traffic for an equipment move (including delivery of materials to the median) will be considered for approval if the action cannot reasonably be completed with the erection of a lane closure. Contractor shall be responsible for the installation of Signs CS-3, "Expect Stopped Traffic" and Signs W3-4 "Be Prepared to Stop", in accordance with the Single Lane Closure Detail immediately prior to the equipment move. **Signs will be required on any adjacent ramps within proximity to the stoppage**. These signs shall be covered when not applicable.

State Police will be used to stop traffic. Cost for State Police will be the responsibility of the Authority. The times requested for trooper assisted equipment moves by on-duty troopers cannot be guaranteed. The MTA will not be held responsible for any delays or costs associated with the delay, postponement or cancellation of an on-duty trooper assisted equipment move.

The maximum time for which traffic may be stopped and held for an equipment move across mainline or ramp at any single time shall be five (5) minutes. The duration shall be measured as the time betweenthe time the last car passes the Resident until the time the Resident determines that all travel lanes are clear. The traffic shall only be stopped for the minimum period of time required to complete the approved activity. The Contractor shall reimburse the Authority at a rate of $500 per minute for each minute in excess of the five-minute allowance.

Unapproved movement of equipment or materials across the travel lanes shall be considered a violation of the Maintenance of Traffic Requirements and is subject to a minimum fine of $500 per occurrence with an additional $500 per minute thereafter.

Request for Complete Stoppage of Traffic

A request for a complete stoppage of traffic must be submitted to the Resident for approval. The Resident is required to receive approval from the Maine Turnpike Authority for all stoppages. The request shall be submitted to the Authority by the Resident at least five (5) working days prior to the day of the requested stoppage of traffic and two (2) days for a stoppage less than five minutes. All requests must be received by 12:00 p.m. noon to be considered as received on that day. Requests received after 12:00 p.m. shall be considered as received the following day. The Contractor shall plan the work accordingly.

During the erection or removal of overhead structures or signs

Traffic shall be stopped and may be held for periods of up to 25 minutes during these operations. Before the roadway is reopened, all materials shall be secured so they will not endanger traffic passing underneath. The Contractor will reimburse the Authority at the rate of $2,500.00 per five-minute period for each roadway not reopened (northbound and southbound), in excess of the 25-minute limit. Total penalty shall be deducted from the next pay estimate.

Blasting of Ledge

The maximum time for which traffic may be stopped at any single time shall be six (6) minutes. This duration shall be measured as the time between the time that the last car passes the Resident, until the time the Resident determines that all travel lanes are cleared of blast debris. The Contractor shall reduce the size of the blast, change the design and method of the blast, use more mats, or otherwise alter the blasting so that the traffic is not stopped for more than six minutes. If, due to the throw of rock onto the highway or other blasting related activities, traffic is stopped for more than six minutes, the Contractor shall pay a penalty of $1,000.00 per minute for every minute traffic is stopped in excess of the six-minute limit. The penalty shall be measured separately on the northbound and southbound roadway (or eastbound and westbound roadway). Total penalties will be deducted from the next pay estimate. Whenever the volume of traffic is excessive such that a six-minute interruption would cause objectionable congestion, in the opinion of the Authority, the hours during which blasting may occur may be further restricted. A detailed blasting plan shall be submitted as required in Supplemental Specific or Special Provision Sections 105 or 107.

652.3.5 Installation of Traffic Control Devices

All traffic control devices shall be in conformance with NCHRP 350 requirements and MASH 16 requirements if manufactured after December 31, 2019 and installed as per manufactures recommendations.

Portable signs shall be erected on temporary sign supports approved crashworthy devices so that the bottom of the sign is either 1) 12 inches or 2) greater than 5 feet above the traveled way. The bottom of all regulatory signs and ramp exit signs shall be a minimum of 5 feet above the traveled way. The contractor is responsible for maintaining the temporary sign structures so that the sign face remains in a vertical position. Temporary signs supports shall not be used for signs that will remain in place at a single location for more than one month.

No signs on easels shall be placed on 4 foot shoulders with guardrail, signs required at these location shall be placed on taller easels on the median side of the guardrail.

Post-mounted signs shall be erected so the bottom of the sign is no less than 5 feet above the traveled way, and 7 feet above the traveled way in business, commercial, and residential areas. Post-mounted signs must be erected so that the sign face is in a true vertical position. All signs shall be placed so that they are not obstructed in any manner and immediately modified to ensure proper visibility if obstructed.

The bottom of mainline and ramp traffic control signs intending to remain longer than 3 days, except as provided in 2009 MUTCD Section 6F.03 paragraph 12, shall be mounted 5 feet or greater above the edge of pavement on posts or portable sign supports.

The Resident will verify the exact locations of the construction signs in the field.

Construction signs behind guardrail shall be mounted high enough to be visible to traffic.

Vertical panel markers shall be mounted with the top at least 4 feet above the traveled way.

Drums placed along the Turnpike mainline shall have a minimum of one drum weight. Drums that will remain in the same location for more than three days shall have double drum weights. (i.e. a minimum of 40 lbs of drum tire rings). Drums shall not be weighted on the top. Drain holes shall be provided to prevent water from accumulating in the drums During winter periods, drums shall be placed on the grass shoulder or removed from the roadway so winter maintenance operations will not be impacted. This requires the placement of drums behind the median guardrail. Drums shall not be placed on snowbanks.

The Contractor shall operate and maintain the flashing arrow board unit and for dependable service during the life of the contract. The units shall remain in continuous night and day service at locations designated until the Resident designates a new location or discontinuance of service.

The Contractor shall maintain the devices in proper position and clean them as necessary. Maintenance shall include the covering and uncovering of all signs when no longer applicable (even if for a very short duration). The sign shall be considered adequately covered when no part of the sign face is visible either around or through the covering.
The Contractor shall replace damaged traffic control devices with devices of acceptable quality, as directed by the Resident.

The Contractor is required to cover all existing signs, including regulatory and warning signs, within the Work zone which may conflict with the proposed construction signs. The Contractor is also required to cover all permanent construction signs when they conflict with a daily traffic control setup. The method of covering existing signs must be approved by the Resident. The use of adhesives on the sign face is prohibited.

Work Zone Speed Limits

Work Zone Speed (Fines Doubled) is a regulatory speed limit that indicates the maximum legal speed through a work zone which is lower than the normal posted speed. The speed limit shall be displayed by black on white speed limit signs in conjunction with a black on orange "Work Zone" plate. Speed limit signs shall be installed at each mile within the work zone. Any existing regulatory speed limit signs within the reduced speed zone shall be covered once the reduced speed signs have been erected.

Two orange fluorescent flags shall be attached to all speed limit signs that are uncovered for a period of time exceeding one week. This work shall be incidental. Signs that are covered and uncovered on a regular basis are not required to have the supplemental flags.

The reduced speed limit signs shall be used when workers are adjacent to traffic, when travel lane(s) are closed, when indicated on Maintenance of Traffic Control Plans provided or other times as approved by the Resident:

The signs shall be covered or removed when not applicable. The covering and uncovering of signs shall be included for payment under Maintenance of Traffic. Signs relating to reduced speed shall be installed in accordance with the details. The Contractor shall note that all signs including those behind concrete barrier or guardrail are required to be clearly visible to all drivers

at all times.

Lane Closure Installation and Removal Procedure

The Contractor will follow the following procedures when closing any travel lanes on the turnpike roadways:

1. The sign package shall be erected starting with the first sign and proceeding to the start of the taper. The sign crew shall erect signs with the vehicle within the outside shoulder.

2. Position the arrow board with the proper arrow at the beginning of the taper; and,

3. When arrow board is in place, continue with the drums/cones to secure the work area.

To dismantle the lane closure, start with last drums/cone placed and work in reverse order until all the drums are removed. The arrow board which was installed first shall be the final traffic control device removed, excluding the sign package. The remaining sign package shall be picked-up starting with the first sign placed and continuing in the direction of traffic and with the vehicle in the outside shoulder.

Trucking Plan

The Contractor shall submit a trucking plan to the Resident within 10 working days of the award of the Contract. The trucking plan shall consist of at least the following:

- Date of anticipated start of work per each location.
- Haul routes from plant/pit to work area and return.
- Haul routes from work area to disposal area and return.
- Entering / exiting the work area.
- Vehicle safety equipment and Vehicle inspection.
- Personal safety equipment.
- Communications equipment and plan.

The trucking plan will not be paid for separately but shall be incidental to the Contract.

652.3.6 Traffic Control

The existing travel way width shall be maintained to the maximum extent practical.

Vertical panel markers, drums, cones, or striping shall be used to clearly delineate the roadway through the construction area. Two-way traffic operation shall be provided at all times

that the Contractor is not working on the project. One- way traffic shall be controlled through work areas by flaggers, utilizing radios, field telephones, or other means of direct communication.

The traffic control devices shall be moved or removed as the work progresses to assure compatibility between the uses of the traffic control devices and the traffic flow.

Pavement markings shall be altered as required to conform to the existing traffic flow pattern. Repainting of pavement marking lines, if required to maintain the effectiveness of the line, shall be considered **incidental to the** maintenance of traffic control devices, no separate payment will be made. Inappropriate pavement markings shall be removed whenever traffic is rerouted, and temporary construction pavement markings shall be placed. Removal of non-applicable markings and **initial** placement of temporary construction pavement markings will be paid for under the appropriate Contract items. Traffic changes shall not be made unless there is sufficient time, equipment, materials, and personnel available to complete the change properly before the end of the workday. This provision will not be required when traffic is rerouted for brief periods and the route can be clearly defined by channelizing devices, or flaggers, or both.

All vehicles used during the installation and removal of traffic control devices, including lane closures, shall be equipped with a vehicle-mounted lighted arrow board **or high intensity LED full width light bar** acceptable to the Resident. The arrow board **or full width light bar** shall be capable of displaying a left arrow, right arrow, double arrow, and light bar pa**tterns**.

652.4 Flaggers

The Contractor shall furnish flaggers as required by contract documents or as otherwise specified by the Resident. **Flaggers shall not stop traffic on Turnpike mainline or interchange ramps. Only State Police are allowed to stop traffic on mainline or interchange ramps.**

All flaggers must have successfully completed a flagger test approved by the Maine Department of Transportation and administered by a Maine Department of Transportation approved Flagger-Certifier. All flaggers must carry an official certification card with them at all times while flagging.

For daytime conditions, flaggers shall wear a top (vest, shirt or jacket) that is orange, yellow, yellow-green, or fluorescent versions of these colors meeting ANSI 107-2004, Class 3, along with a hat with 360 ˚ retro-reflectivity.

For nighttime conditions, flaggers shall wear all Class 3 apparel, meeting ANSI 107-2004, including a Class 3 top (vest, shirt or jacket) and a Class E bottom (pants or coveralls), shall be worn along with a hardhat with 360 ˚ retro-reflectivity and shall be visible at a minimum distance of 1000 ft. Flagger stations must be illuminated in nighttime conditions to assure visibility and will be specifically addressed in detail in the Contractor's TCP.

Flagger stations shall be located far enough in advance of the workspace so that approaching road users will have sufficient distance to stop at the intended stopping point. While flagging, the flagger should stand either on the shoulder adjacent to the traffic being controlled, or in the closed lane. At a spot obstruction with adequate sight distance, the flagger may stand on the shoulder opposite the closed sections to operate effectively. Under no circumstances shall

the flagger stand in the lane being used by moving traffic or have their back to oncoming traffic. The flagger should be clearly visible to approaching traffic at all times and should have a clear escape route.

When conditions do not allow for proper approach sight distance of a flagger or storage space for waiting vehicles, additional flaggers shall be used at the rear of the backlogged traffic or at a point where approaching vehicles have adequate stopping sight distance to the rear of the backlogged traffic. All flagger stations shall be signed, even when in close proximity. The signs shall be removed or covered when flagger operations are not in place, even if it is for a very short duration.

Flaggers shall be provided as a minimum, a 10-minute break, every 2 hours and a 30 minute or longer lunch period away from the workstation. Flaggers may only receive 1 unpaid break per day; all other breaks must be paid. Sufficient certified flaggers shall be available onsite to provide for continuous flagging operations during break periods. If the flaggers are receiving the appropriate breaks, breaker flagger(s) shall be paid starting 2 hours after the work begins and ending 2 hours before the work ends. A maximum of 1 breaker per 6 flaggers will be paid. (1 breaker flagger for 2 to 6 flaggers, 2 breaker flaggers for 7 to 12 flaggers, etc.). If a flagger station is manned for 10 hours or more, then ½ hour for lunch will be deducted from billable breaker flagger hours.

652.41 Traffic Officers

Local road traffic officers, if required, shall be uniformed police officers. State Police officers and vehicles shall be used to warn and stop traffic on the Maine Turnpike. All State Police shall be scheduled through the Maine Turnpike Authority. The Authority will make payment for the State Police officers and vehicles directly to the State Police.

The Contractor will not be entitled to additional compensation if scheduled Work is not completed due to the unavailability of State Police.

652.5.1 Rumble Strip Crossing

When lane shifts or lane closures require traffic to cross a permanent longitudinal rumble strip for 7 calendar days or less, the Contractor shall install warning signs that read “RUMBLE STRIP CROSSING” with a supplemental Motorcycle Plaque, (W8-15P).

When lane shifts or lane closures require traffic to cross a permanent longitudinal rumble strip for more than 7 calendar days, the Contractor shall pave in the rumble strips in the area that traffic will cross, unless otherwise directed by the Resident. Rumble strips shall be replaced prior to the end of the project, when it is no longer necessary to cross them.

652.6.1 Daylight Work Times

Unless otherwise described in the Contract, the Contractor is allowed to commence work and end work daily according to the Sunrise/Sunset Table at: http://www.sunrisesunset.com/usa/Maine.asp . If the Project town is not listed, the closest town on the list will be used as agreed at the Preconstruction Meeting. Any work conducted before

sunrise or after sunset will be considered Night Work.

652.6.2 Night work

When Night Work occurs (either scheduled or unscheduled), the Contractor shall provide and maintain lighting on all equipment, at all workstations, and all flagger stations.

The lighting facilities shall be capable of providing light of sufficient intensity to permit good workmanship, safety, and proper inspection at all times. The lighting shall be cut off and arranged on stanchions at a height that will provide perimeter lighting for each piece of equipment and will not interfere with traffic, including commercial vehicles, approaching the work site from either direction.

The Contractor shall have available portable floodlights for special areas.

The Contractor shall utilize padding, shielding or other insulation of mechanical and electrical equipment, if necessary, to minimize noise, and shall provide sufficient fuel, spare lamps, generators, etc. to maintain lighting of the work site.

The Contractor shall submit a lighting plan prior to any night work for review showing the type and location of lights to be used for night work. The Resident may require modifications be made to the lighting set up in actual field conditions.

Prior to beginning any Night Work, the Contractor shall furnish a light meter for the Residents use that is capable of measuring the range of light levels from 5 to 20 foot-candles.

Horizontal illumination, for activities on the ground, shall be measured with the photometer parallel to the road surface. For purposes of roadway lighting, the photometer is placed on the pavement. Vertical illumination, for overhead activities, shall be measured with the photometer perpendicular to the road surface. Measurements shall be taken at the height and location of the overhead activity.

Night Work lighting requirements:

Mobile Operations: For mobile-type operations, each piece of equipment (paver, roller, milling machine, etc.) will carry indirect (i.e. balloon type) lights capable of producing at least 10 foot- candles of lighting around the work area of the equipment.

Fixed Operations: For fixed-type operations (flaggers, curb, bridge, pipes, etc.), direct (i.e. tower) lighting will be utilized capable of illuminating the work area with at least 10 foot- candles of light.

Hybrid Operations: For hybrid-type operations (guardrail, sweeping, In-slope excavation, etc.), either direct or indirect lighting may be utilized. The chosen lights must be capable of producing at least 10 foot-candles of light around the work area of the equipment

Inspection Operations: Areas required to be inspected by the Authority will require a minimum of 5 foot-candles of lighting. This may be accomplished through direct or indirect

means.

The Contractor shall apply 2- inch wide retro-reflective tape, with alternating red and white segments, to outline the front back and sides of construction vehicles and equipment, to define their shape and size to the extent practicable. Pickup trucks and personal vehicles are exempt from this requirement.

The Resident or any other representative of the Authority reserves the right to suspend the work at any time and request a meeting to discuss violations and remedies. The Authority shall not be held responsible for any delay in the work due to any suspension under this item.

Failure to follow the approved Lighting Plan will result in a Traffic Control violation.

Payment for lighting, vehicle mounted signs and other costs accrued because of night work will not be made directly but will be considered incidental to the related contract items.

652.6.3 Traffic Coordinator and Personnel

The Contractor shall submit to the Resident for approval a list of traffic control personnel assigned to the Project including qualifications, certifications and experience.

The Traffic Coordinator duties shall include, but are not necessarily limited to:

a. Developing, in conjunction with the Resident and Project superintendent, a traffic control program for the days' work activities which will facilitate traffic in a safe and efficient manner.

b. Ensure that all traffic control implements (signs, arrow boards, barrels, etc.) are on-site so the traffic program can be implemented effectively.

c. Ensure a safe and effective setup or take-down of all signing implements to least impact the traveling motorist; and,

d. Working knowledge of construction signing/traffic control requirements in conformance with the latest issued Manual on Uniform Traffic Control Devices.

e. The Contractor shall supplement the traffic control plan with a daily plan, which includes schedules for utilizing traffic coordinators and flaggers. This plan shall be submitted daily and agreed upon cooperatively with the Resident.

652.7 Method of Measurement

Signs, signs supplied by the Authority, and panel markers will be measured by the square foot for all signs authorized and installed. Flashing arrow boards, portable-changeable message signs, and flashing and steady burn lights, will be measured by each unit authorized and installed on the project. Barricades and cones will be measured by each unit authorized. Drums will be measured by each or as a lump sum authorized and installed, as indicated on the plans and specifications. No additional payment will be made for devices that require replacement due to

poor condition or inadequate retroreflectivity.

Flaggers or traffic officers used during the Contract, for the convenience of the Contractor, will not be measured separately for payment, but shall be incidental to the various pay items. **This includes use of Flaggers for the delivery of materials and equipment to the project or other Flagger use that is for the Contractor's convenience, as determined by the Resident Engineer. If flaggers are required to maintain traffic and there is not a pay item in the contractor for flaggers, then flaggers shall be incidental to the other Section 652 contract items and no separate payment shall be made.**

The accepted quantity of traffic officer and flagger time will be the number of hours the designated station is occupied. The number of hours authorized for payment, **if any**, will be measured to the nearest ¼ hour.

The Authority will make payment for the State Police officers and vehicles directly to the State Police when utilized for mainline traffic control activities. State Police escorts, if required to move oversize material or equipment loads to the jobsite, will not be paid separately, but shall be incidental to the various pay items.

Maintenance of traffic control devices, including Truck mounted impact attenuators and Automated trailer mounted speed limit signs required for the project will be measured by the calendar day or as one lump sum, as indicated in the plans and specifications, for all authorized and installed traffic control devices. Traffic control devices will only be measured for payment the first time used. Subsequent uses shall be incidental to Item 652.36 or 652.361.

The vehicle mounted arrow board, mounted on trucks used for installation and removal of lane closures, will not be measured separately for payment, but shall be incidental to Item 652.36 or 652.361.

The traffic coordinator(s) will not be measured separately for payment but shall be incidental to Item 652.36 or 652.361.

Portable light towers, lighting on equipment and lighting plan will not be measured separately for payment but shall be incidental to the related Contract items.

Sequential Flashing Warning Lights shall be measured for payment by the maximum number of sequential flashing warning lights satisfactorily installed and properly functioning at any one time during the life of the project. Payment shall include all materials and labor to install, maintain and remove all Sequential Flashing Warning Lights.

Automated Trailer Mounted Speed Limit Sign shall incidental to the Maintenance of Traffic Control device item Payment shall include the Trailer, Radar Speed Limit Sign, flashing beacon amber lights, regulatory speed limit sign, fuel, necessary maintenance, and all checking of Radar Speed Limit Signs by manufacturer and all project moves including the transporting and delivery of the unit.

The accepted quantity of temporary portable rumble strips shall be measured by the unit complete in place, per lane closure application. A unit shall consist of 1 group of 3 full-lane width

of rumble strips. As shown in the plans, a maximum of 3 units may be used at each lane closure. A unit shall be measured for each group of rumble strips, each time they are used for a lane closure.

652.8 Basis of Payment

The accepted quantity of signs, signs supplied by the Authority, and panel markers will be paid for at the contract unit price per square foot. Such payment will be full compensation for furnishing (or retrieving from the Authority) and installing all signs, sign supports, and all incidentals necessary to complete the installation of the signs.

The accepted quantity of flashing arrow boards, barricades, battery operated flashing and steady burn lights, and cones will be paid for at the contract unit price each for the actual number of devices authorized, furnished, and installed. Such payment shall be full compensation for all incidentals necessary to install and maintain the respective devices.

The Sequential Flashing Warning Lights will be paid for at the Contract unit price per each. This price shall include all costs associated with furnishing, installing, operating, maintaining, relocating, and removing the Sequential Flashing Warning Lights.

The Truck Mounted Attenuator(s) will be incidental to the Maintenance of Traffic Control device item. This price shall include all costs associated with the use of the vehicle. Payment shall include operator, fuel, truck, maintenance, flashing lights, arrow board and all other incidentals necessary to operate the vehicle.

Failure by the contractor to reinstall cones, barrels, signs, covered/uncovered signs, and similar traffic control devices within an hour of them being displaced, moved, knocked over, un-covered and etc. will result in a $150 fine per traffic control device if the issues is not resolved within 1 hour of notification by the resident. An additional $150 will be assessed for each additional hour that the device has not been corrected. If the traffic control device is critical to the maintenance of traffic creating an actual or potential safety issue with traffic and is not corrected immediately then it will result in a violation letter as described below.

Failure by the contractor to follow the Contracts 652 Supplemental Specifications, Special Provisions and Standard Specification and/or the Manual on Uniform Traffic Control Devices (MUTCD) and/or the Contractors own Traffic Control Plan, or failure to correct a violation, will result in a violation letter and result in a reduction in payment as shown in the schedule below. The Resident or any other representative of the Authority reserves the right to suspend the work at any time and request a meeting to discuss violations and remedies. The Authority shall not be held responsible for any delay in the work due to any suspension under this item. Any reduction in payment under this Special Provision will be in addition to forfeiting payment of maintenance of traffic control devices for that day.

Amount of Penalty Damages per Violation

1st	2nd	3rd & Subsequent
$500	$1,000	$2,500

652.8.1 Maintenance of Traffic Control Devices

Maintenance of Traffic Control Devices will be paid at the contract unit price per calendar day or lump sum price, as indicated in the plans and specifications. Such payment will be full compensation for all days that the Contractor maintains traffic as specified herein, and for moving devices as many times as necessary; for replacing devices damaged, lost, or stolen; and for cleaning, maintaining, and removing all devices used for traffic control, including replacing temporary pavement marking lines.

The contract price for Maintenance of Traffic Control Devices shall be full compensation for all days for such maintenance, encompassing all areas of the contract, regardless of whether or not the work areas or projects are geographically separated.

652.8.2 Other Items

The accepted quantities of flagger hours will be paid for at the contract unit price per hour for each flagging station occupied excluding lunch breaks, and for each approved breaker flagger. Overtime hours, as reported on the certified payrolls, will be paid an additional 30% of the bid price for 652.38. The computation and additional payment for overtime hours will occur during the project close-out process and will be paid as additional hours of 652.38 to the nearest ¼ hour. The contract unit price shall be full compensation for hiring, transporting, equipping, supervising, and the payment of flaggers and all overhead and incidentals necessary to complete the work.

There will be no payment made under any 652 pay items after the expiration of the adjusted total contract time.

The accepted quantities of traffic officer hours will be paid for at the contract unit price per ¼ hour for each station occupied, with no additional payment for overtime. This price shall be full compensation for supplying uniformed officers with police cruisers, and all incidentals necessary to complete the work, including transportation, equipment, and supervision.

Payment for temporary pavement marking lines and pavement marking removal will be made under the respective pay item in Section 627 - Pavement Markings.

Payment for temporary traffic signals will be made under Section 643 - Traffic Signals. The accepted quantity of Portable Changeable Message Signs will be paid for at the Contract unit price each. This price shall be full compensation for furnishing, relocating, maintaining and removing the PCMS. The price also includes all costs associated with setting-up and paying for a data cellular account, technical support, training and any costs associated with the GPS location device.

Progress payment of each PCMS shall be pro-rated over the duration of the Contract. Contract duration shall be from the specified Contract start date to substantial completion or Contract completion, whichever is sooner.

For a PCMS that fails to operate when required, the Contractor will be given 24-hours to repair or replace the PCMS. For periods longer than 24-hours, payment will be reduced based on the pro-rated time that the PCMS is out of service.

Drums will be paid for at the contract unit price each, or at the Contract lump sum price,

as designated in the Plans and specifications. Such payment shall be full compensation for all drums as shown on the Plans or required to complete the work.

The accepted quantity of temporary portable rumble strips will be paid for at the contract unit price per unit which shall include the transport device. Payment is full compensation for providing, relocating, maintaining or replacing, and removing temporary portable rumble strips. If the pay item is not included in the contract quantities, then the Authority does not anticipate the use of this item on the contract. If contractor wishes to utilize temporary portable rumble strips and the item is not in the contract, then the contractor may propose use of them to the Authority for consideration.

Payment will be made under:

Pay Item		Pay Unit
652.30	Flashing Arrow Board	Each
652.31	Type I Barricade	Each
652.311	Type II Barricade	Each
652.312	Type III Barricades	Each
652.32	Battery Operated Light	Each
652.33	Drum	Each
652.331	Drum	Lump Sum
652.34	Cone	Each
652.35	Construction Signs	Square Foot
652.351	Construction Signs-Supplied by Authority	Square Foot
652.36	Maintenance of Traffic Control Devices	Calendar Day
652.361	Maintenance of Traffic Control Devices	Lump Sum
652.38	Flaggers	Hour
652.381	Traffic Officers	Hour
652.41	Portable-Changeable Message Sign	Each
652.46	**Temporary Portable Rumble Strips**	**Unit**
652.47	**Sequential Flashing Warning Lights**	**Each**

SPECIAL PROVISION

SECTION 652

MAINTENANCE OF TRAFFIC

(Specific Project Maintenance of Traffic Requirements)

This Specification describes the specific project maintenance of traffic requirements for this Project.

The following minimum traffic requirements shall be maintained. These requirements may be adjusted based on the traffic volume when authorized by the Authority.

Maine Turnpike Traffic Control Requirements

Mainline lane and shoulder closures are not allowed. A single temporary toll plaza lane closure, specifically the left-most EZ-Pass Only lane within the CASH lanes, shall be closed with temporary concrete barrier. The closure shall include temporary concrete barrier prior to the toll plaza to close the lane, then temporary concrete barrier shall extend approximately 100 feet, as directed by MTA Resident, beyond the toll plaza to create the Contractor's laydown and parking area. Contractor shall coordinate with the MTA Resident to change overhead lane use signals upon implementing this single, left-most EZ-Pass Only lane closure.

The Contractor is responsible to keep the closed lane free of snow and ice at all times for the duration of the closure. The Contractor shall plan the work, including sufficient labor and materials, such that once the closure is setup, the stairwell caps and booth repairs are completed expeditiously without undue delay to minimize the duration of this EZ-Pass Only lane closure. With the exception of the stairwell closure period defined in Special Provision 652 Temporary Toll Plaza Lane Closure, the Contractor shall be prepared at all times to allow MTA to reopen the closed EZ-Pass Only lane with a two-day notice.

See Special Provision 652 Temporary Toll Plaza Lane Closure for other allowable closures.

SPECIAL PROVISION

SECTION 652

MAINTENANCE OF TRAFFIC

(Temporary Toll Plaza Lane Closures)

The following minimum requirements shall be maintained:

Plaza lanes shall remain available for opening at all times except when the Contractor is performing work in, adjacent to or directly over the plaza lanes. A plaza lane closure is required when danger to the traveling public or turnpike employees may exist. The potential of any material falling onto the roadway shall be considered a potential danger. This shall include, but not necessarily be limited to, demolition debris, water, tools, equipment and material.

A plaza lane closure will be required whenever people or equipment will be present in a plaza lane. The Authority may also require adjacent lanes to be closed to protect the traveling public or turnpike employees. Temporary plaza lane closures will only be allowed at the times outlined below. These hours may be adjusted based on the traffic volume each day by the Resident. Plaza lane closures not completely removed by the ending time specified will be subject to a lane rental fee of $100.00 per 10 minutes for every 10 minute increment beyond the specified ending time. Temporary plaza lane closures will not be allowed during periods of inclement weather as determined by the Authority. Temporary plaza lane closures may not be allowed on days or times when complete stoppages of traffic for other Authority projects are scheduled. The Authority reserves the right to order removal of approved plaza lane closures.

Requests for temporary traffic lane closures shall be submitted to the Resident for approval. The Resident is required to receive approval from the Maine Turnpike Authority's Plaza Supervisor for all plaza lane closures. The request shall be submitted to the Plaza Supervisor by the Resident at least one (1) working days prior to the day of the requested plaza lane closure. All requests must be received by 12:00 p.m. noon to be considered as received on that day. Requests received after 12:00 p.m. shall be considered as received the following day. The Contractor shall plan the work accordingly.

Some activities, which require plaza lane closures, will be considered favorably for night work. The Contractor shall submit a request in writing to the Resident. The approval of the request will be at the Resident's discretion and will not be unreasonably withheld.

Wide load and E-ZPass lanes may be closed Monday thru Thursday from 8:00 p.m. to 6:00 a.m. the following morning. The wide load and E-ZPass lane closures must be scheduled one (1) week in advance, and occur outside of the various Holiday restrictions.

Intermediate single lanes may be closed Sunday thru Thursday from 8:00 p.m. to 3:00 p.m. the next day. The Intermediate single lanes closures must be scheduled one (1) day in advance, and occur outside of the various Holiday restrictions.

Traffic Control and Plaza Safety

Temporary traffic control layouts shall be submitted to the Resident a minimum of five days prior to the requested temporary layout for review and approval.

652.7 Method of Measurement

All temporary traffic control devices required, including but not limited to advance warning signs, construction signs, drums, cones, barrels shall not be measured for payment but shall be incidental to pay item 652.361 Maintenance of Traffic Control Devices. No additional payment shall be made for devices that require replacement due to poor condition or inadequate retroreflectivity, or that require multiple setups and takedowns.

SPECIAL PROVISION

SECTION 655

ELECTRICAL WORK

655.01 Description

All work shall be governed by the Standard Specifications except for that work which applies to those sections of the Standard Specifications which are amended by the following modifications, additions and deletions.

Specifically, for the electrical work (in addition to standards specified in individual work sections), the following standards are imposed, as applicable to the work in each instance:

- NEC, National Electrical Code (NFPA No. 70)
- NFPA No. 101, Life Safety Code
- ANSI C 2, National Electrical Safety Code
- ANSI C 73, Dimensions of Attachment Plugs and Receptacles
- NECA standards for installation
- NEMA standards for materials and products
- UL, Underwriters Laboratories

The Contractor will warranty the material supplied by them and their workmanship for a minimum of one (1) year.

655.02 General Provisions

RELATED DOCUMENTS

General provisions of this Contract, including General Provisions and Special Provisions, apply to work of this section.

SUMMARY

This Section specifies several categories of provisions for electrical work, including:

1. Certain adaptive expansions of requirements specified in the Special Provisions.
2. General performance requirements within the electrical systems as a whole.
3. General work to be performed as electrical work, because of its close association.

SUMMARY OF ELECTRICAL WORK

General Outline: The facilities and systems of the electrical work can be described (but not by way of limitation) as follows:

1. Modification of existing electrical service and service/distribution equipment.

2. Installation of electrical control and power distribution systems, including the electrical connections to new equipment.

Permits and Fees: This work shall include the procurement of and payment for any and all permits and fees required for the performance of the electrical work including those that may be required from local utilities for services.

COORDINATION OF ELECTRICAL WORK

Refer to Part II, Special Provisions for general coordination requirements applicable to the entire work. It is recognized that the Contract documents are often diagrammatic in showing certain physical relationships, which shall be established within the electrical work, and in its interface with other work including utilities and mechanical work, and that such establishment is the exclusive responsibility of the Contractor.

Arrange electrical work in a neat, well organized manner with conduit and similar services running parallel with primary lines of the building construction, and with a minimum of 7'0" overhead clearance where physical limitations permit.

Locate operating and control equipment properly and in accordance with the NEC, to provide easy access, and arrange entire electrical work with adequate access for operation and maintenance.

Coordination of Options and Substitutions: Where the Contract documents permit the selection from several product options, and where it becomes necessary to authorize a substitution, the Contractor shall not proceed with purchases until coordination of all interface requirements has been checked and satisfactorily established. Substitutions are subject to approval by the Authority or designated representative per the requirements of the Contract documents.

SUBMITTALS FOR ELECTRICAL WORK

For electrical work, submittals are required for each category of items listed below.

- Shop Drawings, Product Data, Certifications, Test Reports, Warranties, Guarantees, Installation Drawings, and Plaza Work Checklist in Appendix I.
- Installation Drawings shall be modified and submitted to reflect any changes during installation of electrical equipment.

The Contractor, prior to forwarding shop drawings and product data to the Resident, shall check all conditions, make all corrections and sign and date each set. No shop drawings will be reviewed by the Resident without the signature of the Contractor, which shall signify that he has checked the submittals.

PRODUCTS, ELECTRICAL WORK

Refer to Divisions 600 and 700 of the Standard Specifications for general requirements on products, materials and equipment. The following provisions expand or modify the requirements as applicable to electrical work:

Compatibility: Provide products, which are compatible with other products of the electrical work and with other work requiring interface with the electrical work, including electrical connections and control devices. For exposed electrical work, coordinate colors and finishes with other work.

FLOOR AND WALL PENETRATIONS

Where electrical materials penetrate walls or floors that are a part of a fire separation or assembly, the opening shall be effectively sealed to maintain separation integrity. Openings shall be closed using General Electric RTV850 Silicone RTV Foam, or approved equal to form a fire rated, water-tight seal, and installation with automatic mixing only. The penetration seal materials shall pass ASTM E 814 (UL 1479) Standard Method of Fire Tests for Through Penetration Fire Stops up to the required fire resistance.

Where conduits penetrate a wall, floor or ceiling that is part of a weatherproof barrier, a non-shrink weatherproof type grout and or Sika 1A caulking shall be used, in accordance with manufacturer's installation instructions.

All work, materials, labor to fireproof or waterproof conduit penetrations shall be incidental to the various pay items

EXCAVATING FOR ELECTRICAL WORK

The work of this article is defined to include whatever excavating and back-filling is necessary to install the electrical work. Coordinate the work with other excavating and back-filling in the same area, including de-watering; flood protection provisions, and other temporary facilities. Coordinate the work with other work in the same area, including other underground services (existing and new), paving, and concrete work. Coordinate with weather conditions and provide temporary facilities needed for protection and proper performance of installations, excavating and back-filling.

General Standards: Except as otherwise required, comply with the applicable provisions of Divisions 600 and 700 of the Standard Specifications for information related to electrical-work excavating and back-filling. Refer instances of uncertain applicability to the Resident for resolution before proceeding.

ELECTRICAL WORK CLOSEOUT

Construction Equipment: After completion of performance testing and the Authority's performance testing, remove Contractor's tools, test facilities, construction equipment and similar devices and materials used in execution of the work but not incorporated in the work.

ELECTRICAL SYSTEM TEST

The Contractor shall submit certification of the adequacy of each power and/or communications circuit for the following sub-systems, where applicable:

- Lane Controller (LC) System
- Automatic Vehicle Identification (AVI) Readers
- Automatic Vehicle Identification (AVI) Antennas
- Digital Video Audit System (DVAS)
- Traffic Control Pedestal (TCP)
- Vehicle Capture and Recognition System (VCARS)
- Canopy Override Switch (COS)
- Manual Lane Terminal (MLT)
- Receipt Printer (RP)

Verification of the electrical system should be done by turning on/off assigned circuit breakers prior to attachment of equipment to validate panel schedule and that proper voltage is present at termination.

COMMUNICATIONS SYSTEMS

Provide outlets, wireways, device plates, etc., in conformance with the applicable sections of this specification, as may be required.

Wireways shall be in accordance with "Wireways" part of the Technical Specifications and NEC and the following special conditions:

- Minimum size shall be 1 inch unless otherwise noted.

- No more than two standard factory 90-degree bends per 100 feet or three 90 degree 24 inch radius bends and as to adhere to minimum manufacturers bend radius's on data cables.

655.03 Electrical Wireways

RELATED DOCUMENTS

General provisions of the Contract, including General Provisions and Special provisions, apply to work of this section.

SUMMARY

The requirements of this section apply to electrical wireway work specified elsewhere in these Specifications.

The types of electrical wireways required for the project may include the following:

- Electrical metallic tubing.
- Intermediate metal conduit.
- Liquid tight metallic flexible conduit.
- Galvanized rigid metal conduit.
- Nonmetallic conduit. (PVC)
- Surface Plastic NEMA 4R wireways.

QUALITY ASSURANCE

Manufacturers: Firms regularly engaged in manufacture of electrical wireways of types and capacities required, whose products have been in satisfactory use in similar service for not less than three years.

Contractor: A firm with at least three years of successful installation experience on projects with electrical wiring installation work similar to that required for the project. Under this definition, Contractor can also be a subcontractor to the General Contractor for the Project.

NEMA Compliance: Comply with applicable portions of National Electrical Manufacturers Association standards pertaining to nonmetallic duct and fittings for underground installation.

UL Labels: Provide electrical wireways, which have been listed and labeled by Underwriters Laboratories.

NEC Compliance: Comply with National Electrical Code (NFPA No. 70) as applicable to construction and installation of electrical wireways.

PRODUCT DELIVERY, STORAGE AND HANDLING

Provide color-coded end-cap thread protectors on exposed threads of threaded metal conduit. Handle conduit and tubing carefully to prevent bending and end-damage and to avoid scoring finish. Store pipe and tubing inside and protect from weather. When necessary to store outdoors, elevate well above grade and enclose with durable, watertight wrapping.

MATERIALS AND COMPONENTS

For each electrical wireway system required, provide a complete assembly of conduit or tubing with fittings including, but not necessarily limited to, connectors, nipples, couplings, elbows, expansion fittings, supports, and other components and accessories as needed to form a complete system of type required.

Metal Conduit, Tubing and Fittings: Provide metal conduit, tubing and fittings of type, grade, size and weight (wall thickness) required for each service. Where type and grade are not indicated, provide proper selection determined to fulfill wiring requirements, and comply with National Electrical Code for electrical wireways.

Rigid Steel Conduit: FS WW-C-581 and ANSI C80.1.

Intermediate Steel Conduit: FS WW-C-581 and ANSI C80.1.

EMT- Electrical Metallic Tubing: FS WW-C-563A, ANSI C80.3 and UL 797. Installation shall comply with NEC Article 348. Provide high quality, hot dip galvanized, electrical metallic tubing conduit and fittings of type, size and weight (wall thickness) required for each application. EMT shall only be used in enclosed areas that are not subject to possible collision or interference. Where type and grade are not indicated, provide proper selection determined to fulfill wiring requirements, and comply with National Electrical Code. Rain-tight compression type connectors shall be used in all cases. Set-screw type conduit connections or fittings shall not be used.

Galvanized Rigid Metal Conduit Fittings: FS W-F-408, Type and Classes as required.

Liquid-tight Flexible Metal Conduit: Provide liquid-tight flexible metal conduit comprised of single strip, continuous, flexible interlocked, double-wrapped steel, galvanized inside and outside; forming smooth internal wiring channel; with liquid-tight jacket of flexible polyvinyl chloride (PVC).

Liquid-tight Flexible Metal Conduit Fittings: FS W-F-406, Type as required.

Nonmetallic Conduit and Fittings (PVC): Provide nonmetallic conduit and fittings of type, size and weight (wall thickness) required for each service. Where type and grade are not indicated, provide proper selection determined to fulfill wiring requirements, and comply with National Electrical Code for electrical wireways, and with type selected in accordance with applicable standards.

Surface Mounted Plastic NEMA 4R Wireways: Provide wireways for surface mounting as required. Wireways shall be of rectangular cross section of size as required by the National Electrical Code (NFPA No. 70) for conductor fill. Wireways shall be of a design to accommodate wiring devices required.

Conduit and Tubing and Wireway Accessories: Provide conduit, tubing and wireway accessories including straps, hangers, angles expansion and deflection fittings as recommended by conduit, tubing and wireway manufacturers.

Mounting strut materials and hardware: Provide corrosion-resistant hot-dip galvanized strut members and stainless-steel hardware for all equipment and cabinet mounting applications.

INSTALLATION

Install conduit and tubing products as required, in accordance with manufacturer's written instructions, applicable requirements of NEC and National Electrical Contractors Association's "Standard of Installation", and in accordance with recognized industry practices to ensure that products serve intended function.

Complete the installation of electrical wireways before starting installation of cables within wireways.

Where conduit is installed in earth, it shall be Polyvinyl Chloride (PVC) conduit as specified in the Plans.

PVC conduit shall be used in concrete slabs on grade and where noted in the Plans. Metallic conduit is not permitted in the concrete slabs or in substitution of any PVC conduit locations specified on the Plans without specific authorization by the Authority.

Wherever possible, install horizontal wireway runs above water and steam piping.

Install surface Plastic NEMA 4R wireways and accessories as required on elevations. Carefully coordinate with interior finishes and furnishings.

End bell fittings shall be installed on all conduit ends.

At any point where a conduit crosses an expansion joint, or where movement between adjacent sections of conduit can be expected, bronze or alloy expansion fittings shall be installed equal to Type AX as made by the O.Z. Electrical Manufacturing Co., Inc., or equivalent by Hope or Spring City unless such locations are within conduit specified as non-metallic. Such locations shall be handled with a non-metallic equivalent or as specified in Plans.

The Contractor shall submit a proposed method of attaching all ancillary components to the toll canopy to the Resident for approval. The proposed attachment method shall not require drilling, welding or other attachment methods that will damage the toll canopy or its coating. Any areas of galvanized coating that are damaged by the Contractor during installation of ancillary components shall be repaired in accordance with ASTM A780. All damaged painted surfaces shall be repaired in accordance with Standard Specification 506.

655.04 Wires and Connectors

RELATED DOCUMENTS

The general provisions of the Contract, including General Provisions and Special Provisions, apply to the work specified in this section.

SUMMARY

The requirements of this section apply to the wire work specified elsewhere in these Specifications.

The applications for wire and connectors required on the project may include the following:

- Power distribution circuitry.
- Lighting circuitry.
- Appliance and equipment circuitry.

QUALITY ASSURANCE

Manufacturers: Firms regularly engaged in the manufacture of electrical products of the types and ratings required, whose products have been in satisfactory use in similar service for not less than 3 years.

Contractor: A firm with at least three years of successful installation experience on projects with electrical wiring installation work similar to that required for the project. Under this definition, Contractor can also be a subcontractor to the General Contractor for the Project.

NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to construction and installation of electrical cable, wire and connectors.

UL Labels: Provide electrical cable, wire and connectors, which have been listed and labeled by Underwriters Laboratories.

NEMA/ICEA Compliance: Comply with National Electrical Manufacturers Association/Insulated Power Cable Authorities Association Standards publications pertaining to materials, construction and testing wire cable, where applicable.

PRODUCT DELIVERY, STORAGE AND HANDLING

Provide factory-wrapped water-proof flexible barrier material for covering wire and cable on wood reels, where applicable; and weather resistant fiberboard containers for factory-packaging of cable, wire and connectors, to protect against physical damage in transit. Do not install damaged cable, wire or connectors; remove from project site.

Store wire and connectors in factory-installed coverings in a clean, dry indoor space which provides protection against the weather.

MANUFACTURERS

Provide products produced by one of the following or approved equal (for each type of cable, wire and connectors):

Cable and Wire:

- Anaconda Wire and Cable Co.
- Belden Corp.
- General Cable Corp.
- Phelps Dodge Cable and Wire Co.
- Wire and Cable Dept., General Electric Co.
- Rome Cable Corp.

Connectors:

- AMP Inc.
- Burndy Corp.

- Minnesota Mining and Mfg. Co.
- OZ/Gedney Co.
- Thomas & Betts Co.

WIRE AND CONNECTORS

Except as otherwise required, provide wire and connectors of manufacturer's standard materials, as required by published product information; designed and constructed as recommended by the manufacturer, and as required for the installation.

Wire:

Provide factory-fabricated wire of the size, rating, material and type as required for each service. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements and with NEC standards. Select from only the following types, materials, conductor configurations, insulations, and coverings for 120/208 Volt circuits:

UL Type: THWN. (Sizes #16 AWG wire up to #12 AWG wire)

UL Type: XHHW-2. (Sizes #10 AWG wire up to #2 AWG wire)

UL Type: XHHW-2. (Size 500 MCM)

Material: Copper.

Conductors: (AWG wire 24 to AWG wire 18).

> Note: All low voltage signal conductors (including CAT5e and CAT6 data cables) shall be stranded. Conductors for underground, below grade, or in conduit to lane devices shall be shielded and Outdoor (CMX) rated not to be gel filled. Interior building communications cables may be plenum rated for interior wall or cable tray applications.

Concentric-lay-stranded (standard flexibility) (AWG wire 16 and larger).

Interconnection for data communication shall be performed with cables that shall be submitted for approval. The general cable types are designated on the Plans/ Specifications. Minimum bend radius should meet the requirements of the manufacturer and the requirements of the system.

Wire shall be color-coded as noted in the wiring schedules provided in the Plans.

Lead-in cables to extend loop detectors shall be IMSA Type 50-2. Loop lead-in cables shall be manufactured with a size of #14 AWG.

Klik-Its (Power & Tel Enterprise Part #C8820) or approved equivalent shall be used at all loop wire splice locations. All splices must be twisted, soldered and shrink-wrap waterproofed before enclosure is placed.

Home run cables preferably should not be shielded. The use of shielded cable is acceptable provided neither end is grounded.

All cable labeling shall be coordinated with the requirements of the Authority's Toll System Integrator (SI).

INSTALLATION

Install electrical wire and connectors as required, in accordance with the manufacturer's written instructions, the applicable requirements of NEC and the National Electrical Contractors Association's "Standard of Installation", and in accordance with recognized industry practices to ensure that products serve the intended functions.

Coordinate cable and wire installation work with electrical wireway and equipment installation work, as necessary for proper interface.

All wire and cable shall be in first class condition when they are installed. Lo-leak lubricants manufactured for the purpose of a pulling lubricant may be used when necessary.

All wires shall be continuous from outlet and there shall be no unnecessary slack in the conductors.

FIELD QUALITY CONTROL

Prior to energizing, check wire for continuity of circuitry and for short circuits with ohmmeter type testing equipment. Correct malfunction when detected.

Subsequent to wire hook-ups, energize circuitry and demonstrate functioning in accordance with requirements.

655.05 Electrical Boxes and Fittings

RELATED DOCUMENTS

The general provisions of the Contract, including General Provisions and Special Provisions, apply to the work specified in this section.

SUMMARY

The types of electrical boxes and fittings required for the project may include the following:

- NEMA 4X Cabinet for AVI Readers
- Outlet boxes
- Junction boxes
- Pull boxes
- Floor boxes
- Conduit bodies
- Bushings

- Locknuts

QUALITY ASSURANCE

Manufacturers: Firms regularly engaged in the manufacture of electrical units of types and sizes required, whose products have been in satisfactory use in similar service for not less than three years.

Contractor: A firm with at least three years of successful installation experience on projects with electrical installation work similar to that required for the project. Under this definition, Contractor can also be a subcontractor to the General Contractor for the Project.

NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to construction and installation of electrical boxes and fittings.

U.L. Labels: Provide boxes and fittings, which have been listed and labeled by Underwriters Laboratories.

NEMA Compliance: Comply with National Electrical Manufacturers Association standards as applicable to nonmetallic fittings for underground installation.

NECA Standard: Comply with applicable portions of the National Electrical Contractors Association's "Standard of Installation".

MANUFACTURERS

Provide products produced by one of the following or approved equal (for each type of box and fitting):

Control Cabinet:

- Hammond Manufacturing (provided by SI and installed by the Contractor)

Interior Outlet Boxes:

- Appleton Electric Co.
- Arrow Conduit and Fittings Corp.
- National Electric Products Co.
- OZ/Gedney Co.
- Steel City, Midland-Ross Corp.

Junction and Pull Boxes:

- Arrow-Hart, Inc.
- General Electric Co.
- OZ/Gedney Co.
- Square D Co.
- Unitil

Conduit Bodies:

- Appleton Electric Co.

- Crouse-Hinds Co.
- Killark Electric Mfg. Co.
- Pyle-National Co.

Bushings, Knockout Closures and Locknuts:

- Allen-Stevens Conduit Fittings Corp.
- Allied Metal Stamping, Inc.
- Appleton Electric Co.
- Carr Co.
- Raco, Inc.
- Steel City, Midland-Ross Corp.
- Thomas and Betts Co., Inc.

FABRICATED MATERIALS

Interior Outlet Boxes: Provide plastic or stainless steel interior outlet wiring boxes, of the type, shape and size, including depth of box, to suit each respective location and installation; constructed with stamped knockouts in back and sides, and with threaded holes with screws for securing box covers or wiring devices.

Interior Outlet Box Accessories: Provide outlet box accessories as required for each installation, including mounting brackets, wallboard hangers, extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, compatible with outlet boxes being used and meeting requirements of individual wiring situations. Choice of accessories is Installer's option. All covers for outlet boxes to be stainless steel.

Junction and Pull Boxes: Provide plastic or stainless steel or concrete junction and pull boxes as called for in the Plans with screw-on covers; of the type shape and size, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws and washers.

Conduit Bodies: Provide plastic or stainless steel conduit bodies, of the type, shape and size, to suit each respective location and installation, constructed with threaded conduit ends, removable cover, and corrosion-resistant screws.

Bushings, Knockout Closures and Locknuts: Provide corrosion-resistant punched-steel box knockout closures, conduit locknuts and malleable iron conduit bushings of the type and size to suit each respective use and installation.

Mounting strut materials and hardware: Provide corrosion-resistant stainless steel members and stainless steel hardware for all equipment mounting applications. Where strut material is exposed to the weather, and less than 10 feet off the ground, struts shall be stainless steel. When any galvanized strut member or hardware is cut or the galvanizing is compromised, the affected area shall be wire brushed and cleaned to bare metal and the area shall be given two coats of cold galvanizing (following application instructions).

INSTALLATION OF BOXES AND FITTINGS

Install all equipment cabinets in compliance with NEC requirements, in accordance with the manufacturer's written instructions and with recognized industry practices to ensure the boxes and fittings serve the intended purposes

Install electrical boxes and fittings in compliance with NEC requirements, in accordance with the manufacturer's written instructions and with recognized industry practices to ensure that the boxes and fittings serve the intended purposes:

Provide weatherproof outlets for interior and exterior locations exposed to weather or moisture.

Provide knockout closures to cap unused knockout holes where blanks have been removed.

Locate boxes and conduit bodies to ensure accessibility of electrical wiring.

All boxes shall be rigidly secured in position unless otherwise directed

Where standard boxes are not suitable, provide boxes of special design to suit space and function.

The Contractor shall submit a proposed method of attaching all ancillary components to the toll canopy/mast arm to the Resident for approval. The proposed attachment method shall not require drilling, welding or other attachment methods that will damage the toll canopy/mast arm or its coating. Any areas of galvanized coating that are damaged by the Contractor during installation of ancillary components shall be repaired in accordance with ASTM A780.

655.06 Wiring Devices

RELATED DOCUMENTS

The general provisions of the Contract, including General Provisions and Special Provisions, apply to the work specified in this section.

SUMMARY

Wiring devices are defined as single discrete units of electrical distribution systems, which are intended to carry but not utilize electric energy.

The types of electrical wiring devices required for this project include the following:

- Receptacles
- Switches
- Wall plates
- Plugs
- Connectors
- Breakers

QUALITY ASSURANCE

Manufacturers: Firms regularly engaged in manufacture of wiring devices, of types and ratings required, whose products have been in satisfactory use in similar service for not less than three years.

Contractor: A firm with at least three years of successful installation experience on projects with electrical installation work similar to that required for the project.

NEC Compliance: Comply with National Electrical Code (NFPA No. 70) as applicable to construction and installation of electrical wiring devices.

UL Labels: Provide electrical wiring devices, which have been tested, listed and labeled by Underwriters Laboratories.

NEMA Compliance: Comply with National Electrical Manufacturers Association standards for general- and specific-purpose wiring devices.

MANUFACTURERS

Provide products produced by one of the following:

- Arrow-Hart, Inc.
- Bell Electric Co.
- Bryant Electric Co.
- Crouse-Hinds Co.
- Cutler-Hammer, Inc.
- General Electric Co.
- Gould, Inc.
- Harvey Hubbell Inc.
- Pass and Seymour, Inc.
- Slater Electric, Inc.
- Square D Co.
- Hunt Electronics
- Lutron
- Intermatic
- Paragon
- Unitil

FABRICATED DEVICES

Provide factory-fabricated wiring devices, in type and electrical rating for the service required.

Receptacles: Comply with NEMA Stds. Pub. No. WD1 and as follows:

General-Duty Duplex: Provide duplex general-duty type, spec. grade, receptacles, 2-pole, 3-wire grounding, with green hexagonal equipment ground screw, ground terminals and poles internally connected to mounting yoke, 15-ampere, 125-volts, with metal plaster ears, screw terminal connectors, NEMA configuration 5-15R unless otherwise required.

Heavy-Duty Duplex: Provide duplex type, spec. grade, receptacles, 2-pole, 3-wire grounding, with green hexagonal equipment ground screw, 20-ampere, 125-volts, with metal plaster ears, screw terminal connectors, NEMA configuration L5-20R unless otherwise required.

Switches: Comply with NEMA Stds. Pub. No. WD1 and as follows:

Provide general-duty flush toggle switches, 20-ampere, 120/277 VAC, with mounting yoke insulated from mechanism, equipped with plaster ears, and side-wired screw terminals as follows:

Single pole switches	Double pole switches
Three Way switches	Four Way switches

Breakers: Breakers shall be compatible with existing panel circuits. All breakers necessary will be incidental to the Contract pay items.

WIRING DEVICE ACCESSORIES

Wall Plates: Provide single switch and duplex outlet wall plates for wiring devices, with ganging and cutouts as required, provide with metal screws for securing plates to devices, screw heads colored to match finish of plate, and wall plates possessing the following additional construction features:

Material and Finish: 0.04 inch thick, satin finished stainless steel.

INSTALLATION OF WIRING DEVICES

Install wiring devices where required, in accordance with manufacturer's written instructions, applicable requirements of NEC and National Electrical Contractors Association's "Standard of Installation", and in accordance with recognized industry practices to ensure that products serve intended function.

Delay installation of devices until wiring is completed.

Install receptacles and switches only in electrical boxes that are clean and free from excess building materials, debris, etc.

PROTECTION OF WALL PLATES AND RECEPTACLES

Upon installation of wall plates and receptacles, Contractor shall use caution regarding the use of convenience outlets. At time of completion, replace those items which have been damaged, including those burned and scored by faulty plugs.

TESTING

Test wiring devices to ensure electrical continuity of grounding connections, and after energizing circuitry, to demonstrate compliance with requirements.

655.07 Grounding

SUMMARY

Furnish labor and material to provide grounding facilities for the entire electrical installation as required by all inspecting and jurisdictional authorities as herein specified. The following are included, but not limited to, as items requiring grounding:

- Electrical service neutral conductor.
- Neutral conductor of all transformer secondaries.
- Conduits, boxes and other conductor enclosures. Neutral or identified conductor of interior wiring system.
- Distribution panels, power and lighting panel boards.
- Non-current - carrying parts of fixed equipment, such as transformers, motors, starters, control cabinets, disconnects, lighting fixtures, stand-by generator, etc.
- Metallic cabinets and auxiliary systems cabinets.

EQUIPMENT

Furnish and install all boxes and/or access plates required for installation and inspection of grounding connections to cold water piping system or other made electrodes.

Provide brass identifying tags on all ground clamps.

INSTALLATION

Ground connections made to metallic cold water piping system at such locations as will be readily available for inspection. Provide jumper connections around all meters and shut off devices.

Where cold water piping is not available for ground connections, use other available or made electrodes as described in NEC Section 250.

Conduit Grounding: All grounding bushings within all enclosures, including equipment enclosures, shall be wired together and connected internally to the enclosure grounding lug or grounding bus with bare copper conductor. Grounding conductors sized in accordance with NEC shall be used with all grounding bushings.

Equipment Grounding: All electrical equipment shall be grounded. Most other equipment will be furnished with grounding pads or grounding lugs. All ground connections shall be cleaned immediately prior to connection. The Contractor shall provide all grounding material required but not furnished with the equipment.

No grounding conductor shall be smaller than 12 AWG wire unless it is a part of an acceptable cable assembly.

SPECIAL PROVISION

SECTION 655

ELECTRICAL

(AWG Wire)

Description

This task shall include the providing and installation of the AWG wire, as described herein for clean and dirty power wiring, for grounding wires (where applicable) and other locations called for in the Plans and Specifications. All wire installed in conduit must be burial grade, suitable for wet locations.

Basis of Payment

Measurement and payment for the installation of the AWG wire as described herein will be per foot, to the nearest 10 foot interval per run. It shall include the furnishing, installation, routing, termination, splices and connection of the wire per the wiring schedule.

Payment will be made under:

Pay Item		Pay Unit
655.1004	#4/0 AWG Wire	Linear Foot
655.101	#6 AWG Wire	Linear Foot
655.103	#10 AWG Wire	Linear Foot
655.12	#12 AWG Wire	Linear Foot
655.125	500 MCM Wire	Linear Foot

SPECIAL PROVISION

SECTION 655

ELECTRICAL

(4pr/24 (Category 5e) Cable)

Description

This task shall include the providing and installation of the Category 5e cable to replace the existing telephone communication lines running from the toll shelter building to each toll booth at New Gloucester and West Gardiner.

Cable: 4 pair, 24 AWG, Category 5e, twisted pair cable. Conductor material shall be bare copper, inner jacket material shall be PVC, cable shall be insulated, shielded and non-gel filled. Must be direct burial type suited for harsh conditions 4pr/24 category 5e cable, as approved.

Basis of Payment

Measurement and payment for the installation of the 4pr/24 category 5e cable will be by linear foot to the nearest 10 ft. interval. It shall include the removal and disposal of the existing phone wiring, and the furnishing, installation and routing of the cable per the wiring schedule.

Payment will be made under:

Pay Item		Pay Unit
655.141	4pr/24 (Category 5e) Cable	Linear Foot

SPECIAL PROVISION

SECTION 655

ELECTRICAL

(PVC Conduit)

Description

This task shall include the removal and disposal of existing corroded Galvanized Rigid Metal Conduit in the Tunnels at New Gloucester and West Gardiner, as well as the provision and installation of PVC Conduit as shown on the Plan drawings and described herein. All conduit shall be installed per NEC specification. Connections to specialized fittings are to be compatible with adjoining conduit.

Joints shall be made in accordance with ASTM D 2855. Solvent cement shall meet the requirements of ASTM D 2564 with particular attention to matching the viscosity to the conduit size.

Joint adhesives shall be in accordance with ASTM D2517.

All conduit runs shall be watertight. Slope conduit to drain into junction boxes.

All conduits shall have a labeled pull string. Pull strings shall have length markings and should be used for long conduits over 50 feet or for all underground installations. Clean, plug and seal conduit ends after installation.

Basis of Payment

Measurement and payment for installing PVC Conduit as shown on the Plan drawings and described herein will be per linear foot of each type of exposed conduit actually furnished, installed, and accepted at the Contract price per linear foot. It shall include the the furnishing, installing, supporting and connection of the new conduit and all various hardware necessary for the installation. This price shall include the cost of; removal and disposal of existing conduit, furnishing and installing new conduit; pull string, fittings, groundings and bonding; test cleaning interiors of conduits and all materials, labor, equipment and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
655.2021	1” Schedule 80 PVC Conduit	Linear Foot
655.203	1-1/2” Schedule 80 PVC Conduit	Linear Foot
655.2031	2” Schedule 80 PVC Conduit	Linear Foot
655.2032	2-1/2” Schedule 80 PVC Conduit	Linear Foot

SPECIAL PROVISION

SECTION 655

ELECTRICAL

(Liquid Tight Non-Metallic Flexible Conduit)

Description

This task shall include providing and the installation of Liquid Tight Metallic Flexible Conduit as shown on the Plan drawings and described herein. All conduit shall be watertight with flexible PVC coating over galvanized steel flex tubing. Conduit shall be installed and grounded per NEC regulations. All supports shall be stainless steel. Connections shall be specialized fittings to be compatible with adjoining conduit and watertight.

Basis of Payment

Measurement and payment for installing the Liquid Tight Metallic Flexible Conduit as shown on the Plan drawings and described herein will be per linear foot actually furnished, installed, and accepted at the Contract price per linear foot. This price shall include the cost of furnishing and installing the conduit; pull string, fittings, groundings and bonding; test cleaning interiors of conduits and all materials, labor, equipment and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
655.2101	1-1/2” Liquid Tight Metallic Flexible Conduit	Linear Foot
655.2102	2” Liquid Tight Metallic Flexible Conduit	Linear Foot
655.2103	1” Liquid Tight Metallic Flexible Conduit	Linear Foot

SPECIAL PROVISION

SECTION 655

ELECTRICAL

(Installation of Pull Boxes)

Description

This task shall include the removal of existing enclosures in the tolling tunnels at New Gloucester and WestGardiner, and the providing and installing of:

- The type F pull box as shown on the Plan drawings and detailed herein. The F pull box shall be installed in booth pits, or building utility pits, or where this size is to be used in a wet location or exterior location.
    - Materials: 4” x 4” x 4” plastic, medium duty; equal to or better than Appleton JIC-2

- The type H pull box as shown on the Plan drawings and detailed herein. The H pull box shall be installed in the toll tunnel, where this size is to be used in a wet location or exterior location.
    - Materials: 12” x 9” x 4” plastic, medium duty; equal to or better than Polycase ML-92F

- The type I pull box as shown on the Plan drawings and detailed herein. The I pull box shall be installed in the toll tunnel, where this size is to be used in a wet location or exterior location.
    - Materials: 6” x 4” x 4” plastic, indoor rated; equal to Polycase ZH-060404 or better.

Basis of Payment

Measurement and payment for installing the pull boxes as shown on the Plan drawings and described herein will be per each item. It shall include the removal and disposal of existing pull boxes, and the furnishing, installation, mounting of the box, and the drilling of holes into the box for conduits.

Payment will be made under:

Pay Item		Pay Unit
655.225	Type F Pull Box Indoor	Each
655.227	Type H Pull Box Indoor	Each
655.228	Type I Pull Box Indoor	Each

SPECIAL PROVISION

SECTION 655

ELECTRICAL

(Panelboard Cabinets)

Provide and install new panelboard cabinets as designated on the Plan drawings. Each panelboard cabinet shall be of the dead-front, safety type with a minimum space for single pole breakers to match the number of spaces of the existing panelboard. Cabinets shall be rated as NEMA 250, Type 1 and constructed of zinc coated sheet steel and shall conform to Underwriters Laboratories, Inc, Standard for Cabinet and Boxes. Cabinet shall be provided with trims having adjustable trim clamps. Trims, unless otherwise noted, shall be fitted with hinged doors.

Panelboard cabinets shall consist of 60-amp single phase, 100-amp single phase, and 225-amp single phase rated panels. Panelboard cabinet height shall not exceed 72 inch and shall be mounted so that the distance from the floor to center of the top circuit breaker will not exceed 6 feet. Panelboards shall be installed in accordance with the most current version of the NEC. Panel boards shall be mounted approximately 1 5/8” off the wall concrete tunnel wall on stainless steel unitstrut members.

Overcurrent protective devices shall be bolt-on circuit breakers, replaceable without disturbing adjacent units.

Directory of circuits shall be provided in each panelboard in a transparent card holder and be typewritten. Panelboard identification shall be riveted or self-adhesive, laminated acrylic or melamine label. Sub-panels shall include source of supply identification.

Provide two spare keys for each type of panelboard cabinet lock.

Coordinate layout and installation of panel boards with Resident Engineer and MTA Director of Intelligent Transportation Services (ITS) prior to starting work. It is expected that existing panel boards will be relocated out from under the toll booth enclosure.

Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service if required:

1) Notify owner no fewer than five days in advance of proposed interruption of electrical service.
2) Do not proceed with interruption of electrical service without Owner’s written permission.

Basis of Payment

Measurement and payment for installing the panelboard cabinet as shown on the Plan drawings and described herein will be per each item. It shall include the furnishing, installation,

new breaker replacement, mounting of the cabinet, and the drilling of holes into the box for conduits.

Payment will be made under:

Pay Item		Pay Unit
655.431	60 AMP Panelboard Cabinet	Each
655.432	100 AMP Panelboard Cabinet	Each
655.433	225 AMP Panelboard Cabinet	Each

SPECIAL PROVISION

SECTION 655

ELECTRICAL

(PVC Conduit Condulets)

Description

This task shall include the removal and disposal of corroded rigid metal condulets and the installation of PVC condulets where called for on the plans. Fittings for PVC condulets are to be joined using couplings and approved solvent, as recommended by the manufacturer. Types of condulets include, but are not limited to “LB”, “T”, “LR”, “LL”. All openings shall have rubber gaskets.

Basis of Payment

Measurement and payment for installing the PVC condulets as described herein will be per item. It shall include the furnishing, installation and mounting of the condulet, and all associated hardware.

Pay Items are as follows:

Pay Item		Pay Unit
655.501	1” PVC Conduit Condulets	Each
655.502	1½” PVC Conduit Condulets	Each
655.503	2” PVC Conduit Condulets	Each
655.5031	2-1/2” PVC Conduit Condulets	Each

SPECIAL PROVISION

SECTION 655

ELECTRICAL

(Plastic Wireway)

Description

This task shall include providing and the installation of plastic wireway in the booth pit as shown on the Plan drawings and/or described herein. Wireways shall be plastic NEMA 4R and shall be installed per NEC regulations. All supports for wireways shall be stainless steel.

Basis of Payment

Measurement and payment for installing the Plastic Wireways as shown on the Plan drawings and described herein will be per foot, to the nearest two foot increment above the final installed segment. It shall include the furnishing, installing, supporting and connection of the wireway and all misc. hardware necessary for the installation. It shall also include all end caps, covers, drilling of holes for conduits, fabrications for 90 degree bends, etc.

Payment will be made under:

Pay Item		Pay Unit
655.63	4-inch x 4-inch Plastic NEMA 4R Wireway	Linear Foot
655.64	6-inch x 6-inch Plastic NEMA4R Wireway	Linear Foot

SECTION 655

ELECTRICAL

(Receptacle Boxes)

Description

Convenience NEMA type 5-20R duplex and NEMA type 5-20R quadplex receptacles that are damaged by water infiltration shall be replaced in kind and relocated away from the existing booth openings in the tunnels at New Gloucester and West Gardiner.

Basis of Payment

Work shall include furnishing all materials and hardware, and labor and equipment to install. All conduit and wires will be paid under separate pay items.

Payment will be made under:

Pay Item		Pay Unit
655.82	Duplex Receptacle	Each
655.84	Quadplex Receptacle	Each

SPECIAL PROVISION

SECTION 800

TOLL TUNNEL REPAIRS

(Stairwell Enclosure)

800.01 Description

The work shall consist of furnishing and installing materials and components to remove the existing canvas stairwell enclosure and building new timber framed enclosures as shown on the Plans or described herein. The stairwells closest to the toll building at each plaza shall be capped with a timber framed enclosure with EPDM membrane roofing as shown in the Plans. The stairwells furthest from the toll building at each plaza shall consist of a full height timber framed enclosure with EPDM roofing and a new doorway as shown in the Plans. The work for the new doorway includes all materials, equipment, labor and supervision, and performing all operations necessary to furnish and install steel doors and frames complete in every respect, as shown on the drawings and as specified herein.

The Contractor will be allowed a seven-day period to close the tunnel stairwell, restricting toll staff passage, for purposes of constructing the stairwell enclosure and other repairs. Outside of this seven-day period, the Contractor shall provide, at a minimum, during daily shift changes at 6 AM, 2 PM, and 10 PM, safe passage for MTA staff, through a stairwell and tunnel that are reasonably clear of dust, noxious odors, fumes, and other hazards that could impede safe and reasonable passage by MTA staff.

800.02 Materials.

Materials shall meet the following requirements:

A. Wood: Framing, Sheathing, and Fasteners

Framing Members and Miscellaneous Blocking: Standard Dimensional Pressure Treated Lumber, Grade No. 1 or better, suitable for ground contact. Lumber shall be treated with alkaline copper quaternary (ACQ) or equivalent preservative and kiln-dried after treatment (KDAT). Install all studs, plates, and blocking so that they are accurately level, plumb, and true. Verify alignment at regular intervals during installation. Any framing found out of tolerance per the Resident shall be corrected prior to proceeding with finishes or sheathing.

Moisture Content – The maximum moisture content of treated lumber and timber material prior to treatment shall be 19%. Material treated with water-borne preservatives in accordance with AWPA Standards shall be dried after treatment to a moisture content not exceeding 19% and shall be maintained at a moisture content of 19% or less until it is incorporated into the work.

Preservative Treatment – preservative treatment of lumber and timber materials shall conform to the requirements of Subsection 800.07 B.

Exterior Plywood: Provide 3/4-inch thick CDX grade plywood. Panels shall be exterior glue bonded, rated for Exposure 1, and suitable for structural applications such as subflooring, roof sheathing, or wall sheathing as indicated on the drawings. Plywood shall bear the APA (Engineered Wood Association) grade stamp showing panel thickness, span rating, and exposure classification. Fasten in accordance with manufacturer's recommendations, APA guidelines, and applicable building codes.

Exterior Siding: Provide T1-11 plywood siding panels, minimum 19/32" thickness, bearing the APA grade stamp. Panels shall be manufactured with exterior-type glue, rated Exposure 1 or better, and available in groove patterns. Panels shall have one side textured and grooved for exposed finish use. Install with vertical orientation with overlapping edges. Panels shall be provided in lengths to not require a horizontal splice. In the event the vertical height of the structure requires a horizontal splice, install galvanized steel z-flashing at the seam. Fasten per APA installation guidelines and local building code requirements.

Interior Plywood: Provide ½-inch thick BC Graded plywood. The "B" side of the plywood shall face the interior of the tunnel. Plywood shall bear the APA (Engineered Wood Association) grade stamp showing panel thickness, span rating, and exposure classification. Fasten in accordance with manufacturer's recommendations, APA guidelines, and applicable building codes.

Fasteners: Fasteners, connectors and steel components in contact with treated lumber shall be hot-dip galvanized, stainless steel, or otherwise corrosion-resistant in accordance with ASTM A153 (AASHTO M 232) or equivalent.

Unless otherwise specified, bolts, studs, threaded rods, nuts, and washers shall conform to the requirements of ASTM A 307, Grade A. Carbon steel nuts (unless otherwise specified) shall conform to the requirements of ASTM A 563 and ASTM A 563 M.

Nails shall conform to the requirements of ASTM F 1667.

Lag screws shall be of low to medium carbon steel and shall be of good commercial quality.

Miscellaneous Steel: Structural steel shapes shall meet the requirements of ASTM A36.

B. Roofing: EPDM

EPDM Roofing shall be 45 mil thickness and have an exposed face color of black. EPDM shall be manufactured by Firestone Building Products or approved equal. Sheet flashing used at the wall to roof transition shall be aluminum drip edge flashing installed in accordance with manufacturers recommendations.

C. Paint

Interior and Exterior siding shall be painted using two coats of Sherwin-Williams Emerald Exterior Acrylic Latex Paint. Paint colors shall be coordinated and approved by the Authority prior to ordering. Sherwin Williams Multi-Purpose Exterior Latex Primer/Sealer shall be applied prior to paint.

D. Door

Stairwell enclosure exterior door shall be 36”x80”, complying with SDI SD 100, Grade II, Heavy Duty, Model 1, Galvanized for exterior locations. Doors shall be made of commercial quality, level, cold rolled steel and free of scale, pitting or other surface defects. Face sheets shall be not less than 16 gage and shall be hot dip galvanized. security door with a window and keycard access.

a. Cold Rolled Steel Sheets: Commercial quality carbon steel, complying with ASTM A 366 and ASTM A 568.
b. Galvanized Steel Sheets: Zinc-coated carbon steel sheets of commercial quality, complying with ASTM A 526 having ASTM A 525, G60 zinc coating, mill phosphatized.
c. Supports and Anchors:
    i. Furnish wall anchors as required to secure frames to adjacent construction, formed of not less than 18 gage galvanized steel sheet (before galvanizing), as follows:
        1. Concrete Masonry Unit Construction: Adjustable, T-shape flat, corrugated or perforated, to suit frame size with leg not less than 3 inches wide by 10 inches long. Furnish at least 4 anchors per jamb.
        2. Floor Anchors: Provide floor anchors for each jamb and for mullions which extend to the floor, formed of not less than 0.0625 inch thick (No. 16 gage) galvanized steel sheet, as follows:
        3. Monolithic Concrete Slabs: Clip type anchors, with 2 holes to receive fasteners, welded to bottom of jamb and mullions.
        4. Head Anchors: Provide 2 anchors at head of frames exceeding 36 inch wide.
    ii. Spreader Bars: Provide 2 removable spreader bars across the bottom of frames, tack welded to jambs and mullions.
d. Inserts, Bolts and Fasteners: Manufacturer's standard units, except hot-dip galvanize items to be built into exterior walls, complying with ASTM A 153, Class C or D, as applicable. Expansion anchors shall be "Kwik-Bolts" as manufactured by Hilti Fastening Systems or approved equal.
e. Prime Finish: Clean, pretreat, and apply manufacturer’s standard primer. Shop primer shall be manufacturer’s standard, fast-curing, lead-and-chromate-free primer complying with SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.
f. Field-Applied Coating:
    i. Prime Coat: Touch up and repair all damaged or scratched primer on metal doors with manufacturer-approved primer to provide a uniform, continuous finish ready for final coating.
    ii. Intermediate Coat: Alkyd, Exterior, matching topcoat.
    iii. Topcoat: Exterior, semi-gloss (MPI Gloss Level 5) MPI #47.
g. All finish hardware shall be of the best grade of solid metal, entirely free from imperfections in manufacture and finish. Finish shall be US 26D Satin Chromium Plated and US 32D Satin Stainless Steel, as applicable. Door closer units shall have sprayed lacquer finish to match balance of hardware. The following items and manufacturers therof indicate the quality and design of the hardware required.
    i. Hinges: All door butts shall be Stanley No. FBB199 (US 32D), shall conform to ANSI A156.1 (A2111). Equivalent hinges manufactured by Hager Hinge Co. are also acceptable.

ii. Locksets shall Best Lock 35H x 16H x L x US 32D with anti-friction latch bolts and interchangeable cores. Function will be determined at time of hardware submittal by the Resident at no additional cost.
iii. Door Closers shall be LCN Smoothee Series with parallel arm "Cush-N-Stop" for push side and LCN's heaviest duty arm for pull side. Comparable closers manufactured by Sargent and Russwin will be considered for use. Provide coordinator at pairs of doors with adjustable safety release and internal override.
iv. Silencers shall be manufactured by Trimco, Sargent & Co. or Glynn-Johnson.
v. Thresholds shall be of a style approved by the Resident, manufactured by Reese, National Guard or Pemko. All exterior doors shall have an extruded aluminum threshold with an integral slip-resistant surface set in sealant to provide watertight condition. Thresholds shall be secured to floor construction with suitable stainless steel flat head screws in expansion shields. Slip-resistant coating shall be equal to "PemKote" by Pemko. If size is not shown, provided threshold width equal to jamb depth.

Threshold – Type A:	Pemko 171A 1/PemKote
Threshold – Type B:	Pemko 270A and 282A, each with ¼" high w/PemKote

vi. Kick plates and mop plates shall be 22 gage stainless steel, 8" high by width of door less 2", attached with stainless steel screws, as manufactured by Brookline, Ives or Rockwood.
vii. Weather-stripping Systems shall be provided at all exterior doors and frames consisting of a dense, semi-rigid polymeric material which remains resilient and retains its weathering ability through temperature extremes. Weather-stripping and sweep shall be compatible with the threshold provided. Weather-stripping shall be of a style approved by the Resident, manufactured by Reese, National Guard or Pemko.

Door Shoe:	Pemko 234AV (cold weather seal)
Jamb & Head:	Pemko 319CR

viii. Floor Stops, and Wall Stops shall be manufactured by H.B. Ives Co., Brookline Industries Inc., Stanley, or Glynn-Johnson.
ix. Exit Device and Pull:
x. Electric Strike: Provide Galaxy Model 1006-12/24D-630 X KM-630 with removable core for Best Cylinder.
xi. Card Reader: Provided by the authority.

E. Insulation

Insulation shall be closed cell spray foam insulation meeting thermal resistance value R-12.

800.03 General Fabrication Requirements

A. Wood

Unless otherwise specified, all timber materials shall be fabricated prior to preservative treatment.

B. Door

1. The fabrication requirements for standard steel doors are as follows:
    a. Provide metal security doors with a window and keycard as indicated on the Drawings and complying with SDI SD 100, Grade II, Heavy Duty, Model 1, galvanized for exterior locations. Doors shall be made of commercial quality, level, cold rolled steel and free of scale, pitting or other surface defects. Face sheets shall be not less than 16 gage and shall be hot dip galvanized. Minimum door thickness shall be 1-3/4 inches.
    b. All doors shall be strong, rigid and neat in appearance, free from warpage and buckle. Corner bends shall be true, straight and of the minimum radius for the gage of metal used.
    c. Doors shall be reinforced, stiffened and sound deadened with impregnated kraft honeycomb core (or approved closed-cell insulation at exterior locations), completely filling the inside of the door and laminated to the inside faces of panels. Other core construction, standard with approved manufacturer's meeting specified U.L. Label requirements and providing effective sound deadening, are acceptable.
    d. Top and bottom edges of all doors shall be closed with a continuous recessed steel channel not less than 16 gage extending the full width of the door and spot welded to both faces (hot-dip galvanized for exterior doors). Exterior doors shall have an additional flush closing hot-dip galvanized channel at their top and bottom edges with suitable openings be provided in the bottom closure to permit the escape of entrapped moisture.
    e. Beveled edge profiles shall be provided on both vertical edges of doors.
    f. Finish Hardware Preparation:
        i. Prepare doors and frames to receive mortised and concealed finish hardware in accordance with the approved Finish Hardware Schedule and templates provided by hardware manufacturer. Comply with applicable requirements of ANSI A 115 series specifications for door and frame preparation for hardware. Where surface mounted hardware is to be applied, frames shall have reinforcing plates.
        ii. Minimum thickness of hardware reinforcing plates shall be as follows:

            Hinge reinforcements - 7 gage 1-1/4" x 10" minimum size.

            Strike reinforcements - 12 gage.

            Flush bolt reinforcements - 12 gage.

            Closer reinforcements - 12 gage.

            Reinforcements for surface-mounted hardware - 12 gage.

iii. Locate knobs, levers, panic devices, push plates, and pulls in accordance with the requirements of ANSI A117.1-86, "Specifications for Making Buildings and Facilities Accessible to and Usable by, Physically Handicapped People" and ADA Guidelines. Locate other finish hardware items in accordance with "Recommended Locations for Builder's Hardware", published by Door and Hardware Institute.

g. Shop Painting:
   i. Clean, treat and paint exposed surfaces of steel door and frame units, including galvanized surfaces.
   ii. Clean steel surfaces of mill scale, rust, oil, grease, dirt and other foreign materials before application of paint.
   iii. Apply shop coat of prime paint of even consistency and bake to provide a uniformly finished surface ready to receive finish paint.

2. The fabrication requirements for standard steel frames are as follows:
   a. Provide metal frames for doors and transoms, including frames for wood doors, of types and styles as shown on Drawings and schedules butted and wrap-around), utilizing concealed fastenings, unless otherwise indicated.
   b. Frames for exterior openings and interior U.L. labeled doors shall be made of commercial grade cold-rolled steel, not less than 14 gage. Exterior frames shall be hot dip galvanized steel. Frames shall be designed for a minimum 25 pounds per square foot horizontal load.
   c. Frames for other interior openings shall be either commercial grade cold-rolled steel or commercial grade hot-rolled and pickled steel. Metal thickness for frames shall be not less than 16 gage.
   d. Frames for exterior doors, interior masonry walls and drywall openings shall be press brake formed with 5/8" high integral stops. Corners shall be back seam and face welded with face welds ground neatly smooth.
   e. Fabricate frames of full welded unit construction, with corners mitered, reinforced, continuously welded the full depth and width of frame, with welds dressed smooth and flush. Knock-down type frames are not acceptable. Frames shall be manufactured by the same manufacturer who is supplying the hollow metal doors

800.04 Submittals

Unless otherwise specified, as soon as practical after award of the Contract, the Contractor shall prepare and submit Working Drawings and Product Submittals in accordance with subsection 105.7. Submittals shall include manufacturers specifications, product data and installation instructions for all items furnished. The Contractor shall not be relieved of responsibility for any deviation from the requirements of the specifications unless the Contractor has specifically informed the Turnpike in writing of such deviation at the time of submission and the Turnpike has given written approval to the specific deviation. The Contractor shall not be relieved from responsibility for errors or omissions. No portion of the work shall be commenced until the Authority has approved the submittal.

Submittal and working drawing review times shall be in accordance with section 105.7.2 of the Maine Turnpike Authority Supplemental Specifications.

800.05 Storage

A. General

Deliver products in manufacturers original containers, dry, undamaged, with seals and labels intact.

B. Wood

Timber materials stored on the site shall be kept in orderly piles, open stacked, and on supports that provide at least 12 inches of ground clearance. For outside storage, the ground area in the vicinity of the material shall be cleared of grass, weeds, and rubbish. Treated timber shall be stacked together, with no separation between the tiers and courses. Free circulation of air shall be provided between the pile and the ground.

Timber shall be stored under cover. The covering shall adequately protect these materials from direct and blowing rain or snow while providing for full circulation of air and adequate drainage.

All timber shall meet the moisture requirements of Subsection 800.02 before being incorporated into the work.

Fabricated material shall be stored in a manner that will prevent dimensional changes in the members prior to assembly.

C. Door

Store doors and frames at the site under cover in accordance with the manufacturer's recommendations. Place units on wood dunnage at least 4 inches high, or otherwise store on floors in manner that will prevent rust and damage. Avoid use of non-vented plastic or canvas shelters which could create humidity chambers. If cartons become wet, remove them immediately. Provide 1/4 inch to 1/2 inch space between stacked doors and frames to promote air circulation.

800.06 Handling

Materials shall be carefully handled to avoid damaging the edges or surface and kept clean.

Materials shall be picked up or moved with slings or other devices, as required, that will not damage or mar the surface. Peavies, cant hooks, timber dogs, or other pointed tools will not be permitted.

Cranes, lifting devices and any other equipment for all structural timber erection shall be of adequate design and capacity to safely erect, align, and secure all members and components in

their final positions without damage. The Contractor is solely responsible for the methods and equipment employed for the erection of the structural timber members.

800.07 Framing and Installation

A. Wood

Installation, handling and storage of all materials shall comply with the manufacturer's instructions and recommendations.

The Contractor shall make provisions to allow safe access to the work for the Authority in order to inspect the work, facilitate ongoing inspection of the work and to measure the work for payment purposes.

Complete installation to provide weathertight service.

Completed installation shall conform to all applicable National, State and local codes.

Timber shall be accurately cut and framed to a close fit in such a manner that the joints will have full and even bearing over the entire contact surface. Except as indicated in the Contract, shimming will not be permitted in making joints, and open joints will not be accepted. Nails shall be driven with the heads set flush with the surface of the wood. Except as directed by the Resident, structure framing and boarding shall be constructed square, plumb, and straight.

When permitted by the Resident, forms or temporary braces may be attached to treated material. Upon removal, any holes, cuts, or abrasions shall be treated in accordance with Subsection B Wood Preservative Treatment.

B. Wood Preservative Treatment

Timber and lumber shall be pressure treated utilizing Micronized Copper Quaternary (MCQ) preservative treatment. Treatment shall be applied to a total absorption of 0.4 pounds per cubic foot of wood.

Treatment of cuts, abrasions and holes – Cuts, abrasions, and holes bored after treatment shall be treated with two coats of copper naphthenate solution. Cuts and abrasions shall be carefully trimmed prior to treatment. Holes left unfilled shall be filled with wooden plugs treated with copper naphthenate solution.

Temporary Attachments – Holes remaining after the removal of nails used to attach temporary forms or bracing to treated material shall be filled by driving galvanized nails flush with the surface or plugging the holes with wooden plugs treated with copper naphthenate solution.

C. Wood Connections

Holes for Bolts, Dowels, Rods, and Lag Screws

a. Holes for metal round drift-bolts or dowels shall be bored with a bit 1/16” less in diameter than the drift-bolt or dowel to be used.
b. Holes for machine bolts shall be bored with a bit the same diameter as the bolt.
c. Holes for rods shall be bored with a bit 1/16” grater in diameter than the rod.
d. Lead holes for lag screws, and wood screws shall conform to the requirements specified within the latest edition of the AITC Timber Construction Manual.

Bolts and Washers

e. A washer of the size and type specified shall be used under all bolt heads and nuts that would otherwise come in contact with wood.
f. All nuts shall be effectively locked after they have been finally tightened.

D. Door

Install hollow metal units and accessories in accordance with final shop drawings, the manufacturer's approved installation instructions, and as specified herein.

Placing Frames: Comply with provisions of SDI-105 "Recommended Erection Instructions For Steel Frames", unless otherwise indicated.

Place frames prior to construction of enclosing walls and ceilings. Protect hardware securements from mortar spillage, joint compound, and other damage. Set frames accurately in position, plumbed, aligned, and securely braced until permanent anchors are set. After wall construction is completed, remove temporary braces and spreaders leaving surfaces smooth and undamaged. Door frame installation also includes setting of thresholds where applicable.

Install fire-rated frames in accordance with NFPA Pamphlet No. 80.

Install finish hardware in strict accordance with the final approved shop drawings and the manufacturers' instructions, and adjust for easy action All knobs, levers, panic devices, push plates, pulls and other hardware shall be installed in accordance with the requirements of ANSI A117 and ADAAG.. Set locksets level and true with the proper backset. Adjust striking plates to be in exact alignment with bolts and latches. Adjust spindles and latch bolts for easy action. Set all screws flush with the metal surface without any broken or damaged heads.

All wrapping on knobs, handles, pulls, etc., furnished by the manufacturer shall be replaced on the hardware after it is installed and shall remain until final acceptance of the work, at which time the Contractor shall remove and dispose of all coverings. Hang doors plumb and true with a uniform clearance at the head and jambs, in accordance with SDI-100 and NFPA Pamphlet 80, and with all hardware in perfect working order.

800.10 Method of Measurement

The Stairwell Enclosure work will be measured by Lump Sum.

800.11 Basis of Payment

Stairwell Enclosures will be paid at the Contract lump sum price, completed and accepted, which shall be full compensation for the work called for in the Contract, including, but not necessarily be limited to: Timber framing, steel angle supports, expansion anchors, EPDM roofing, flashing, interior and exterior siding, paint, exterior security door, insulation, and all materials, labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
800.31	Stairwell Enclosure	Lump Sum

SPECIAL PROVISION

SECTION 800

TOLL TUNNEL REPAIRS

(Tollbooth Canopy Drainage Modifications)

800.01 Description

This work shall consist of furnishing and installing the materials and components to modify the existing toll canopy drainage system as shown on the Plans and described herein. This work shall also include the pipe support system and all connections required to complete the work, replacement of existing damaged floor drains and floor drain clean outs, and sump pit and sump pump installation. The work shall also include removing existing canopy drainage system that is not in use and leftover during the ORT Conversion.

New Gloucester Toll Plaza:

Work shall consist of partial removal of the existing canopy drain system roadside, through tunnel ceiling, and into the tunnel. Schedule 80 PVC pipe shall be installed to the existing canopy drain system coming through the tunnel ceiling to route the canopy drainage to the existing floor drains as shown on the Plans and in accordance with this specification.

Existing floor drains and cleanouts shall be replacedas shown on the Plans and in accordance with this specification. Prior to replacement of the floor drains and cleanouts, all pipes shall be cleaned and descaled with chain cleaning then flushed to remove any loose debris. Pipes shall then be sealed with 2 coats of Picote Xpress Epoxy coating system or approved equal.

This work shall also include a sump pit and pump at the far end of the tunnel, as indicated in the Plans. The scope also includes furnishing and installing drain lines from each sump pit to an exterior discharge location with a heat trace system, as approved by the Resident.

Core drilling through existing concrete walls will be required to accommodate new piping. All core openings shall be appropriately sized to allow installation of link seals with stainless steel hardware, or an equivalent watertight sealing system, in the annular space between the pipe and concrete.

This work shall include trenching for the drain line from the sump pit to the exterior discharge location outside the tunnel. At the discharge location, stone ditch protection shall be installed using plain riprap with a maximum stone size of 18 inches. The riprap shall extend 4 feet beyond the pipe outlet and be at least 3 feet in width. Repair of all disturbed earth surfaces including loam, seed, and mulch shall also be included in the work.

West Gardiner Toll Plaza:

The work includes installing a sump pit and pump at the west end of the tunnel, as indicated in the Plans. The scope also includes furnishing and installing drain lines from the sump pit to an exterior discharge location with a heat trace system, as approved by the Resident. The work also

includes cleaning the existing functioning floor drain and outlet pipe on the east end of the tunnel as shown in the Plans. The floor drain and outlet pipe shall be cleaned and descaled with chain cleaning then flushed to remove any loose debris. Pipe shall then be sealed with two coats of Picote Xpress Epoxy Coating system or approved equal.

Core drilling through existing concrete walls will be required to accommodate new piping. All core openings shall be appropriately sized to allow installation of link seals with stainless steel hardware, or an equivalent watertight sealing system, in the annular space between the pipe and concrete.

This work shall include trenching for the drain line from the sump pit to the exterior discharge location outside the tunnel. At the discharge location, stone ditch protection shall be installed using plain riprap with a maximum stone size of 18 inches. The riprap shall extend 4 feet beyond the pipe outlet and be at least 3 feet in width. Repair of all disturbed earth surfaces including loam, seed, and mulch shall also be included in the work.

Sump Pit Installation at both Toll Plazas Includes:

- Saw cutting with dust control to create clean, vertical wall edges
- Demolition, removal, and off-site disposal of existing concrete
- Excavation and backfill as necessary to install the sump in accordance with the sump pit manufacturer's instructions
- Regrading, loam, seed, and mulch of all disturbed areas.
- Placement of new concrete with a minimum thickness of 6 inches around the installed sump pit to existing line and grade

800.02 Materials.

Materials shall meet the following requirements:

a. Added pipe shall be 2" diameter schedule 80 PVC pipe meeting the requirements of ASTM D1784 and D1785.

b. Schedule 80 PVC pipe fittings and connections shall meet the requirements of ASTM D2467 and ASTM D1785.

c. Pipes hangers shall galvanized split ring hangers electro-galvanized steel finish for standard plumbing applications. Hangers shall be sized to pipe outside diameter, include threaded rod connection nut, and be suitable for vertical or horizontal suspension of PVC pipe. All hardware shall be galvanized for corrosion resistance. Alternative pipe hanging methods maybe approved by the Resident.

d. Sump Basin:
    1. Basis of Design: Apollo 24" Basin as distributed by Nash Distribution
        i. Product Width: 24 inches
        ii. Product Height: 24 inches
        iii. Capacity: 39 gallons
        iv. **Material:** Impact-resistant LLDPE plastic

v. Features: Factory-installed, pre-drilled weep holes

e. Submersible Sump Pump
   1. Basis of Design: Zoeller M95 Sump Pump, or approved equal
      i. 115V, 1 phase, ½" HP, oil-filled motor
      ii. 1.5" discharge
      iii. Cord Length: 15' with UL listed, 3 wire, grounded plug
      iv. Cast Iron construction with stainless steel hardware

   2. Accessories
      i. Zoeller Unicheck, combination union and check valve, installed just above the basin to allow easy removal of the pump for cleaning and repair.
      ii. Zoeller Pump Stand installed under pump to provide a settling basin
      iii. Z Control Apak Indoor Alarm with Reed Sensor

f. Floor Drains
   1. Basis of Design – Watts FD-100-B Epoxy coated cast iron floor drain with anchor flange, reversible clamping collar with primary and secondary weepholes, and adjustable heavy duty round heel proof nickel bronze strainer. Or approved equal.
      i. 8" adjustable Strainer Head
      ii. Sediment Bucket
      iii. Backwater Valve
      iv. Outlet Size: Existing piping shall be field verified by contractor prior to ordering

g. Cleanouts
   1. Basis of Design: Zurn ZS-1400 adjustable floor cleanout, Dura Coated Cast Iron body, with gas and watertight ABS tapered thread plug. Provide size equal to piping served with maximum size of 4" as verified in the field. Or approved equal
      i. Load Rating: Up to 2,000 pounds or as scheduled
      ii. Body: Dura Coated cast iron, with gas and water tight non-corroding ABS tapered plug and standard or EZ1 top assembly.
      iii. Polished Stainless Steel Extra Heavy Duty Top
      iv. Outlet Size: Existing piping shall be field verified by contractor prior to ordering

800.03 Submittals

Submit product data on all piping components, connections, fitting, and hanger and support devices. Product data to include, but not limited to materials, finishes, approvals, load ratings, and dimensional information.

Sump Pit and Pump: The Contractor shall provide product data and shop drawings for all sump pit basins, sump pumps, and outlet piping from the sump basin to the exterior of the toll plaza to the Resident for approval.

Floor Drains and Clean Outs: The Contractor is responsible for verifying all existing dimensions on-site. Based on field verification, the Contractor shall develop a detailed removal procedure and submit it for approval. Additionally, the Contractor shall provide product data and shop drawings for all floor drains and clean outs, including all necessary fittings and connections required to tie into the existing system to the Resident for approval.

800.04 Installation

Pipes shall be installed sloped to drain by gravity and maintain a minimum slope of 2%.

All work, materials, and equipment shall copy with the rules and regulations of all codes and ordinance of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. Plumbing work shall be performed under by, or under the direct supervision of a licensed master plumber. All installations must remain accessible for required inspections and shall not be concealed until approved by the Resident; the contractor shall be responsible for any reinspections resulting from incomplete, noncompliant, or inaccessible work.

Pipe Hanger and Support System shall meet the following:

Pipe hanger installation shall comply with MSS SP-69 and MSS SP-89. Provide hangers, supports, clamps, and attachments as required to properly support piping from the tunnel structure.

1. Provide hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers and other accessories.
2. Hanger rods shall be threaded both ends or continuous threaded rods of circular cross section. Use adjusting locknuts at upper attachments and hangers. No wire, chain, or perforated straps are allowed.
3. Hanger adjustments shall adjust to distribute loads equally on attachments to achieve indicated slope of pipe.
4. Trim excess length of continuous-thread hanger and support rods to 1-½".
5. Pipe protection saddles shall be formed from carbon steel, 1/8 inch minimum thickness.
6. Hangers and support components shall be hot dip galvanized after fabrication in accordance with ASTM A123. All hanger hardware shall be hot dip galvanized.
7. Provide lateral bracing with pipe hangers and supports to prevent swaying.
8. Provide hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by plumbing code and ASME B1.9. Piping shall be supported in a manner as to maintain its alignment and prevent sagging.
9. Space hangers according to the pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
10. Hangers shall be placed next to the pipe joint not more than 18 inches from the point joint.
11. Place hanger within 12 inches of each horizontal elbow.
12. Pipe hanger and support maximum horizontal spacing shall be 48 inches and maximum vertical spacing shall be 10 feet. Unless otherwise specified by the manufacturer and as approved by the Resident.

Existing floor drains cleanouts shall be replaced as noted in the contract plans. Existing floor drains cleanouts shall be removed, and existing riser pipe shall be cut clean and extended as necessary for new floor cleanouts to be flush with finished concrete floor. The work shall also include saw cutting with dust control to create clean, vertical wall edges; demolition, removal, and off-site disposal of existing concrete; and placement of new concrete to match existing line a grade.

Sump pit basin shall be installed at locations indicated on the plans. Installation shall proceed as follows:

1. Excavation: Saw cut existing concrete slab with dust control to a minimum dimension of 36" x 36". Remove concrete and underlying granular borrow to form a neat excavation.
2. Subgrade Preparation: Install drainage and separation geotextile fabric around the entire perimeter and base of the excavation. Place a minimum of 6 inches of clean ¾" drainage stone beneath the sump pit basin. Install a minimum of 12 inches of clean ¾" drainage stone around the perimeter of the basin.
3. Basin Placement: Set the sump pit basin such that the top cover is flush with the existing concrete tunnel floor.
4. Concrete Restoration: Place 6 inches of concrete over the drainage stone to restore the slab surface to existing line and grade.

800.05 Method of Measurement

The Tollbooth Canopy Drainage Modifications will be measured by Lump Sum.

800.06 Basis of Payment

The following paragraphs are added:

Tollbooth Canopy Drainage Modifications will be paid at the Contract lump sum price, completed and accepted, which shall be full compensation for the work called for in the Contract, including, but not necessarily limited to: Removal of existing pipe, installation of new pipe, all required connections and fittings, pipe hanger and support system, development of shop drawings, installing sump pit and pumps, trenching and installing sump pit discharge pipe outside of the tunnel, regrading, loam, seeding, mulching, replacing damaged floor drains and floor drain clean outs, cleaning, descaling, and sealing floor drain pipes, removing all drain pipes and components that are not in use, capping canopy drain wall penetrations that are not in use, and all materials, labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
800.32	Tollbooth Canopy Drainage Modifications	Lump Sum

SPECIAL PROVISION

SECTION 800

TOLL TUNNEL REPAIRS

(Heating, Ventilation, and Dehumidification)

800.01 Description

Section 800 and Divisions 01 through 28 specifies materials, procedures, and requirements for the construction of the Heating, Ventilation, and Dehumidification at New Gloucester and West Gardiner Toll Tunnels, complete with all appurtenances, including any and all associated utilities and services within the limits as shown on the Drawings.

The Contractor shall submit to the Resident for approval a cost breakdown of the major components of work for the Heating, Ventilation, and Dehumidification, by Division, for sections 01 through 28. This breakdown will be used as a basis for monthly pay estimates.

Toll tunnel walk-thrus shall occur 30 days prior to anticipated completion and MTA occupancy of the Tunnels. Contractor shall allow the MTA access to the tunnels as outline herein for MTA staff passage and maintenance of toll support equipment.

The Contractor shall ensure and be responsible for the total and complete coordination of all work in the Toll Plaza Tunnel Repairs. The Contractor shall generate coordination drawings for the Repairs. Coordination drawings shall:

1. Be computer generated.
2. Show a dimensionally accurate representation of all equipment that was approved by the shop drawing process.
3. Show architectural features, structural features, piping, conduit, ductwork and any other items that require coordination which shall be accurately sized.
4. Be submitted to and approved by the MTA prior to the purchasing of any approved equipment.

800.02 General

The work includes heating, ventilating, and dehumidification reconstruction, emergency lighting, coordination with Maine Turnpike toll vendor, maintenance of traffic and all other work incidental thereto in accordance with the Plans and Specifications.

800.05 Method of Measurement

The heating, ventilating, and dehumidification reconstruction, emergency lighting, coordination with Maine Turnpike toll vendor, maintenance of traffic and all other work incidental thereto, including the work described above, will be measured for payment by the lump sum,

complete and accepted.

All earthwork required for make-up air handling unit support, including excavation for support frame and foundation, and repair of all disturbed earth surfaces including loam, seed, and mulch, will not be measured for payment but shall be incidental to the Heating, Ventilation, and Dehumidification pay item.

Mobilization related to construction of the Toll Plaza Tunnel Repairs shall be measured for payment under Pay Item 659.10.

800.06 Basis of Payment

The Lump Sum payment for Heating, Ventilation, and Dehumidification of the New Gloucester and West Gardiner Toll Tunnels shall be full compensation for the cost of furnishing all materials, equipment, supplies, tools, incidentals, labor and supervision necessary to satisfactorily complete the work in all respects, in accordance with the Contract Documents and to the satisfaction of the Resident.

Payment will be made under:

Pay Item		Pay Unit
800.33	Heating, Ventilation, and Dehumidification	Lump Sum

APPENDIX 1
DIVISION 02 THROUGH 28
HEATING, VENTILATION, AND DEHUMIDIFICATION SPECIFICATIONS

SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 230700 for plumbing insulation.

END OF SECTION 220700

SECTION 221123 – FACILITY FUEL GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division 23 Section: “Common Work Results”

1.2 SUMMARY

A. This Section includes fuel gas piping, specialties, and accessories.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Specialty valves
2. Pressure regulators.
3. Meters

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

C. Maintenance Data: For fuel gas specialties and accessories to include in maintenance manuals specified in Division 1.

D. Seismic Delegated-Design Submittal:

1. For piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

a. Determine seismic restraint sizes and locations.
b. Provide seismic restraints as scheduled or specified.
c. Provide calculations and materials if required for restraint of un-isolated equipment.
d. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

2. Seismic restraints shall be designed in accordance with seismic force levels as detailed herein.

    a. Applicable Code: IBC
    b. Seismic Design Category: See structural plans.
    c. Design Spectral Response at Short Periods (SDS): See structural plans.
    d. Short Period Spectral Response Acceleration (SS): See structural plans.
    e. Building Use Group or Occupancy Category: See structural plans.

1.4 QUALITY ASSURANCE

A. All work shall be performed by fuel gas licensed technicians.

B. Installations of fuel gas shall comply with the local fuel gas code: Maine Fuel Board Laws & Rules, NFPA 58.

C. Electrical Components and Devices: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. FM Standard: Provide components listed in FM's "Fire Protection Approval Guide" if specified to be FM approved.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Valves:

    a. American Valve.
    b. Conbraco Industries, Inc.; Apollo Div.
    c. Crane Valves.
    d. Grinnell Corp.
    e. Honeywell, Inc.
    f. McDonald: A. Y. McDonald Mfg. Co.
    g. Milwaukee Valve Co., Inc.
    h. Nibco, Inc.
    i. Mueller Co.; Mueller Gas Products Div.
    j. Watts Industries, Inc.

2. Meters:

    a. American Meter Co.
    b. Badger Meter, Inc.; Utility Products Div.
    c. Equimeter, Inc.
    d. National Meter.
    e. Schlumberger Industries; Gas Div.

3. Pressure Regulators:

    a. American Meter Co.
    b. Equimeter, Inc.
    c. Fisher Controls International, Inc.
    d. Maxitrol Co.
    e. National Meter.
    f. Richards Industries, Inc.; Jordan Valve Div.
    g. Schlumberger Industries; Gas Div.

2.2 PIPES, TUBES, FITTINGS, AND JOINING MATERIALS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel.

B. PE Pipe: ASTM D 2513, SDR 11.

1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
c. Aboveground Portion: PE transition fitting.
d. Outlet shall be threaded or flanged or suitable for welded connection.
e. Tracer wire connection.
f. Ultraviolet shield.
g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

C. Transition Fittings: Type, material, and end connections to match piping being joined.

D. Detectable Warning Tape: Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

E. Common Joining Materials: Refer to Division 23 Section "Common Work Results" for joining materials not in this Section.

2.3 SPECIALTY VALVES

A. Valves, NPS 2 and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.

B. Valves, NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel flanges.

C. Appliance Connector Valves: ANSI Z21.15 and IAS listed.

D. Gas Stops: Bronze body with AGA stamp, plug type with bronze plug and flat or square head, ball type with chrome-plated brass ball and lever handle, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal and lever handle; 2-psig minimum pressure rating.

E. Gas Valves, NPS 2 and Smaller: ASME B16.33 and IAS-listed bronze body and 125-psig pressure rating. Tamperproof Feature: Include design for locking.

2.4 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.

7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

D. Pressure gages shall conform to ASME B40.100, Type I, Class 1. Pressure-gage size shall be 3-1/2-inch nominal diameter. Case shall be corrosion-resistant steel conforming to any of the AISI 300 series of ASTM A 666, with a No. 4 standard commercial polish or better. All gages shall be equipped with adjustable red marking pointer and damper screw adjustment in inlet connection.

2.5 PRESSURE REGULATORS

A. Provide service, line, and appliance pressure regulators as indicated and as required by fuel code. Regulators may include vent limiting device, instead of vent connection to outside, if approved by authorities having jurisdiction. Provide venting as required by fuel code.

B. Line Pressure Regulators: ANSI Z21.80 with 10-psig inlet pressure rating, unless otherwise indicated.

C. Appliance Pressure Regulators: ANSI Z21.18.

D. Pressure Regulator Vents: Factory- or field-installed, corrosion-resistant screen in opening if not connected to vent piping.

2.6 SEISMIC RESTRAINTS

A. Seismic-restraint devices shall have horizontal and vertical load testing and analysis performed according to OSHPD and shall bear anchorage preapproval "R" number, from OSHPD or another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If pre-approved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer. Testing and calculations must include both shear and tensile loads and 1 test or analysis at 45 degrees to the weakest mode.

B. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint.

C. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint.

D. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required.

E. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

A. Comply with requirements in Division 31 for excavating, trenching, and backfilling.

3.3 PREPARATION

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

B. Inspect gas piping according to fuel gas code to determine that gas utilization devices are turned off in piping section affected.

C. Comply with fuel gas code requirements for prevention of accidental ignition.

D. Make arrangements with local utility for gas service to the Owner’s distribution system. Provide service to the building as required by the gas supplier. Coordinate all activities between the Owner and gas supplier. The installation of the gas service shall comply with the published gas supplier standards. Pay all utility company charges; include charges in the base bid.

3.4 PIPING APPLICATIONS

A. Flanges, unions, transition, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, unless otherwise indicated.

B. Fuel Gas Piping: Use the following:

1. NPS 2 and Smaller: steel pipe, malleable-iron threaded fittings, and threaded joints.
2. NPS 2-1/2 and Larger: Steel pipe, steel welding fittings, and welded joints.
3. Gas Service Piping at Meters and Regulators: Steel pipe, steel welding fittings, and welded joints.
4. Underground Fuel Gas Piping, outdoors: Provide underground, PE, gas piping according to ASTM D 2774. Install underground piping buried at least 36 inches below finished grade.

C. Concealed (gas piping that, when in place in a finished building, would require removal of permanent construction to gain access to the piping) Locations: Except as specified below, install concealed gas piping in airtight conduit constructed of Schedule 40, seamless, black steel pipe with welded joints. Vent conduit to outside and terminate with screened vent cap.

1. Above-Ceiling Locations: Gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves above ceilings.
2. In Floors: Not permitted.
3. Concealed piping shall not be installed in solid partitions.
4. Prohibited Locations: Do not install gas piping where not allowed by fuel gas code.
5. In-slab (within building) Fuel Gas Piping: Not permitted.

3.5 VALVE APPLICATIONS

A. Appliance Shutoff Valves for Pressure 0.5 psig or Less: Appliance connector valve or gas stop.

B. Appliance Shutoff Valves for Pressure 0.5 to 2 psig: Gas stop or gas valve.

C. Piping Line Valves, NPS 2 and Smaller: Gas valve.

D. Piping Line Valves, NPS 2-1/2 and Larger: Plug valve or general-duty valve.

E. Valves at Service Meter, NPS 2 and Smaller: Gas valve.

F. Valves at Service Meter, NPS 2-1/2 and Larger: Plug valve.

3.6 PIPING INSTALLATION

A. Refer to Division 23 Section "Common Work Results" for installation of:

1. Basic piping requirements.
2. Joint construction requirements.
3. Hanger, support, and anchor devices.
4. Firestopping
5. Sleeves and Escutcheons
6. Wall penetration system at each service pipe penetration through foundation wall.
7. Dielectric fittings
8. Valves
9. Mechanical Identification

B. Drips and Sediment Traps: Provide drips at points where condensate may collect. Locate where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches long, and same size as connected pipe. Provide with space between bottom of drip and floor for removal of plug or cap.

C. Provide fuel gas piping at uniform grade of ¼” per 15 feet.

D. Use eccentric reducer fittings to make reductions in pipe sizes. Provide fittings with level side down.

E. Connect branch piping from top or side of horizontal piping.

F. Provide strainer on inlet of each line pressure regulator.

G. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

3.7 SEISMIC RESTRAINT OF PIPING

A. Seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

B. Installation of seismic restraints must not cause any change of position of equipment or piping resulting in stresses or misalignment.

C. Coordinate work with other trades to avoid rigid contact with the building.

D. Overstressing of the building structure must not occur because of overhead support of equipment. Generally bracing may occur from flanges of structural beams, upper truss cords in bar joist construction, or cast in place inserts or wedge type drill-in concrete anchors.

E. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment, piping or conduit. Cable assemblies shall be installed taut on non-isolated systems. Seismic solid braces may be used in place of cables on rigidly attached systems only.

1. The support rods must be braced when necessary to accept compressive loads with steel angles and rod clamp assemblies.
2. At all locations where restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with pipe clevis cross bolt braces.
3. Seismically restrain the following piping: Fuel gas piping that is 1" I.D. or larger.
4. Piping exclusions:

    a. Gas piping less than 1" inside diameter.
    b. All piping suspended by individual hangers 12" or less as measured from the top of the pipe to the bottom of the support where the hanger is attached. However, if the 12" limit is exceeded by any hanger in the run, seismic bracing is required for the run.
    c. The 12" exemption applies for trapeze-supported systems if the top of each item supported by the trapeze qualifies.

5. Transverse piping restraints shall be at 20' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
6. Longitudinal restraints shall be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
7. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24" of the elbow or tee or combined stresses are within allowable limits at longer distances.
8. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.
9. Branch lines may not be used to restrain main lines.

F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

3.8 CONNECTIONS

A. Connect piping to appliances using appliance flexible connectors, shutoff valves, and unions. Provide valve upstream from and within 72 inches of each appliance. Provide union downstream from valve.

B. Sediment Traps: Provide tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance using gas.

3.9 PAINTING

A. Paint exposed, exterior metal piping, valves, regulators, service meters and meter bars, and piping specialties, except components with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

    a. Prime Coat: Alkyd anticorrosive metal primer.
    b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
    c. Topcoat: Exterior alkyd enamel
    d. Color: As selected by Architect

B. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 FIELD QUALITY CONTROL

A. Inspect, test, and purge piping according to fuel gas code and requirements of authorities having jurisdiction.

B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

C. Report test results promptly and in writing to Architect and authorities having jurisdiction.

D. Verify capacities and pressure ratings of service meters, pressure regulators, valves, and specialties.

E. Verify correct pressure settings for pressure regulators.

F. Verify that specified piping tests are complete.

G. Verify that the gas piping has been grounded by Division 26 in accordance with NFPA requirements.

H. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

END OF SECTION 221123

SECTION 221316 – PLUMBING SANITARY AND STORM PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division 23 Section: “Common Work Results”

1.2 SUMMARY

A. This Section includes piping and specialties.
1. HVAC condensate waste.

B. Drawings show the general layout of piping and accessories but do not show all required fittings and offsets that may be necessary to connect piping to equipment and to coordinate with other trades. Fabricate piping based on field measurements. Provide all necessary fittings and offsets.

C. General layout shown, provide piping to fixtures as required by the local plumbing code. A licensed master plumber shall perform or supervise the work and provide layouts, piping, and fittings as required by code.

1.3 PERFORMANCE REQUIREMENTS

A. Comply with the utility requirements for the connection of to the municipal utility services. Obtain and pay for all necessary permits from the applicable municipal department. Obtain authority to connect to their existing mains.

B. Provide components and installation capable of producing piping systems with working-pressure ratings per local plumbing code.

1.4 SUBMITTALS

A. Product Data: Include rated capacities and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections.

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with the local building and plumbing codes.

PART 2 - PRODUCTS

2.1 PVC DRAINAGE PIPING

A. Pipe and fittings shall be manufactured from PVC compound with a cell class of 12454 per ASTM D-1784 and conform with National Sanitation Foundation (NSF) standard 14. Pipe shall be iron pipe size (IPS) conforming to ASTM D-1785 and ASTM D-2665. Fittings shall conform to ASTM D-2665.

B. All pipe and fittings to be produced by a single manufacturer and to be installed in accordance with manufacturer's recommendations and local code requirements. Solvent cements shall conform to ASTM D-2564, primer shall conform to ASTM F-656. The system to be manufactured by Charlotte Pipe and Foundry Co. or approved equal; and shall be intended for non-pressure drainage applications where the temperature will not exceed 140°F.

C. Solvent cement joints for PVC pipe and fittings shall be clean from dirt and moisture. Pipe shall be cut square and pipe shall be deburred. Where surfaces to be joined are cleaned and free of dirt, moisture, oil and other foreign material, apply primer in accordance with ASTM F656.

2.2 PVC PRESSURE PIPING

A. All pipe and fittings to be produced by a single manufacturer and to be installed in accordance with manufacturer's recommendations and local code requirements. Solvent cements shall conform to ASTM D-2564, primer shall conform to ASTM F-656. The system to be manufactured by Charlotte Pipe and Foundry Co. and is intended for pressure applications where the temperature will not exceed 140°F.

B. Solid Wall: Pipe and fittings shall be manufactured from PVC compound with a cell class of 12454 per ASTM D-1784 and conform with National Sanitation Foundation (NSF) standards 14 and 61. Pipe shall be iron pipe size (IPS) conforming to ASTM D-1785. Fittings shall conform to ASTM D-2466.

2.3 AUTOMATIC CONDENSATE PUMP UNITS

A. Manufacturers:

1. Blue Diamond
2. Bell & Gossett
3. Little Giant

4. Hartell
5. Marsh

B. The pumps shall be of the high efficiency type specifically designed for quiet operation.

1. Pump Housing: ABS Material
2. O-Ring: EPDM
3. Bearing: Carbon/Alumina Ceramic
4. Impeller: Nylon/PPO
5. Motor: High Efficiency ECM
6. All Other Wetted Parts: Type 316 Stainless Steel
7. Shaft-less, seal-less construction
8. Pump to be suitable for 140°F operation.
9. Green LED to indicate when pump is operating
10. Tank Volume: 0.184 gallons total (0.132 gallons usable)
11. Main cable with shock-proof plug

C. Provide condensate removal pumps come as a kit ready for installation. Kits shall include:

1. Condensate Pump
2. Mounting bracket (designed for rear wall or left side wall mounting)
3. Pressure hose connection kit
4. Pressure hose: 19 feet length.
5. Non-return valve.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.

B. HVAC Unit Condensate Indirect Waste: Drain Lines: ¾” minimum diameter; Schedule 40 PVC.

3.2 PIPING INSTALLATION

A. Refer to Division 23 Section "Common Work Results" for installation of:

1. Basic piping requirements.
2. Joint construction requirements.
3. Hanger, support, and anchor devices.
4. Firestopping
5. Sleeves and Escutcheons
6. Wall penetration system at each service pipe penetration through foundation wall.
7. Dielectric fittings

8. Valves
9. Mechanical Identification

B. Provide PVC soil and waste drainage and vent piping according to ASTM D 2665.

C. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling. Aboveground Pressure Piping: Pipe fitting.

D. Flexible Transition Couplings for Underground Non-pressure Drainage Piping: ASTM C 1173 with elastomeric sleeve; ends same size as piping to be joined, and corrosion-resistant metal band on each end.

E. Make changes in direction for drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

F. Provide drainage piping beginning at low point of each system. Provide true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Provide required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

G. Provide drainage and vent piping at the minimum slopes as required by the local plumbing code.

H. Provide cleanouts at grade and extend to where building drains connect to site piping. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

3.3 SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for drain piping and tubing:

1. Install a union in piping at each threaded unit connection.
2. Install an adjustable stainless steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:

    a. Details indicated on Drawings.
    b. Manufacturer's requirements.

c. Governing codes.
d. In the absence of requirements, comply with requirements of ASHRAE handbooks.

4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.
6. Piping shall be equal to or larger than the drain pan connection size.
7. If required by manufacturer for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with manufacturer's requirements.
8. Route indoor unit condensate drains to sink traps, floor drains, plumbing code compliant, or other locations as indicated.

B. Gravity Drains:

1. Piping shall be provided with a 1/8” foot minimum slope.
2. Height of unit must be carefully coordinated to provide for proper condensate drainage.

C. Pumped Drains:

1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.
2. Provide units for collecting condensate and extend to open drain, floor drain, mop sink, or other approved location.
3. Mount pump level, secured to wall.

a. Condensate supply hose must be routed with a downward slope to the pump.
b. Secure the hose using hose clamps.
c. After securing hose on the non-return valve, lock non- return valve by rotating valve one quarter turn clockwise.

4. After installing the condensate pump, test it to ensure that it functions correctly. To test the function, pour water into the tank until the activation level is reached and the pump starts. If air in the pump causes the integrated dry-run protection to actuate (pump deactivates, green and red operating lamp flash), add additional water and re-test.
5. Shutoff Valves: Provide full-port ball valve on each pump discharge.

3.4 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

3.5 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Test piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch w.g. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

C. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

D. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.

E. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

3.6 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 221316

SECTION 230500 – COMMON WORK RESULTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. This section applies to Plumbing Division 22 & and HVAC Division 23 sections.

1.2 GENERAL

A. Section 230500 includes items common to all the division specification sections.

B. Provide services, skilled and common labor, and all apparatus and materials required for the complete installation as shown and within the intent of the contract documents, field conditions, and code requirements.

C. The intention of these Contract Documents is to call for finished work, fully tested and ready for operation. Any components or labor not mentioned in the Contract Documents but required for functioning systems shall be provided. Should there appear to be any discrepancies or questions of intent, the Contractor shall refer the matter to the Architect/Engineer for a decision before start of any related work.

D. Consistency and Completeness: The contract documents are intended to include all components; however, the contract documents may not be perfect. Repetitive, common components (such as volume dampers, thermostats, condensate drains, trap primers, vent pipes, valves, etc.) are shown throughout. If a common component is missing in from the drawings, provide as similar per other areas. There will be no change orders for missing such components, the contractor shall provide consistent, complete, functioning systems.

E. Should the Drawings or the Specifications disagree in themselves or with each other, the Contractor shall provide the better quality or greater quantity of work and/or materials unless otherwise directed by written addendum to the Contract Documents.

F. Materials or work described in words, which so applied, have a well-known technical or trade meaning shall be held to refer to such recognized standards. Since the plans and specifications cover the dimensions and features of the work and do not set forth the analysis of the design, it is the duty of the Contractor fulfilling them to ascertain the true intent in any case where it is doubtful.

1.3 MANUFACTURERS INSTRUCTIONS

A. Provide equipment and components to comply with manufacturer's written installation instructions and published drawings.

B. Follow manufacturer’s instructions for inspection, start-up, calibration, commissioning, and testing.

1.4 DEFINITIONS

A. “Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.

B. "Provide": Furnish and install, complete and ready for the intended use.

C. “Shall”: The word “shall” is used to indicate mandatory requirements strictly to be followed in order to conform to the standard and procedures and from which no deviation is permitted.

D. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and attics.

E. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

F. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

G. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

H. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

I. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

1.5 SUBMITTALS

A. Provide in accordance with Division 1 of the specifications.

1.6 SUBSTITUTIONS

A. Provide in accordance with Division 1 of the specifications.

B. Engineer will consider Contractor's request for substitution when the following conditions are satisfied. If the following conditions are not satisfied, Engineer will return requests without action, except to record noncompliance with these requirements:

1. Requested substitution offers Owner a substantial advantage in cost, time, energy conservation, or other considerations, after deducting additional responsibilities Owner must assume. Owner's additional responsibilities may include compensation to Engineer for redesign and evaluation services, increased cost of other construction by Owner, and similar considerations.
2. Requested substitution does not require revisions to the Contract Documents.
3. Requested substitution is consistent with the Contract Documents and will produce indicated results.
4. Substitution request is fully documented and properly submitted.
5. Requested substitution will not adversely affect Contractor's Construction Schedule.
6. Requested substitution has received necessary approvals of authorities having jurisdiction.
7. Requested substitution is compatible with other portions of the Work and shall be acceptable to all contractors involved.
8. Equipment electrical characteristics different than scheduled may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified at no additional cost.
9. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.
10. Requested substitution has been coordinated with other portions of the Work.
11. Requested substitution provides specified warranty.

1.7 QUALITY ASSURANCE

A. Work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications.

B. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

C. Installer Qualifications: Work shall be done by skilled mechanics shall have successfully completed an apprenticeship program or another craft training program.

D. The Contractor shall hold a license to perform the work as issued by the local jurisdiction.

1.8 COORDINATION

A. Coordinate use of project space and sequence of installation of work, which is indicated diagrammatically on drawings. Follow routings shown, as closely as practicable, with due allowance for available physical space; make runs parallel with lines of building. Utilize space efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

B. Coordinate use of project space and sequence of installation of work.

C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for installations. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

D. Coordinate requirements for access panels and doors for items requiring access that are concealed behind finished surfaces. Access panels shall be provided for any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced, maintained, or replaced.

1. Access panels and doors are specified and provided by Division 8.

1.9 TEST ADJUST AND BALANCE READINESS

A. The Contractor shall provide and coordinate the services of qualified, responsible sub-contractors, suppliers and personnel as required to correct, repair, and/or replace deficient items or conditions found during this project, including the testing, adjusting, and balancing period.

B. In order that systems may be properly tested, balanced, and adjusted as required herein by these Specifications, the Contractor shall operate the systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. The Contractor shall allow adequate time for the testing and balancing activities of the Owner provided services, during the construction period, and prior to Substantial Completion as defined in the Uniform General Conditions of this Construction Document.

C. The Drawings and Specifications indicate adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the Contractor to provide these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access as requested by the TAB Firm. Also, any malfunction encountered by TAB personnel and reported to the Contractor shall be corrected by the Contractor immediately so that the balancing work can proceed with the minimum of delays.

D. Complete operational readiness of the HVAC systems also requires that the following be accomplished:

1. Distribution Systems:

    a. Verify installation for conformity to design. Ducts shall be terminated and tested as required by the Specification.
    b. Dampers shall be properly located and functional. Dampers shall have tight closure and open fully with smooth and free operation.
    c. RGD'S and terminal devices shall be provided and secured in a fully open position.
    d. Air handling systems and associated apparatus shall be sealed to eliminate uncontrolled bypass or leakage of air. Clean filters shall be in place, coils shall be clean with fins straightened, bearings properly greased, and the system shall be completely operational. The Contractor shall verify that systems are operating within the design pressure limits of the piping and ductwork.
    e. Under normal operating conditions, check condensate drains for proper connections and functioning. Cooling coil drain pans have a positive slope to drain. Cooling coil condensate drain trap maintains an air seal.
    f. Fans shall be operating and verified for freedom from vibration, proper fan rotation.
    g. Bearings shall be greased.
    h. Terminal units shall be provided and functional (i.e., controls functioning).

2. Water Circulating Systems:

    a. Verify installation for conformity to design. Hydronic systems are pressure tested, flushed, filled, and properly vented; valves are fully open. Examine HVAC system and equipment installations to verify that indicated balancing devices are properly provided, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation
    b. Valves shall be set to their fully open position. After the system is flushed and checked for proper operation, strainers shall be removed and cleaned. The Contractor shall repeat the operation until circulating water is clean and then the start-up strainers shall be discarded.
    c. Record motor amperage on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating. Thermal overload protection is in place.
    d. In preparation of TAB, water circulating systems shall be full and free of air, expansion tanks shall be set for proper water level, and air vents shall be provided at high points of systems and operating freely. Chemicals shall be added to closed systems to treat piping and inhibit corrosion. The system static pressure shall be adequate to completely fill the system without operating the pumps.
    e. Check and set operating parameters of the heat transfer and control devices to the design requirements.
    f. Proper balancing devices shall be in place and located correctly. Heat transfer coils shall be checked for correct piping connections.

3. Building Automation System (BAS)

a. The BAS Contractor shall verify that control components are provided in accordance with project requirements and are functional.
b. The BAS Contractor shall verify that controlling instruments are calibrated and set for design operating conditions except for components that require input from the TAB Agency, but a default shall be set. The Control Contractor shall cooperate with the TAB Agency and provide software and interfaces to communicate with the system.
c. The BAS Contractor shall thoroughly check controls, sensors, operators, sequences, etc. before notifying the TAB Agency that the BAS is operational. The BAS Contractor shall provide technical support (technicians and necessary computers) to the TAB Agency for a complete check of these systems.
d. Prior to occupancy, each ventilation system shall be tested to ensure that OA dampers operate properly in accordance with system design.
e. Fire Alarm: Division 26 shall thoroughly check detection devices, sequences, inter-locks, etc. before notifying the TAB Agency that the system is operational. Division 26 shall certify that the systems are totally operational to the Contractor prior to the TAB beginning.

1.10 RENOVATION PROJECT REQUIREMENTS

A. The Contractor shall cooperate with the Owner to minimize conflicts with the Owner's operations.

B. The Contractor shall study drawings and specifications, visit the site, and get acquainted with the existing conditions and the requirements of the plans and specifications. No claim will be recognized for extra compensation due to the failure of the Contractor to be familiarized with the conditions and extent of the proposed work. The Contractor shall execute alterations, additions, removals, relocations, or new work, etc., as indicated, or required to provide a complete installation in accordance with the intent of the drawing and specifications.

C. Use of Site: Limit use of premises to work in areas indicated. Do not disturb portions of site beyond areas in which the Work is indicated. Keep driveways and entrances serving premises clear and available to Owner. Schedule deliveries to minimize use of driveways and entrances and minimize space and time requirements for storage of materials and equipment on-site.

D. Follow the recommended procedures of the SMACNA IAQ Guidelines for Occupied Buildings under Construction.

E. Continuity of Services: The building will be in use during construction operations. Maintain existing systems in operation within rooms of building. Schedules for various phases of contract work shall be coordinated with other trades and with Owner’s Representative. Provide, as part of the contract, temporary plumbing and mechanical and electrical connections and relocations as required to accomplish the above. Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services. Notify Owner at least two days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions. Indicate

method of providing temporary utilities. Do not proceed with utility interruptions without Owner's written permission.

F. Cutting And Patching: Provide temporary support of Work to be cut. Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations. Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.

1. Where existing services/systems are required to be removed relocated, or abandoned, bypass such services/systems before cutting to prevent interruption to occupied areas.
2. Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay. Cut in-place construction to provide for installation of other components or performance of other construction and subsequently patch as required to restore surfaces to their original condition.
3. Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original installer; comply with original installer's written recommendations.
4. Patch construction by filling, repairing, refinishing, closing, and similar operations following performance of other Work. Patch with durable seams that are as invisible as possible. Provide materials and comply with installation requirements specified in other Sections. Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing. Clean piping, conduit, and similar features before applying paint or other finishing materials. Restore damaged pipe covering to its original condition.
5. Any structural member weakened or impaired by cutting, notching, or otherwise shall be reinforced, repaired, or replaced to be left in safe structural condition in accordance with the local building code requirements.
6. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition.
7. Cleaning: Clean areas and spaces where cutting and patching are performed. Completely remove paint, mortar, oils, putty, and similar materials.

PART 2 - PRODUCT

2.1 PRODUCT CRITERIA

A. Any costs incurred due to deviations from basis of design unit shall be responsibility of the contractor.

B. Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 5 years.

C. Equipment Service: Products shall be supported by a service organization that maintains a complete inventory of repair parts and is located reasonably close to the site.

D. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

E. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.

F. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped, or otherwise permanently marked on each item of equipment.

G. Asbestos products or equipment or materials containing asbestos shall not be used.

2.2 PROGRAMMABLE 3-PHASE LINE VOLTAGE MONITORS

A. Provide for all inverter-driven equipment.

B. Provide an ICM Controls Model #ICM450A or equal, for motor protection from premature failure and damage caused by common voltage faults such as phase unbalance, over/under voltage, phase loss and phase reversal.

1. Voltage: Universal, 190-600 VAC
2. Simultaneous 3-phase true RMS voltage monitoring
3. Factory calibrated.
4. 3-phase voltages simultaneously displayed on LCD
5. Fault memory
6. Fault monitoring: High / low voltage, voltage unbalance, phase loss, phase reversal
7. Simple configuration
8. Fully adjustable variables
9. Modbus RS485 communications
10. LED indicators
11. Common ¼” quick connect terminations.

2.3 IDENTIFICATION

A. Equipment:

1. Terminology: Match schedules as closely as possible.
2. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

    a. Lettering Size: Minimum letter height of 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.
    b. Stencil Material: Fiberboard or metal.
    c. Paint: Exterior, alkyd enamel. Paint may be in pressurized spray-can form.

B. In addition to the equipment tag, equipment located above the ceiling that requires servicing shall be labeled on the ceiling grid using a labeling machine.

C. Piping Identification Devices

1. Manufactured Pipe Markers, General: Seton, Brady, or approved equal; preprinted, color-coded, with lettering indicating service, and showing direction of flow.
2. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length. Size of letters and length of color field per ASME A13.1.
3. Pipes with OD, Including Insulation; Full-band snap-around pipe markers extending 360 degrees around pipe at each location. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow. Length of color field and size of letters shall be proportional to pipe OD.
4. Types: Self-adhesive type: Seton Opti-Code; Snap-around type: Seton Setmark; Wrap-around type: Seton Ultra-mark; PVF over-laminated polyester construction seals in and protects graphics; suitable for outdoor or harsh environments.

2.4 PIPE JOINING MATERIALS

A. Provide per local code.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

C. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Press Connections

1. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC; ProPress, Apollo, or approved equal.
2. Press ends shall have Viega Smart Connect, Apollo Leak Before Press, or similar technology designed into the fitting itself, allowing identification of an un-pressed fitting during pressure testing. The function of this feature is to provide the installer quick and easy identification of connections which have not been pressed prior to putting the system into operation.
3. Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of ASME B16.51 and IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed, or an alternative supplied by the fitting manufacturer.
4. Steel: Cold Press Mechanical Joint Fitting shall conform to material requirements of ASTM A420 or ASME B16.3 and performance criteria ANSI/CSA LC4. Sealing elements for press fittings shall be HNBR. Sealing elements shall be factory installed, or

an alternative supplied by the fitting manufacturer. Piping and fittings shall comply with CSA LC-4 and local codes.

E. Mechanical Coupling Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents and exterior environment. Gasket design shall be such that the entire coupling housing is isolated from the system contents to prevent galvanic action and inhibit galvanic corrosion.

F. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

G. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

H. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

I. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

J. Solvent Cements for Joining Plastic Piping: CPVC Piping: ASTM F 493. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

K. Plastic-to-Metal Transition Fittings: one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657. Plain-End Pipe and Fittings: Use butt fusion. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. Provide dielectric isolation at the connection of dissimilar metals. Provide brass ball valves or fittings; or Watts Series LF3000 (lead free) or approved equal.

2.5 SLEEVES & ESCUTCHEONS

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Provide penetration system where service pipes penetrate through foundation wall or floor. Make installation watertight. Mechanical Sleeve Seals: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve; Thunderline Link-Seal, Advanced Product & Systems, LLC, Garlock, or approved equal.

1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Glass-reinforced nylon.
3. Connecting Bolts and Nuts: Stainless steel, of length required to secure pressure plates to sealing elements.

G. Escutcheons shall be manufactured from nonferrous metals and shall be chrome-plated. Metals and finish shall conform to ASME A112.19.2. Escutcheons shall be one-piece type where mounted on chrome-plated pipe or tubing, and one-piece of split-pattern type elsewhere. ID shall closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers the opening. Escutcheons shall have setscrews for maintaining a fixed position against a surface.

2.6 HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-Line Systems, Inc.
2. Carpenter & Patterson, Inc.
3. Grinnell Corp.
4. Hubbard Enterprises/Holdrite
5. National Pipe Hanger Corp.
6. Piping Technology & Products, Inc.
7. Unistrut
8. Anvil International, Inc.
9. Empire

B. Provide in accordance with MSS SP69 - Manufacturers Standardization Society: Pipe Hangers and Supports- Selection and Application. Steel pipe hangers and supports shall have the manufacturer’s name, part number, and applicable size stamped on the part itself for identification.

C. The materials of pipe hanging and supporting elements shall be in accordance with MSS SP-58. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications." Do not allow dissimilar metals to come into contact.

D. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel." Steel Pipe Welding: Qualify processes and operators according to

ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications." Comply with provisions in ASME B31 Series, "Code for Pressure Piping." Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

E. Delegated-Design Submittal: For hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. Show fabrication and installation details and include calculations. Provide for the following: trapeze pipe hangers, metal framing systems, pipe stands, equipment supports.

F. Hangers:

1. Uninsulated pipes 2 inch and smaller: Adjustable steel swivel ring (band type) hanger, Type 10, B-Line B3170; Adjustable steel swivel J-hanger, Type 5, B-Line B3690; Malleable iron ring hanger, Type 12, B-Line B3198R or hinged ring hanger, B3198H.Adjustable steel clevis hanger, Type 1, B-Line B3100.
2. Uninsulated pipes 2-1/2 inch and larger: Adjustable steel clevis hanger, Type 1, B-Line B3100.
3. Insulated Hot piping: 2 inch and smaller pipes: use adjustable steel clevis with galvanized sheet metal shield. Type 1, B-Line B3100 with Type 40, B-Line B3151 series insulation protection shield. 2-1/2 inch and larger pipes: Type 41 or Type 43 with Type 39A/39B, B3160-B3165 series pipe covering protection saddle.
4. Insulated Cold piping: use adjustable steel clevis with galvanized sheet metal shield. Type 1, B-Line B3100 with Type 40, B-Line B3151 series insulation protection shield.
5. Copper Tubing Supports Hangers shall be sized to fit copper tubing outside diameters. Adjustable steel swivel ring (band type) hanger, Type 10, B-Line B3170CT. Malleable iron ring hanger, Type 12, B-Line B3198RCT or hinged ring hanger B3198HCT. Adjustable steel clevis hanger, Type 1, B-Line B3104CT. For supporting copper tube to strut use plastic inserted vibration isolation clamps, B-Line BVT series.
6. Plastic Pipe Supports: V-Bottom clevis hanger with galvanized 18-gauge continuous support channel, Type 1, B-Line B3106 and B3106V plastic pipe support channel, to form a continuous support system for plastic pipe or flexible tubing.

G. Pipe Clamps: When flexibility in the hanger assembly is required due to horizontal movement, use pipe clamps with weldless eye nuts, Type 4, B-Line B3140. For insulated lines use double bolted pipe clamps, Type 3, B-Line B3144.

H. Multiple or Trapeze Hanger: Trapeze hangers shall be constructed from 12-gauge roll formed ASTM A1011 SS Grade 33 structural steel channel, 1-5/8 inch by 1-5/8-inch minimum, B-Line B22 strut or stronger as required. Mount pipes to trapeze with 2-piece pipe straps sized for outside diameter of pipe, B-Line B2000 Series.

I. Wall Supports: Pipes 4” and smaller: Carbon steel J-hanger, B-Line B3690. Pipes larger than 4”: Welded strut bracket and pipe straps, Type 31 light welded steel bracket, B-Line B3064. Provide Type 32 or Type 33 for heavier loads.

J. Floor Supports: Hot piping under 6 inch and cold piping: Carbon steel adjustable pipe saddle and nipple attached to steel base stand sized for pipe elevation. Type 38 adjustable pipe saddle,

B-Line B3093 and B3088T base stand; or Type 39, B3090 and B3088 base stand. Pipe saddle shall be screwed or welded to appropriate base stand. Hot piping 6 inch and larger: Adjustable Roller stand with base plate, Type 46, B3118SL. Adjustable roller support and steel support sized for elevation, B-Line B3124.

K. Vertical Supports: Steel riser clamp sized to fit OD of pipe, Type 8, B-Line B3373.

L. Supplementary Structural Supports: Design and fabricate supports using structural quality steel bolted framing materials as manufactured by Cooper B-Line. Channels shall be roll formed, 12-gauge ASTM A1011 SS Grade 33 steel, 1-5/8 inch by 1-5/8 inch or greater as required by loading conditions. Submit designs for pipe tunnels, pipe galleries, etc., to engineer for approval. Use clamps and fittings designed for use with the strut system.

M. Beam Clamps shall be used where piping is to be suspended from building steel. Clamp type shall be selected based on load to be supported, and load configuration. C-Clamps shall have locknuts and cup point set screws, Type 23, B-Line B351L. Refer to manufacturer's recommendation for setscrew torque. Retaining straps shall be used to maintain the clamps position on the beam where required.

N. Concrete Inserts: Cast in place spot concrete inserts shall be used where applicable; either steel or malleable iron body, Type 18, B-Line B2500 or B3014. Spot inserts shall allow for lateral adjustment and have means for attachment to forms. Select inserts to suit threaded hanger rod sizes, B-Line N2500 or B3014N series. Continuous concrete inserts shall be used where applicable. Channels shall be 12 gauge, ASTM A1011 SS Grade 33 structural quality carbon steel, complete with Styrofoam inserts and end caps with nail holes for attachment to forms. The continuous concrete insert shall have a load rating of 2,000 lbs./ft. in concrete, B-Line B22I, 32I, or 52I. Select channel nuts suitable for strut and rod sizes.

O. For air conditioning and other vibrating system applications, use a clamp that has a vibration dampening insert and a nylon inserted locknut. For copper and steel tubing use B-Line BVT-Series Vibraclamps. For larger tubing or piping subjected to vibration, use neoprene or spring hangers as required. For base mounted equipment use vibration pads, molded neoprene mounts, or spring mounts as required.

P. Accessories

1. Hanger Rods shall be threaded both ends or continuous threaded rods of circular cross section. Use adjusting locknuts at upper attachments and hangers. No wire, chain, or perforated straps are allowed.
2. Shields shall be 180-degree galvanized sheet metal, 12-inch minimum length, 18-gauge minimum thickness, designed to match outside diameter of the insulated pipe, B-Line B3151.
3. Pipe protection saddles shall be formed from carbon steel, 1/8-inch minimum thickness, sized for insulation thickness. Saddles for pipe sizes greater than 12 inch shall have a center support rib.

Q. Indoor Finishes: Hangers and clamps for support of bare copper piping shall be coated with copper colored epoxy paint, B-Line Dura-Copper®. Additional PVC coating of the epoxy painted hanger shall be used where necessary. Hangers for other than bare copper pipe shall be zinc plated in accordance with ASTM B633; or shall have an electro-deposited green epoxy finish, B-Line Dura-Green®. Strut channels shall be pre-galvanized in accordance with ASTM A653 SS Grade 33 G90 OR have an electro-deposited green epoxy finish, B-Line Dura-Green®.

R. Outdoor Finishes: Hangers and strut located outdoors shall be hot dip galvanized after fabrication in accordance with ASTM A123. Hanger hardware shall be hot dip galvanized or stainless steel. Zinc plated hardware is not acceptable for outdoor or corrosive use.

S. Unistrut (MFMA) Manufacturer Metal Framing System:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Unistrut Corporation
   b. Cooper B-Line, Inc.
   c. Flex-Strut Inc.
   d. Thomas & Betts Corporation.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes. Standard: MFMA-4.
3. Channels: Continuous slotted steel channel with in-turned lips. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
5. Coating: Unistrut Perma-green or similar.

2.7 MISCELLANEOUS

A. Grout: ASTM C 1107, Grade B, non-shrink, and nonmetallic, dry hydraulic-cement grout. Characteristics: Post-hardening, volume adjusting, non-staining, non-corrosive, nongaseous, and recommended for interior and exterior applications. Design Mix: 5000-psi, 28-day compressive strength. Packaging: Premixed and factory packaged.

B. Equipment shall be vibration isolated to prevent vibration transmission to the building structure.

PART 3 - EXECUTION

3.1 DEMOLITION AND REMOVALS

A. Refer to Division 1 for general demolition requirements and procedures.

B. Disconnect, demolish, and remove plumbing and mechanical systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and cap and seal remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap and seal ducts with same or compatible ductwork material.
5. Equipment to be Removed: Disconnect and cap services and remove equipment.
6. Equipment to be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 COMMON REQUIREMENTS

A. Work shall be conducted, installed, and completed in a neat and professional manner reflecting a minimum level of competent workmanship.

B. The drawings show the general arrangement of systems and equipment but do not show all required fittings and offsets that may be necessary to connect pipes and ductwork to equipment, and to coordinate with other trades. Provide necessary fittings, offsets and runs based on field measurements and at no additional cost. Coordinate with other trades for space available and relative location of equipment and accessories. Pipe and duct location on the drawings shall be altered by the contractor where necessary to avoid interferences and clearance difficulties.

C. Fabricate based on field measurements.

D. Corrections or comments made on the shop or coordination drawings during the review do not relieve Contractor from compliance with requirements of the drawings and specifications. The Contractor is responsible for: confirming and correcting quantities; checking electrical characteristics and dimensions; selecting fabrication processes and techniques of construction; coordinating his work with that of other trades; and performing work in a safe and satisfactory manner.

E. Protection and Cleaning: Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations. Damaged or defective items shall be replaced. Protect finished parts of equipment. Close duct and pipe openings with caps or plugs during installation.

Tightly cover and protect fixtures and equipment against dirt, water, chemical, or mechanical injury. At completion of work thoroughly clean fixtures, exposed materials, and equipment.

F. Provide piping, ductwork, and equipment to allow maximum headroom unless specific mounting heights are indicated. Provide equipment level and plumb, parallel, and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

G. Provide equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

H. Coordinate location of piping, ductwork, sleeves, inserts, hangers, and equipment. Locate to clear other construction, services, and utilities.

I. Provide piping and ductwork in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

J. Provide systems above accessible ceilings to allow sufficient space for ceiling panel removal.

K. Verify final equipment locations for roughing-in.

L. Do not enclose, cover, or put into operation until inspected and approved by authorities having jurisdiction.

M. The contract documents indicate required valves, fittings, and accessories. If additional materials are required by code or manufacturer’s instructions, they shall be provided at no cost to the owner.

N. Any hot work operations that are performed during this project shall be permitted by use of the FM Global Hot Work Permit System. The FM Global Hot Work Permit System shall be used to supervise all hot work operations (cutting, welding, brazing, grinding, soldering, etc.,) performed outside of any designated welding areas. A written policy statement shall specify who has the authority to issue permits on all shifts. In addition, a constant fire watch shall be continued for 1 hr. after work is completed and the area shall be monitored for an additional 3 hrs. after that.

3.3 PIPING INSTALLATIONS

A. Provide piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

1. Provide piping to permit valve servicing.
2. Provide equipment and other components to allow right of way for piping installed at required slope.
3. Provide free of sags and bends.
4. Provide unions or flanges at connections to equipment.

5. Provide fittings for changes in direction and branch connections.
6. Make allowances for application of insulation.

B. Provide piping adjacent to equipment and machines to allow service and maintenance.

C. Use transition fitting to join dissimilar piping materials. Connect piping in sizes indicated, but not smaller than sizes of unit connections.

D. Select system components with pressure rating equal to or greater than system operating pressure.

E. Plastic piping: Piping shall be installed to avoid damage from adjacent light fixtures. In certain construction situations, these plastic pipes may be installed near recessed light fixtures in ceilings. Light fixtures may have exterior temperatures as high as 194°F.

F. Plumbing: General layout shown, provide piping and components as required by the local plumbing code. A licensed master plumber shall perform or supervise the work and provide layouts, piping, and fittings as required by code.

3.4 PIPING JOINT CONSTRUCTION

A. Pipe and tube required by the applicable standard to be cleaned and capped shall be delivered to the job site with factory-applied endcaps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture. Protect stored pipe and tube from moisture and dirt. Elevate above grade. When stored inside, do not exceed the structural capacity of the floor. Protect fittings, flanges, and piping specialties from moisture and dirt. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

B. Joints shall be fabricated, joined, and tested per the piping and fitting manufacturer’s instructions. Joint preparation, setting and alignment, joining process, timing, hanger spacing, and working pressure shall be in accordance with the pipe and fitting manufacturer’s specifications.

C. Join pipe and fittings according to the following requirements and the relevant specification section specifying piping systems.

D. Ream ends of pipes and tubes and remove burrs. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

E. Installer Qualifications

1. Pipe fitters shall be qualified in the procedure used to perform the pipe joining.
2. The contractor is responsible for documenting the qualification and training records of each pipe fitter. Pipe fitters shall have current, formal training on the pipe jointing method.
3. Contractor must submit documentation that lists personnel assigned to this project prior to beginning construction who have successfully completed formal training conducted by

an authorized manufacturer's representative. The Contractor Training documentation shall be specific to the manufacturer of the pipe and fittings.

4. Personnel's training documentation must be current and have been updated within the past two (2) years. Training received more than two years prior to operation with no evidence of activity within the past 6 months shall not be considered current.
5. Piping Warranty: Contractor shall provide, and document required training and required by the piping system manufacturer to maintain the piping manufacturer's warranty.

F. Provide dielectric isolation at the connection of the dissimilar piping (copper and steel).

G. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

H. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

I. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

J. Press connections:

1. The joints shall be pressed using the tools approved by the manufacturer.
2. Always examine the pipe to ensure it is fully inserted into the fitting prior to pressing the joint.
3. Pipe ends shall be cut on a right angle (square) to the pipe.
4. Copper: The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tools approved by the manufacturer.
5. Steel: Pipe ends shall be reamed chamfered, and paint, lacquer, grease, oil, or dirt shall be removed from the pipe end with an abrasive cloth, or with the Rigid MegaPress pipe end prep tool. Sealing elements shall be verified for the intended use. Visually examine the fitting sealing element to ensure there is no damage. Utilizing a Viega insertion depth inspection gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the pipe fully into the fitting and mark the pipe wall at the face of the fitting.

K. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators. Bevel plain ends of steel pipe. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

L. Flanged Joints: Provide appropriate gasket material, size, type, and thickness for service application. Provide gasket concentrically positioned. Use suitable lubricants on bolt threads.

M. Joint Construction for Solvent-Cemented Plastic Piping: Clean and dry joining surfaces. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix. PVC Piping: Join according to ASTM D 2855.

3.5 PIPE PENETRATIONS, SLEEVES, & ESCUTCHEONS

A. Pipe penetrations shall be sealed, provide sealants for pipe penetrations

B. Provide allowance for thermal expansion and contraction of copper tubing passing through a wall, floor, ceiling, or partition by wrapping with an approved tape or pipe insulation or by installing through an appropriately sized sleeve.

C. Sleeve Clearance: Sleeve through floors, walls, partitions, and beams shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation.

D. Provide sleeves for pipes passing through concrete and masonry construction. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint. Cut sleeves to length for mounting flush with both surfaces. Provide sleeves in new walls and slabs as new walls and slabs are constructed. Provide steel pipe sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Piping through concrete or masonry shall not be subject to any load from the building construction.

1. Sleeves are not required in drywall construction.
2. Sleeves are not required for core-drilled holes. Provide core drilling as required.

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 7.

F. Exterior- Pipe Penetrations: Provide sleeve-seal systems in sleeves at service piping entries into building. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and provide in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

G. Escutcheons:

1. Provide escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork.
2. Provide escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
3. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

H. Plastic and copper piping penetrating framing members, and within one-inch of the framing, shall be protected with 10-gauge steel nailing plates. The steel plate shall extend along the framing member a minimum of 1.5” beyond the OD of the pipe or tubing.

3.6 PIPE HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Provide hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or provide intermediate supports for smaller diameter pipes as specified for individual pipe hangers. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Provide per manufactures recommendations and calculations.

D. Thermal-Hanger Shield Installation: Provide in pipe hanger or shield for insulated piping.

E. Fastener System Installation: Provide powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Provide fasteners according to powder-actuated tool manufacturer's operating manual. Provide mechanical-expansion anchors in concrete after concrete is placed and completely cured. Provide fasteners according to manufacturer's written instructions.

F. Provide hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. Provide hangers and supports to allow controlled thermal or seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Provide lateral bracing with pipe hangers and supports to prevent swaying.

J. Provide building attachments within concrete slabs or attach to structural steel. Provide additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Provide concrete inserts before concrete is placed; fasten inserts to forms and provide reinforcing bars through openings at top of inserts.

K. Provide for expansion and contraction of the piping system. Since changes in direction in the system are usually sufficient to allow for expansion and contraction, hangers must be placed so as not to restrict this movement

L. Pipe Slopes: Provide hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by plumbing code and ASME B31.9 for building services piping. Piping shall be supported in such a manner as to maintain its alignment and prevent sagging.

M. Insulated Piping: Attach clamps and spacers to piping.

1. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
2. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

N. Equipment Supports: Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor. Grouting: Place grout under supports for equipment and make bearing surface smooth. Provide lateral bracing, to prevent swaying, for equipment supports.

O. Metal Fabrications: Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals. Obtain fusion without undercut or overlap. Remove welding flux immediately. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

P. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

Q. Hanger and Support Schedule

1. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
2. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
3. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Hanger Spacing

1. Support piping and tubing not listed below according to MSS SP-69 and manufacturer's written instructions.
2. Load Distribution: Provide hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment. Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading.
3. Space and provide hangers with the fewest practical rigid anchor points.

4. Piping shall be supported at intervals sufficiently close to maintain correct pipe alignment and to prevent sagging or grade reversal.
5. Pipe shall be supported at branch ends and at changes of direction.
6. Provide hangers for steel piping with the following maximum horizontal spacing and minimum rod sizes:

    a. NPS ¾ to 1: Maximum span, 6 feet; minimum rod size, 3/8 inch.
    b. NPS 1-1/4: Maximum span, 8 feet; minimum rod size, 3/8 inch.
    c. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
    d. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
    e. NPS 2-1/2 to 3: Maximum span, 10 feet; minimum rod size, 1/2 inch.
    f. NPS 4 to 5: Maximum span, 10 feet; minimum rod size, 5/8 inch.
    g. NPS 6 to 8: Maximum span, 10 feet; minimum rod size, 3/4 inch.
    h. NPS 10 to 12: Maximum span, 10 feet; minimum rod size, 7/8 inch.

7. Provide hangers for copper piping with the following maximum horizontal spacing and minimum rod sizes:

    a. NPS ½ and 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
    b. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
    c. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
    d. NPS 1-1/2 to 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
    e. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
    f. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
    g. NPS 4: Maximum span, 10 feet; minimum rod size, 1/2 inch.
    h. Maximum vertical steel and copper pipe attachment spacing: 10 feet.

8. Piping Hangers for Plastic Piping:

    a. Hangers shall not compress, distort, cut, or abrade the piping.
    b. Hangers shall be placed next to the pipe joint not more than 18” from the point joint.
    c. Maximum horizontal spacing and minimum rod diameters (pipe temperature 100°F or lower).
    d. Solvent cemented PVC

        1) NPS 2 and smaller: 48” with 3/8-inch rod.
        2) NPS 2-1/2: 48” with 1/2-inch rod.
        3) NPS 3: 48” with 1/2-inch rod.
        4) NPS 4: 48” with 5/8-inch rod.
        5) NPS 6: 48” with 3/4-inch rod.
        6) NPS 8: 48” with 7/8-inch rod.
        7) NPS 10: 48” with 7/8-inch rod.
        8) NPS 12: 48” with 7/8-inch rod.

    e. Solvent cemented CPVC

        1) NPS 1 and smaller: 36” with 3/8-inch rod.
        2) NPS 1-1/4 to NPS 3: 60” with 3/8-inch rod.

3) NPS 3: 60” with 1/2-inch rod.
4) NPS 4: 60” with 5/8-inch rod.
5) NPS 6 and 8: 60”with 3/4-inch rod.

S. Support vertical piping independently of connected horizontal piping. Support vertical pipes at base and at every floor. Wherever possible, locate riser clamps directly below pipe couplings or shear lugs.

T. Place a hanger within 12 inches of each horizontal elbow.

3.7 VALVE INSTALLATION

A. Valves shall be installed in accordance with the manufacturer’s recommendations.

B. Provide valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown. Locate valves for easy access and provide separate support where necessary.

C. Provide valves in horizontal piping with stem at or above center of pipe.

D. Provide valves in position to allow full stem movement.

E. Provide strainers on supply side of each control valve and elsewhere as indicated or recommended by component manufacturer to have strainer protection. Provide valved drain and hose connection on strainer blow down connection.
1. Provide with provisions for service clearance.
2. Remove and clean strainer after 24 hours of operation and after 30 days of operation.

F. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be services and removed without interference from structure or other pipes and/or equipment.

G. Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at connections to screw-type control valves.

H. Provide check valves at each pump discharge and elsewhere as required to control flow direction.

I. Provide hose end drain valves for equipment, at base of each water riser, at low points in horizontal piping, and where required to drain water piping.

3.8 IDENTIFICATION

A. Provide equipment markers on each item of scheduled equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated. Locate markers

where accessible and visible. Equipment located above the ceiling that requires servicing shall be labeled on the ceiling using a labeling machine.

1. Letters shall be ¼" high, black.
2. Label equipment above ceiling that requires servicing or access. Locate labels on the ceiling grid, adjacent to the ceiling tile that provides the best access to the valve or item that requires servicing.

B. Piping Identification:

1. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; mechanical rooms; accessible maintenance spaces such as shafts and plenums; and exterior exposed locations as follows:

   a. Near each valve and control device.
   b. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   c. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
   d. At access doors and similar access points that permit view of concealed piping.
   e. Near major equipment items and other points of origination and termination.
   f. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
   g. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

2. Directional Flow Arrows: Arrows shall be provided to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
3. Apply "Electric Traced" labels to the outside of heat-traced insulation.

C. Relocate mechanical identification materials and devices that have become visually blocked by other work. Clean faces of mechanical identification devices.

3.9 ERECTION OF SUPPORTS AND ANCHORAGES

A. Fasten wall-hanging items securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated. Fasten recessed-type items to reinforcement built into walls.

B. Wood: Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor materials and equipment. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Provide fasteners without splitting wood members. Attach to substrates as required to support applied loads.

C. Metal: Provide in accordance with Division 5. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor materials and equipment. Field Welding: Comply with AWS D1.1.

D. Grouting: Provide per manufacturer's instructions. Mix and provide grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors. Clean surfaces that will encounter grout. Provide forms as required for placement of grout. Avoid air entrapment during placement of grout. Place grout, completely filling equipment bases. Place grout on concrete bases and provide smooth bearing surface for equipment. Place grout around anchors. Cure placed grout.

3.10 FIRESTOPPING

A. Provide through-penetration firestop systems. Refer to Division 7 for materials. Seal penetrations through fire-or smoke-rated wall, partition, ceiling, or roof assemblies with firestopping systems. Refer to Architectural plans for location of rated assemblies.

B. Provide through-penetration firestop systems to comply with firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.

C. UL-Classified Systems shall be provided for rated walls and floors.

D. Engage an experienced installer who is certified, licensed or otherwise qualified by the firestopping manufacturer as having been provided the necessary training to provide firestop products per specified requirements.

E. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are provided according to specified requirements.

F. Provide through-penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.

G. Provide components for each through-penetration firestop system that are needed to provide fill materials. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.

H. General: Use only through-penetration firestop system products that have been tested for specific fire-resistance-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance. Keep areas of work accessible until inspection by authorities having jurisdiction.

I. Inspecting Agency: Owner may engage a qualified, independent inspecting agency to inspect through-penetration firestops. Independent inspecting agency shall comply with ASTM E 2174 requirements including those related to qualifications, conducting inspections, and preparing test reports. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with requirements. Proceed with enclosing through-penetration firestop systems with other construction only after inspection reports are issued and firestop installations comply with requirements.

J. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and provide new materials to produce systems complying with specified requirements.

3.11 PAINTING

A. Painting of plumbing and mechanical systems, equipment, and components is specified in Division 9.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.12 ROOFING

A. Refer to Division 7.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

C. Roof Pipe Stand Installation: Provide per manufactures recommendations and calculations. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount them on a smooth roof surface. Do not penetrate roof membrane. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.

D. Roof Pipe Penetrations: Provide curb system with cover and pipe boots.

E. Do not locate mechanical equipment within 10-feet of the roof edge.

3.13 PROJECT CLOSEOUT

A. Starting and Adjusting

1. Start equipment and operating components to confirm proper operation. Remove malfunctioning units, replace them with new units, and retest.
2. Adjust equipment for proper operation. Adjust operating components for proper operation without binding.
3. Test each piece of equipment to verify proper operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Provide commissioning per manufacturer's instructions. This start-up shall include verification of proper installation, system initiation, adjustment, and fine tuning.
5. Start-up shall not be considered complete until the sequence of operation, including alarms, has been sufficiently demonstrated to the Owner or Owner’s designated representative. This jobsite visit shall occur only after hook-ups, tie-ins, and terminations have been completed and signed-off on the manufacturer’s start-up request form.

B. Follow Closeout procedures as per Division 1.

C. Provide Demonstration and Training in accordance Division 1.

D. Provide Project Record Documents in accordance with Division 1. In addition, per ASHRAE 90.1-2016: Provide record drawings of the actual installation to the building owner. Record drawings shall include, as a minimum, the location and performance data on each piece of equipment; general configuration of the duct and pipe distribution system, including sizes; and the terminal air or water design flow rates.

E. Provide Operation and Maintenance information in accordance with Division 1. In addition, per ASHRAE 90.1: Provide an operating manual and a maintenance manual to the building owner. Manuals shall include, at a minimum, the following:

1. Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance.
2. Operation manuals and maintenance manuals for each piece of equipment and system requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions shall be clearly identified.
3. Names and addresses of at least one service agency.
4. HVAC controls system maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field-determined set points shall be permanently recorded on control drawings at control devices or, for digital control systems, in programming comments.

END OF SECTION 230500

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division Section: “Common Work Results”

1.2 SUMMARY

A. Testing, Adjusting, and Balancing

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Reports:

1. Deficiency Report: Following examination of installed system, prior to balancing, submit report indicating system deficiencies that would prevent proper testing, adjusting, and balancing of systems and equipment to meet specified performance.
2. TAB Report: Submit the complete testing, adjusting, and balancing report, including any drawings indicating air outlets, thermostats, and equipment identified to correspond with data sheets.
3. Reports shall be on TABB/SMACNA, AABC, or NEBB forms that indicate information addressing each of the testing methods, readings, and adjustments.

C. Closeout Submittals: Provide complete copy of TAB report. Include report in Operation and Maintenance Manual.

1.4 QUALITY ASSURANCE

A. An independent entity shall perform the TAB work.

B. Special Warranty

1. Provide warranty for period of 90 days following submission of completed report, during which time Owner may request a recheck of up to 10% of total number of terminals, or resetting of any outlet, coil, or device listed in the test report.
2. Warranty shall meet the requirements of the following programs:

    a. TABB – Quality Assurance Program
    b. AABC – National Project Performance Guarantee
    c. NEBB – Conformance Certification

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

E. TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

1. Systems are started and operating in a safe and normal condition.
2. Temperature control systems are installed, complete, and operable.
3. Verify HVAC control system is operating within the design limitations.
4. Confirm that the sequences of operation comply with Contract Documents.
5. Automatic and manual dampers are operable and fully open.
6. Verify that controllers are calibrated and function as intended.
7. Verify that controller set points are as indicated.
8. Verify the operation of lockout or interlock systems.
9. Verify the operation of valve and damper actuators.
10. Verify that controlled devices are properly installed and connected to correct controller.
11. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
12. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
13. Suitable access to balancing devices and equipment is provided.
14. Thermal overload protection is in place for equipment.
15. Start-up air filters are removed.
16. Final filters are clean and properly installed.
17. Duct and fan systems are clean.

18. Fans are rotating correctly.
19. Life safety and volume dampers are in place and open.
20. Air coil fins are cleaned and combed.
21. Access doors are closed, and duct end caps are in place.
22. Air outlets are installed and connected.
23. Hydronic systems are pressure tested, flushed, filled, and properly vented.
24. Leak testing on duct system has been performed.
25. Pumps are rotating correctly.
26. Start-up/construction strainers have been removed and all permanent strainers are clean and in place.
27. Gauges and/or test ports are properly located for balancing.
28. Service and balance valves are fully open.

B. If deficiencies are evident, submit Deficiency Report to Architect. Do not begin testing, adjusting, and balancing of environmental systems until deficiencies have been remedied.

3.2 AIR SYSTEMS PROCEDURES

A. Adhere to the follow procedure:

1. TABB – SMACNA TAB Procedural Guide, with particular focus on the following chapters: Preliminary TAB Procedures, General Air System TAB Procedures, & TABB Procedures for Specific Air Systems.
2. AABC – National Standards for Total System Balance.
3. NEBB – Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

B. Minimum air procedures shall include the following:

1. Provide TAB for all air systems and components.
2. Test and adjust fan RPM to design requirements.
3. Test and record motor full load nameplate rating and actual ampere draw.
4. Test and record system static pressures, fan suction, and discharge.
5. Adjust all main supply and return air duct to within tolerances of proper design CFM.
6. Test and adjust each diffuser, grille, and register. Reading and tests of diffusers, grilles, and registers shall include design velocity (FPM) and adjusted velocity, design CFM, and adjusted CFM.
7. Test and record outside air, mixed air, and discharge temperatures (D.B. for heating cycle, D.B. and W.B. for cooling cycle).
8. In coordination with the BAS contractor, set adjustments of automatically operated dampers to operate as specified, indicated and/or noted.
9. Test and adjust air handling and distribution systems to provide required supply, return, outside, and exhaust air quantities within design tolerance.
10. Make air velocity measurements in ducts by Pitot tube traverse across entire cross-sectional area of duct in accordance with SMACNA equal area method or Log Linear method.
11. Measure air quantities at all air inlets and outlets.
12. Use volume control devices to regulate air quantities only to the extent that adjustments do not create objectionable air motion or sound levels.

13. Vary total system air quantities by adjustment of fan speeds. Provide drive changes recommendations. Vary branch air quantities by damper regulation.
14. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for loading of filters and coils.
15. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions within specified tolerances.
16. Where modulating dampers or economizers are provided, take measurement at full return air, minimum outside air, and 100% outside air mode of operation.

C. Set system's airflow rates within the following tolerances:
1. Air Handling Systems: Adjust to within plus 10 percent of outlet total plus allowable leakage rate.
2. Air Outlets and Inlets: Adjust total to within plus or minus 10 percent of design for the space.
3. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.3 HYDRONIC SYSTEM PROCEDURES

A. Adhere to the follow procedure:

1. TABB – SMACNA TAB Procedural Guide, with particular focus on the following chapter: Hydronic System TAB Procedures.
2. AABC – National Standards for Total System Balance.
3. NEBB – Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

B. Hydronic balancing shall include the following minimum data:

1. Provide TAB for all hydronic systems and components.
2. Prepare itemized equipment schedules listing all heating and/or cooling elements and equipment in the systems to be balanced. List in order on equipment schedules, by pump or zone according to the design, all heating and/or cooling elements, all zone balancing valves, and circuit pumps, ending with the last items of equipment or transfer element in the respective zone or circuit. Include on schedule sheet column titles listing the location, type of element or apparatus, design conditions, and measured conditions. Prepare individual pump report sheets for each zone or circuit.
3. Adjust hydronic systems to provide plus or minus 10 percent of required design quantities.
4. Use calibrated Venturi tubes, orifices, metered fittings, pressure gages, and direct- reading instrumentation to determine flow rates for system balance. Where flow- metering devices are not installed, flow balance on temperature difference across various heat transfer elements in the system is acceptable.
5. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
6. Effect system balance with automatic control valves fully open to heat or cooling transfer elements.

7. Adjust hydronic distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
8. Test pumps and adjust flow. Record the following on pump report sheets:

    a. Suction and discharge pressure.
    b. Running amps and brake horsepower of pump motor under full flow and no flow conditions.
    c. Pressure-drop across pump in feet of water and total GPM pump is handling under full flow conditions.

9. Where available pump capacity is less than total flow requirements or individual system parts, proportional balancing must be performed.

C. Set system's water flow rates within the following tolerances:
1. Hydronic Systems: Adjust to within 10 percent of design flow.
2. Hydronic terminal devices: Adjust to within plus or minus 10 percent of design flow.

3.4 ADJUSTING

A. Recorded data shall represent actual measured or observed conditions.

B. Permanently mark the setting of valves, dampers, and other adjustment devices allowing for settings to be restored. Set and lock memory stops.

C. Final report to include identification of all key outlets, key branches, and key trunks in each air system that shows a critical path of no dampening from the fan to terminal device.

D. Final report to include identification of all key terminal devices, key branches, and key trunks in each hydronic system that shows a critical path of no throttling of valves from the pump to terminal device.

E. Leave systems in proper working order by replacing guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

END OF SECTION 230593

SECTION – 230700 – MECHANICAL INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division 23 Section "Common Work Results for Mechanical"

1.2 SUMMARY

A. This Section includes insulation and related components for Division 22 & Division 23.

1.3 ACTION SUBMITTALS

A. Product Data: Identify thermal conductivity, Greenguard Certification, thickness, and jackets (both factory and field applied, if any), for each type of product indicated. For adhesives and sealants, provide documentation including printed a statement of VOC content.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

C. Indoors: Materials shall have a flame spread index of less than 25 and a smoke developed index of less than 50 when tested in accordance with ASTM E 84, latest revision.

D. Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

E. Provide accessory materials as part of insulation work under his section shall include closure materials, adhesives, mastics, and support materials; shall be as recommended by insulation material manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

B. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.

C. Store tapes, adhesives, mastics, cements, and insulation materials in ambient conditions in accordance with the recommendations of the manufacturer.

D. Follow manufacturer's recommended handling practices.

E. The contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The contractor shall also use all means necessary to protect work and materials installed by other trades.

F. Fiber Glass and Mold: Contractor shall take precaution to protect insulation. Any fiber glass insulation that becomes wet or torn should be replaced at no additional cost. Air handling insulation used in the air stream must be discarded if exposed to water.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields. Coordinate clearance requirements with other trades for insulation application.

B. Schedule insulation application after testing systems. Insulation application may begin on segments of systems that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Certainteed
2. Knauf
3. Owens-Corning
4. John Mansville
5. Armstrong
6. Aeroflex USA
7. Nomaco K-Flex
8. Pabco.

2.2 PIPING INSULATION MATERIALS

A. Glass Fiber:

1. Knauf 1000° Pipe Insulation with ECOSE Technology meeting ASTM C547 Type IV Grade A, ASTM C585, and ASTM C795; rigid, molded, noncombustible per ASTM E136; k value: ASTM C335, 0.23 at 75°F mean temperature. Maximum Service Temperature: 1000°F, or Johns Manville's Micro-Lok® *HP* meeting ASTM C547, Type I, maximum service temperature of 850°F meeting the other requirements. Vapor Retarder Jacket: ASJ/SSL conforming to ASTM C1136 Type I, secured with self-sealing longitudinal laps and butt strips.
2. PVC Fitting Covers: The Proto Fitting Cover System or Johns Manville Zeston® polyvinyl chloride (PVC) parts shall consist of one piece and two piece pre-molded high impact UV-resistant PVC fitting covers with fiberglass inserts and accessories, which include elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings. Fittings shall be made of Zeston® or LoSMOKE® grade PVC, 25/50 rated per ASTM E-84. Thermal Value of fiberglass insert: K value of 0.26 at 75°F; resistance to fungi and bacteria. (ASTM G 21, ASTM G 22): does not promote growth of fungi or bacteria.

B. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
3. Materials shall have a maximum thermal conductivity of 0.27 Btu-in/h-ft2- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
4. Materials shall have a maximum water vapor transmission of 0.08 perm-inches when tested in accordance with ASTM E 96, Procedure-A, latest revision.
5. Provide Armaflex WB finish for outdoor exposed piping.

C. Field-Applied Jackets For Piping: ASTM C 921, Type 1, unless otherwise indicated.

1. PVC: Johns Manville's Zeston® PVC fittings, jacketing, and accessories or Proto Corporation 25/50 or Indoor/Outdoor, UV-resistant fittings, jacketing and accessories, white. The fitting cover system consists of pre-molded, high-impact PVC materials with fiber glass inserts. Fiber glass insert has a thermal conductivity (k value) of 0.26 at 75° F mean temperature. Closures: stainless steel tacks, matching PVC tape, or PVC adhesive per manufacturer's recommendations.
2. Metal jackets: provide with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.
3. Aluminum Jacket: Factory cut and rolled to required size. Comply with ASTM B 209, 3003 alloy, and H-14 temper. Finish and Thickness: Corrugated finish, 0.010 inch thick.

Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and Kraft paper. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

2.3 DUCTWORK INSULATION MATERIALS

A. Flexible Fiber Glass Blanket: Glass Mineral Wool Blanket Insulation: Glass Mineral Wool bonded with a bio-based thermosetting resin. Comply with ASTM C 553, Types I, II, and III, ASTM C 1136 Type II, and ASTM C 1290, Type III. UL/ULC Classified per UL 723 for FSK, FHC 25/50 per ASTM E 84 for PSK only.

1. Factory-applied jacket: ASJ: White, Kraft paper, fiberglass reinforced scrim with aluminum foil backing; complying with ASTM C 1136, Type I.
2. Basis-of-Design Product: Subject to compliance with requirements, provide Knauf Insulation; Atmosphere Duct Wrap.
3. Density: 1.5 PCF
4. R-Value: R6.0 minimum for 1-1/2” thick blanket (k=0.25).

B. Rigid Fiber Glass Board: Johns Manville’s 817 Series Spin-Glass® or Knauf Insulation Board with ECOSE Technology meeting ASTM C 612 Type IA and IB; rigid. Maximum Service Temperature: 450°. Density: Minimum 3.0 PCF; R4.2 per inch. Vapor Retarder Jacket: ASJ conforming to ASTM C1136 Type I, or FSK or PSK conforming to ASTM C1136 Type II in combination with protective jacket where necessary. R-Value: R6.0 minimum for 1-1/2” thick blanket (k=0.25).

C. Exterior Ductwork:

1. Insulation: Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70°F and 220°. Comply with ASTM C534, Type II for sheet materials.

    a. Thermal Resistance: R12 Minimum.
    b. Compressive Strength, ASTM D 1621: 16 psi or greater.
    c. Flexural Strength, ASTM C 203: 40 psi or greater.
    d. Water Absorption, ASTM C 209: 0.1 percent by volume.
    e. Water Vapor Permeance, ASTM E 96, 0.05 perms.

2. Insulation: Rigid foam insulating sheathing, complying with ASTM C 1289; closed cell polyisocyanurate, CFC- and HCFC-free.

    a. Thermal Resistance, ASTM C 518: R12 Minimum.
    b. Compressive Strength, ASTM D 1621: 16 psi or greater.
    c. Flexural Strength, ASTM C 203: 40 psi or greater.
    d. Water Absorption, ASTM C 209: 0.1 percent by volume.
    e. Water Vapor Permeance, ASTM E 96, 0.05 perms.

3. High-performance jacketing: VentureClad-1577, Polygard-Alumagard All-Weather, or approved equal; high performance jacketing product shall perform well over a wide temperature range; -30°F to +300°F service temperature.

    a. Zero permeability, absolute vapor barrier; High puncture and tear resistance
    b. Contain tested and approved mold inhibiting agents.
    c. A 5-ply self-adhesive material shall be installed easily with no off-site fabrication required. The cold weather acrylic adhesive shall apply easily at temperatures as cold as minus 10°F.
    d. Flame spread/smoke developed: 10/20 (UL 723)
    e. 6-mil thickness (PSTC-133); Provide in natural aluminum stucco embossed finish.

PART 3 - EXECUTION

3.1 GENERAL APPLICATION REQUIREMENTS

A. Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature. Insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification. Store tapes, adhesives, mastics, cements, and insulation materials in ambient conditions in accordance with the recommendations of the manufacturer. Follow manufacturer’s recommended handling practices. The contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The contractor shall also use all means necessary to protect work and materials installed by other trades. Contractor shall take precaution to protect insulation. Any fiber glass insulation that becomes wet or torn should be replaced at no additional cost. Air handling insulation used in the air stream must be discarded if exposed to water.

B. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application. Verify that systems to be insulated have been tested and are free of defects. Verify that surfaces to be insulated are clean and dry. Proceed with installation only after unsatisfactory conditions have been corrected. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin. Ensure that pipe and fitting surfaces over which insulation is to be installed are clean and dry. Ensure that insulation is clean, dry, and in good mechanical condition with factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation. Ensure that pressure testing of piping and fittings has been completed prior to installing insulation.

C. Installer Qualifications: Skilled mechanics shall have successfully completed an apprenticeship program or another craft training program.

D. Provide insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout, including the

length of ducts and fittings, valves, and specialties. Provide per "National Commercial & Industrial Insulation Standards" – MICA Manual.

E. Provide insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each system as specified in insulation system schedules.

F. Provide accessories compatible with insulation materials and suitable for the service.

G. Provide insulation with longitudinal seams at top and bottom of horizontal pipe runs and equipment. Provide multiple layers of insulation with longitudinal and end seams staggered.

H. There shall be no glass fibers exposed to the air. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

I. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

J. Jackets And Finishes: Draw jacket tight and smooth. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c. For below ambient services, apply vapor-barrier mastic over staples. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

K. Keep insulation materials dry during application and finishing.

L. Provide insulation over fittings, valves, and specialties, with continuous thermal and the least number of joints practical.

M. Provide removable insulation covers at fittings and equipment that require servicing and locations with service requirements.

N. Locate seams in the least visible location.

O. Cold surfaces that may “sweat” must be insulated. Vapor barrier must be maintained, insulation shall be applied with a continuous, unbroken moisture and vapor seal.

1. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
2. Hangers, supports, anchors, or other projections that are secured to cold surfaces shall be insulated and vapor sealed to prevent condensation.
3. Seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
4. Provide insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity.
5. Extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier

mastic. Provide insert materials and provide insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

P. For above-ambient services, do not install insulation to the following: testing agency labels and stamps, nameplates, and cleanouts.

Q. Insulation thicknesses and installations shall meet or exceed the requirements of the local energy code, or thicknesses indicated, whichever is of superior insulating performance. If piping type is omitted from list below, provide insulation per energy code or as per similar duty.

R. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

S. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

T. Insulate instrument connections for specialties (examples: thermometers, sensors, etc.) on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

U. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

V. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

W. Penetrations

1. Division 7 for firestopping materials and requirements for penetrations through fire and smoke barriers.
2. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Provide insulation continuously through walls and partitions.
3. Insulation Installation at Roof or Aboveground Exterior Wall Penetrations: Provide insulation continuously through penetrations.

    a. Seal penetrations with flashing sealant.
    b. For applications requiring only indoor insulation, terminate insulation above roof/wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, provide insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
    c. Extend jacket of outdoor insulation outside roof/wall flashing at least 2 inches below top of roof flashing.
    d. Seal jacket to roof/wall flashing with flashing sealant.

4. Insulation Installation at Fire-Rated Penetrations:

a. Fire Dampers: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
b. Pipe or duct penetrations (no fire damper): Provide insulation continuously through penetrations of fire-rated walls and partitions. Comply with requirements in Division 7 for firestopping and fire-resistive joint sealers.

3.2 INSTALLATION OF PIPING INSULATION

A. Metal shields shall be provided between hangers or supports and the piping insulation.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement and finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
2. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section close to the next and hold in place with tie wire. Bond pieces with adhesive.
3. Insulate using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement.
4. For below-ambient services, provide a design that maintains vapor barrier.
5. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Provide vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
6. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover.
7. For services not specified to receive a field-applied jacket except for flexible elastomeric, provide fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

C. Flexible Elastomeric Insulation

1. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Flanges: Provide pipe insulation to outer diameter of pipe flange. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation. Secure insulation to flanges and

seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3. Insulation Installation on Pipe Fittings and Elbows: Provide mitered sections of pipe insulation. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
4. Insulation Installation on Valves and Pipe Specialties: Provide preformed valve covers manufactured of the same material as pipe insulation when available. When preformed valve covers are not available, provide cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. Provide insulation to flanges as specified for flange insulation application. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
5. After the adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Prior to applying the finish, the insulation shall be wiped clean with denatured alcohol. The finish shall not be tinted. To insure good adhesion, the temperature should be above 50°F during application and drying.
6. Outdoor exposed piping shall be painted with two coats of Armaflex WB Finish. Prior to applying the Finish, the insulation shall be wiped clean with denatured alcohol. The Finish shall not be tinted. Outdoor exposed piping shall have seams located on the lower half of the pipe.

3.3 PIPE APPLICATION SCHEDULE

A. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements. For piping systems not indicated, insulate to with a similar thickness and type as those specified. Insulation thicknesses and installations shall meet or exceed the requirements of the local energy code, or thicknesses indicated, whichever is of superior insulating performance.

B. PVC jackets shall be provided with 1-inch overlap at longitudinal seams and end joints, for horizontal applications. Seal with manufacturers recommended adhesive. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge. Provide PVC jackets in the following locations:

1. For piping exposed in the tunnels.
2. Exposed vertical piping in finished spaces.

C. Heating hot water supply and return:

1. 141F to 200F HWS:

   a. Pipe size 1-1/4” and less: Glass Fiber; 1” thickness.
   b. Pipe size 1-1/2” and larger: Glass Fiber; 1-1/2” thickness.

2. Insulation is not required for exposed piping through floor for convectors and radiators.

3. Insulation is not required strainers, control valves, unions, and balancing valves associated with piping 1” or less diameter. Insulate piping to within approximately 3/4-inch of un-insulated items.

3.4 INSTALLATION OF DUCTWORK INSULATION

A. Flexible Fiberglass Blanket Insulation Installation:

1. Secure with adhesive and insulation pins. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces. Apply adhesive to entire circumference of ducts and to surfaces of fittings and transitions.
2. Firmly butt joints.
3. Provide either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts.
4. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
5. Provide insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Provide insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces. Apply adhesive to entire circumference of ducts and to surfaces of fittings and transitions.
2. Provide either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts.
3. Provide insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Provide insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
4. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

C. For ducts and plenums with surface temperatures below ambient, provide a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Provide vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal. Provide vapor stops for ductwork and plenums operating below

50°F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

D. Fire-rated insulation system installation: Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating. Insulate duct access panels and doors to achieve the same fire rating as duct.

3.5 DUCTWORK APPLICATION SCHEDULE

A. For duct systems not indicated, insulate to with a similar thickness and type as those specified. Insulation thicknesses and installations shall meet or exceed the requirements of the local energy code, or thicknesses indicated, whichever is of superior insulating performance.

B. Application schedules identify ductwork thickness, and jacket requirements. For duct systems not indicated, insulate to with a similar thickness and type as those specified. Insulation thicknesses and installations shall meet or exceed the requirements of the local energy code, or thicknesses indicated, whichever is of superior insulating performance.

C. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment: Flex connectors, metal ducts with duct liner, factory-insulated flexible ducts, factory-insulated plenums, casings, and access doors.

D. Supply Ducts:

1. Makeup air exposed to heated spaces (tunnels included: No insulation required.
2. Indirectly conditioned spaces (plenum returns, crawl spaces,): R1.9 minimum.

E. Exterior Supply Ducts: 2-1/2" Rigid Roof Insulation Board with high performance jacket; R12 minimum.

END OF SECTION 230700

SECTION 230900 – DIRECT DIGITAL CONTROL (DDC) SYSTEM

1.1 GENERAL

1.2 SUMMARY

A. There are no existing central building automation systems currently in place at either of the toll plaza facilities included in the scope of this project.

B. It shall be the intent of this contract that the contractor shall furnish and install a standalone control system as required for control of new HVAC systems installed under the scope of this project. For equipment such as the humidifiers, which incorporate factory installed controls, such equipment shall operate as a standalone system through its package controls as specified.

C. Application specific controllers shall include user interface pads for local monitoring and adjustment and shall be configured for future BAS integration via Bacnet communication protocol.

D. The Controls Contractor's work shall consist of the provision of all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, project-specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, warranty, specified services and items required by the Contract that are required for the functional turn-key operation of the complete and fully functional Controls Systems. Documents are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans, which are required to meet the functional intent, shall be provided without additional cost to the Owner.

E. Provide all labor, materials, equipment, and service necessary for a complete and operating building automation system.

F. Related Sections include the following:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
2. Division 23 Section "Common Work Results"
3. Division 23 Sections with controller interfaces shall be integrated with the work of this Section.
4. Division 23 Section "Testing, Adjusting, and Balancing"

1.3 SUBMITTALS

A. Product Data and Shop Drawings: Meet requirements of Division 1. In addition, the contractor shall provide shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have

been approved for conformity with design intent. Provide drawings in PDF format. When manufacturer's cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply enough to complete work. BAS manufacturer is responsible for furnishing quantities required based upon contract documents.

B. Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with the specifications or which is deemed valuable in documenting and understanding the system to be installed.

C. BAS manufacturer shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software being provided for this project. No work may begin on any segment of this project until the Engineer and Owner have reviewed submittals for conformity with the plan and specifications.

D. Quantities of items submitted shall be reviewed by the Engineer and Owner. Such review shall not relieve the BAS manufacturer of furnishing quantities required based upon contract documents.

E. Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with the specifications or which is deemed valuable in documenting and understanding the system to be installed.

F. All shop drawings shall be provided to the Owner electronically as .dwg or .dxf file formats once they have been approved and as-built drawings have been completed.

G. Submit the following:

1. A complete bill of materials of equipment to be used indicating quantities, manufacturers, and model numbers.
2. A schedule of all control valves including the valve size, pressure drop, model number (including pattern and connections), flow, CV, body pressure rating, and location.
3. A schedule of all control dampers including damper size, pressure drop, manufacturer, and model number.
4. Provide all manufacturers' technical cut sheets for major system components. When technical cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Include:

    a. Building Controllers
    b. Custom Application Controllers
    c. Application Specific Controllers
    d. Portable Operator Terminals
    e. Auxiliary Control Devices

5. Provide proposed BAS architectural diagram depicting various controller types, workstations, device locations, addresses, and communication cable requirements.
6. Provide detailed termination drawings showing all required field and factory terminations, as well as terminal tie-ins to DDC controls provided by mechanical equipment manufacturers. Terminal numbers shall be clearly labeled.
7. Provide a sequence of operation for each controlled mechanical system and terminal end devices.
8. Provide a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet system level device (i.e. Building Controller & Operator Workstations) type. This defines the points list for proper coordination of interoperability with other building systems for this project.

H. Project Record Documents: Upon completion of installation, record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:

I. Project Record Drawings - These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .dwg and .pdf drawing files shall be provided.

1. Testing and Commissioning Reports and Checklists signed off by trained factory (equipment manufacturers) and field (BAS) commissioning personnel.
2. Operating and Maintenance (O & M) Manuals - These shall be as-built versions of the submittal product data. In addition to the information required for the submittals, Operating & Maintenance manual shall include:

    a. Procedures for operating the BAS including logging on/off, alarm management, generation of reports, trends, overrides of computer control, modification of setpoints, and other interactive system requirements.
    b. Explanation of how to design and install new points, new DDC controllers, and other BAS hardware.
    c. Documentation, installation, and maintenance information for all third-party hardware/software products provided including personal computers, printers, hubs, sensors, valves, etc.
    d. Original issue media for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
    e. Licenses, Guarantee, and Warranty documents for all equipment and systems.

J. Training Manuals: The BAS manufacturer shall provide a course outline and copies of training manuals at least two weeks prior to the start of any corporate training class to be attended by the Owner.

1.4 QUALITY ASSURANCE

A. All products used in this project installation shall be new and currently under manufacture and shall have been applied in similar installations for a minimum of two years. This installation shall not be used as a test site for any new products unless explicitly approved by the owner's representative in writing. Spare parts shall be available for at least five years after completion of this contract.

B. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the temperature control system manufacturer. Use only employees who are qualified, skilled, experienced, manufacturer trained and familiar with the specific equipment, software and configurations to be provided for this Project.

1. Installer shall have an established working relationship with Control System Manufacturer.
2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

C. Provide a complete, neat and workmanlike installation.

D. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Comply with NFPA 90A and IMC-2021.

G. Comply with ASHRAE 135 for DDC system control components.

H. The contractor shall protect all work and material from damage by his/her work or employees. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

I. Codes and Standards: Meet requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.

1. Underwriters Laboratories: Products shall be UL-916-PAZX listed.
2. National Electrical Code -- NFPA 70.
3. Federal Communications Commission -- Part J.
4. ASHRAE/ANSI 135-2012 (BACnet) - Controllers shall conform to the listed version of the BACnet specification to improve interoperability with various building system manufacturers' control systems and devices.

J. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.

3. BACnet MS/TP: MS/TP bus protocol is part of the BACnet ANSI/ASHRAE™ Standard 135-2008 that uses the EIA-485 (RS-485) physical layer standard for data transmission (called the segment). Multiple segments can be logically tied together.
4. BACnet-IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
5. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.

1.5 CONTRACTOR QUALIFICATIONS

A. Qualified Bidders: System shall be as manufactured, installed, and serviced by:

1. XL Automation
2. Maine Controls - Schneider Electric
3. Trident - Automated Logic
4. Trane

B. The BAS Manufacturer shall have factory trained and certified personnel providing all engineering, service, startup, and commissioning field labor for the project from their local office location. BAS manufacturer shall be able to provide training certifications for all local office personnel upon request.

C. The BAS shall be provided by a single manufacturer and this manufacturer's equipment must consist of operator workstation software, web-based hardware/software, open standard protocol hardware/software, custom application programming language, graphical programming language, building controllers, custom application controllers, and application specific controllers. All other products specified herein (i.e., sensors, valves, dampers, actuators, etc.) need not be manufactured by the BAS manufacturer listed in this specification.

D. Longevity: The Facilities Management System contractor shall have a minimum of ten years' experience installing and servicing computerized Building Automation Systems (BAS). All subcontractors utilized by the BAS contractor shall have a minimum of five-year experience within their appropriate trades.

E. Past Projects: The BAS contractor shall have completed a minimum of ten projects within the last five years that are at least equal in dollar value and scope to this project. A list of similar projects, dollar volume, scope, contact name and contact number shall be provided by the BAS contractor if asked for by the owner.

F. The BAS manufacturer shall have an established business office within 50 miles of the project site and must provide 24 hours/day, 7 days/week response in the event of a customer warranty or service call.

G. The BAS contractor shall have an established 24-hour emergency service organization. A dedicated telephone number shall be provided to the owner for requesting emergency service. A maximum of four-hour, electronic service technician on sight, response time shall be guaranteed by the BAS contractor.

H. Parts Stocking: The BAS contractor shall have an independently verifiable inventory of electronic service parts. This electronic service parts inventory must have a worth of at least $100,000 per year over the last five years.

1.6 COORDINATION

A. Where the mechanical work will be installed near, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition.

B. Coordinate details of telephone line, internet service provider, and associated requirements.

C. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

D. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the controls system specified in this section. These controls shall be integrated into the system and coordinated by the contractor.

F. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

G. Sheet Metal Subcontractor:

1. Installation of duct-mounted control devices.
2. Access doors where indicated and as required for proper servicing.

H. HVAC Contractor:

1. Installation of immersion wells and sockets, along with associated shut-off cocks.
2. Installation of pipe-mounted control devices.

I. Testing and Balancing Contractor:

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
2. The contractor shall provide training in the use of these tools.
3. In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
4. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

J. Electrical Subcontractor: Complying with the principle of "unit responsibility" all electrical work for automatic controls, except as otherwise specified, or shown on the electrical drawings shall be included in Division 23. Electrical work shall, in general, comply with the following, unless otherwise directed by Division 26:

1. Power wiring.
2. All control wiring shown on electric plans such as unit heater line-voltage room thermostats.
3. Duct smoke detectors required for air handler shutdown are supplied under Division 26. Coordinate required length of sampling tube, for full span of ductwork. The contractor shall connect the DDC system to the auxiliary contacts provided on the smoke detector for system safeties and to provide alarms to the DDC system.
4. All electrical work shall comply with the N.E.C. and local electrical codes.
5. All safety devices shall be wired through both hand and auto positions of motor starting device to insure 100% safety shut-off.
6. Provide auxiliary contacts as required for interlock by BAS Contractor; the supplier shall estimate an allowance of at least one auxiliary contract per starter.

K. Coordinate with controls specified in other sections of divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the BAS contractor as follows:

1. All communication media and equipment shall be provided as specified hereinafter.
2. Each supplier of a control product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
3. The BAS contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
4. The BAS contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.8 WARRANTY

A. Refer to Division 1 Requirements.

B. At the end of the final start-up, testing, and commissioning phase, if equipment and systems are operating satisfactorily to the engineer, the engineer shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of acceptance shall be the start of warranty. All work shall have a single warranty date, even when the owner has received beneficial use due to an early system start-up.

C. All components, system software, and parts supplied by the BAS contractor shall be guaranteed against defects in materials and workmanship for one year from acceptance date. The BAS contractor at no charge shall furnish Labor to repair, reprogram, or replace components during the warranty period. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the owner's request for warranty service within 24 hours during normal business hours.

D. Provide remote service diagnostic monitoring from the nearest service location. At the request of the owner, a service diagnostic call will be made to troubleshoot and resolve (if possible) any reported system complaints. The owner will provide a dedicated telephone line for connection to the system.

E. Operator workstation software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies as identified by the contractor shall be provided at no charge during the warranty period. Any upgrades or functional enhancements associated with the above-mentioned items also can be provided during the warranty period for an additional charge to the owner by purchasing an in-warranty service agreement from the contractor. Written authorization by the owner must, however, be granted prior to the installation of any of the above-mentioned items.

1.9 SYSTEM MAINTENANCE AND REMOTE ANALYSIS

A. The BAS Manufacturer shall provide BAS remote support and system analysis for a period of two (2) years, beginning at the date of substantial completion.

B. The BAS manufacturer shall setup a secure remote connection for data collection, analytics and remote technical support for the HVAC systems included in this contract.

1. Provide technician support during the warranty period to diagnose issues remotely through the secure remote connection.
2. The building owner is responsible for providing adequate internet access.

C. Connectivity / Remote Access / Network Security

1. Provide and maintain secure remote access to the facilities BAS or other building systems. Users accessing service through this connection shall not have access to the building

owners' network. Secure remote access to the BAS shall not require ANY inbound ports on a firewall to be "exposed" or "forwarded".

2. Secure remote access to the BAS shall be available anywhere, anytime, using a compatible client device (PC/tablet/phone)
3. The Owner will provide up to Three (3) IP drops and IP addresses on the owner's network to gain access to the internet. The BAS manufacturer shall coordinate with the Owners IT team, verify the proposed system shall meet all network security requirements and any other network configuration information necessary to each control contractor for the purpose of configuring each Area Controller on the network. It shall be the responsibility of the BAS manufacturer to coordinate with the owner for network connectivity.

D. The BAS Manufacturer shall provide a professional analysis for the facility HVAC systems. The analysis shall consist of an evaluation of HVAC systems including charts and graphs which indicate both current building performance and opportunities for building and HVAC system performance improvement.

E. The following shall be provided after substantial completion of the project:

1. Orientation meeting with the building owner's representative to identify the HVAC systems that will be evaluated.
2. System setup for data collection and analytics. BAS Manufacturer to setup a secure remote data collection and analytics for identified systems.
3. Assessment analysis shall be performed by trained personnel with relevant professional credentials in HVAC systems, energy management, and building optimization methodologies.
4. Consultation meeting with owner to review performance reports and improvement opportunities.

F. Do not assign or transfer maintenance service to agent or subcontractor without prior written consent of owner.

1.10 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project specific software and documentation shall become the owner's property upon project completion. This includes the following:

1. Operator Graphic files
2. As-built hardware design drawings
3. Operating & Maintenance Manuals
4. BAS System software database

PART 2 - PRODUCTS

2.1 BUILDING AUTOMATION SYSTEM

A. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules.

B. Provide new wiring and network devices as required to provide a complete and workable control network.

C. DDC system shall be Web based or Web compatible.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated. System Performance Objectives:

1. DDC system shall manage HVAC systems.
2. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
3. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
4. DDC system shall operate while unattended by an operator and through operator interaction.
5. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. DDC System Data Storage:

1. Include server(s) with disk drive data storage to archive not less than 36 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
2. When logged onto a server, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
3. Server(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
4. Server(s) shall use IT industry-standard database platforms such as Microsoft SQL Server and Microsoft Data Engine (MSDE).

C. Performance Standards. System shall conform to the following minimum standards over network connections.

D. Environmental Conditions for Controllers, Gateways, Routers, Instruments and Actuators: Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application. Products shall be protected with NEMA enclosures suitable for the location where installed.

E. Continuity of Operation after Electric Power Interruption: Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.

B. Provide new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

E. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.

F. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in Section 230993. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

G. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.4 DDC EQUIPMENT

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.
d. Software applications, scheduling, and alarm processing.
e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, anti-short-cycling, PID control, DDC with fine tuning, and trend logging.
b. HVAC Control Programs
c. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
d. Remote communications.
e. Maintenance management.

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include given communications; discrete/digital, analog, and pulse I/O; and monitoring, controlling, or addressing data points.
3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA).
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.5 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics, monitor system and report failures.
3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using

MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

4. Enclosure: Dustproof rated for operation at extreme ambient temperatures.

2.6 SENSING DEVICES

A. Where feasible, provide the same sensor type throughout the project. Avoid using transmitters unless necessary.

B. Thermistors: Precision thermistors may be used in applications below 200°F. Sensor accuracy over the application range shall be 0.36°F or less between 32 to 150°F. Stability error of the thermistor over five years shall not exceed 0.25°F cumulative. A/D conversion resolution error shall be kept to 0.1°F. Total error for a thermistor circuit shall not exceed 0.5 °F.

C. Resistance Temperature Detectors (RTDs): Provide RTD sensors with platinum elements compatible with the digital controllers. Encapsulate sensors in epoxy, series 300 stainless steel, anodized aluminum, or copper. Temperature sensor accuracy shall be 0.1 percent (1 ohm) of expected ohms (1000 ohms) at 32°F. Temperature sensor stability error over five years shall not exceed 0.25°F cumulative. Direct connection of RTDs to digital controllers without transmitters is preferred. When RTDs are connected directly, lead resistance error shall be less than 0.25°F. The total error for a RTD circuit shall not exceed 0.5°F.

D. Per ASHRAE 90.1-2016: Outdoor air, return air, mixed air, and supply air sensors shall be calibrated within the following accuracies:

1. Dry-bulb and wet-bulb temperatures shall be accurate to ±2°F over the range of 40°F to 80°F.
2. Enthalpy and the value of a differential enthalpy sensor shall be accurate to ±3 Btu/lb. over the range of 20 to 36 Btu/lb.
3. Relative humidity shall be accurate to ±5% over the range of 20% to 80% RH.

E. Temperature Sensor Details

1. Room Type: Provide the sensing element components within a decorative protective cover suitable for surrounding decor.

    a. Provide room temperature sensors with:

        1) Timed override button
        2) Setpoint adjustment lever or knob.
        3) Override switch.
        4) Digital temperature display.
        5) Insulating Bases: For temperature sensors/thermostats located on exterior walls.

2. Duct Probe Type: Ensure the probe is long enough to properly sense the air stream temperature.

3. Duct Averaging Type: Continuous averaging sensors shall be one foot in length for each 4 square feet of duct cross-sectional area, and a minimum length of 6 ft.
4. Pipe Immersion Type: Provide minimum three-inch immersion. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel when used in steel piping, and brass when used in copper piping. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior.
5. Outside Air Type: Provide the sensing element on the building's north side with a protective weather shade that positions the sensor approximately 3 inches off the wall surface, does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain.

F. Transmitters: Provide transmitters with 4 to 20 mA or 0 to 10 VDC linear output scaled to the sensed input. Transmitters shall be matched to the respective sensor, factory calibrated and sealed. Size transmitters for an output near 50 percent of its full-scale range at normal operating conditions. The total transmitter error shall not exceed 0.1 percent at any point across the measured span. Supply voltage shall be 12 to 24 volts AC or DC. Transmitters shall have non-interactive offset and span adjustments. For temperature sensing, transmitter drift shall not exceed 0.03 °F a year.

G. Relative Humidity Transmitters: Provide transmitters with an accuracy equal to plus or minus 3 percent from 0 to 90% scale, and less than one percent drift per year. Sensing elements shall be the polymer type. Vaisala Model HMD50U or equal.

H. Current Transducers: Provide current transducers to monitor motor amperage, unless current switches are shown on design drawings or point tables.

I. Pressure Transmitters/Transducers:

1. Manufacturers:

   a. BEC Controls Corporation.
   b. General Eastern Instruments.
   c. MAMAC Systems, Inc.
   d. ROTRONIC Instrument Corp.
   e. TCS/Basys Controls.
   f. Vaisala.
   g. Kele

2. Duct Differential Pressure Transmitters: Kele M30/40 and T30/40 Series, or approved equal; reliable, stable, low-air pressure transmitters with 4-20 mA outputs.
3. Duct pressure high-limit: Kele Model 1900-5-MR manual reset pressure switch is designed to monitor duct static and shut down the blower when excess pressure occurs. The switch must be manually reset before the system can start again. Switch contacts are SPDT with solder-type connections. The Model 1900-5-MR measures static pressure only, not differential pressure.
4. Air Differential Pressure Switches, Kele 1900 Series, are designed to monitor the differential pressure of air in HVAC applications. These automatic reset switches are available in ranges from 0.07" to 20" W.C. and shall have SPDT screw-type electrical connections.

5. Filter pressure drop: Kele Model A-602 air filter kit includes two static pressure tips and aluminum tubing and fittings, and it allows the Kele 1900 Series to monitor filter pressure drop.
6. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated. Accuracy: 2 percent of full scale with repeatability of 0.5 percent. Output: 4 to 20 mA. Building Static-Pressure Range: 0- to 0.25-inch wg. Duct Static-Pressure Range: 0- to 5-inch wg.
7. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
8. Hydronic Differential Pressure Transmitters: Bell & Gossett ST Series; Setra or approved equal. Transmitter shall provide an isolated linear 4-20 mA dc output. The unit shall be accurate to ± 0.07% of full span and shall withstand over ranges up to a static pressure of 2300 psi with negligible change in output. It shall have stainless steel wetted parts with 1/4" NPT process connection. Unit shall be protected against radio frequency interference and shall have a watertight (NEMA Type 6/6P) electrical enclosure with ½" NPT conduit connection.

2.7 GAS DETECTION

A. CO Detector: Kele Model KCO-A; sensor provided in heavy-duty steel enclosures, and the sensors use low-temperature components that are ideal for open parking garages in cold climates. The sensor shall be a microprocessor-controlled sensor with a 4-20 mA analog output based on a 0-200 ppm sensing range. The microprocessor controls the heating of the sensor and subsequent reading of the CO level. The microprocessor shall compensate for any drift in the sensor over time. The microprocessor system shall include self-diagnostic, self-restarting, and remote failure reporting. The output signal will drop below 4 mA if a fault is discovered. If power problems cause the unit to malfunction, the unit will self-check and restart. Calibration of the unit requires the application of a hydrated test gas, and the push of a button performs the recalibration.

1. Microprocessor-controlled recalibration
2. Heavy-duty enclosures
3. Operating temperature down to -20°F (-29°C)
4. Temperature and humidity compensated.
5. Accuracy ±5%; Sensor drift ±10% 2 years; Sensor life 10 years

2.8 OUTPUT HARDWARE

A. Motorized control dampers, unless otherwise specified elsewhere, shall be as follows:

1. Submittals shall include leakage, maximum airflow and maximum pressure ratings based on AMCA Publication 500. Dampers shall meet the leakage requirements of the International Energy Conservation Code by leaking less than 3 cfm/sq. ft. at 1" of static pressure and shall be AMCA licensed as Class 1A. Dampers shall be Ruskin model CD60 or approved equal.
2. Control dampers shall be the parallel or opposed blade type as follows: Outdoor and/or return air mixing dampers shall be parallel blade, arranged to direct airstreams toward each

other. Other modulating dampers shall be the opposed blade type. Two-position shutoff dampers may be parallel or opposed blade type with blade and side seals.

3. Frame: 5" x minimum 16 gage roll formed, galvanized steel hat-shaped channel, reinforced at corners. Structurally equivalent to 13-gage U-channel. Damper blades shall not exceed 8" in width or 48" in length. Blades shall be suitable for medium velocity performance 2000 fpm. Blades shall be not less than 16-gauge.
4. Bearings shall be corrosion resistant, permanently lubricated stainless steel sleeve type turning in an extruded hole in the damper frame.
5. All blade edges, top, and bottom of the frame shall be provided with replaceable butyl rubber or neoprene seals. Side seals shall be spring-loaded stainless steel.
6. Individual damper sections shall not be larger than 48" x 60". Provide a minimum of one damper actuator per section.
7. Modulating dampers shall provide a linear flow characteristic where possible.
8. Dampers shall have exposed linkages. Dampers over 48" in applications where sectioning is not applicable shall be supplied with a jackshaft to provide sufficient force throughout the intended operating range.

B. Electronic damper/valve actuation shall be provided.

1. Manufactured, brand labeled or distributed by Belimo or approved equal.
2. Size for torque required for damper seal at load conditions.
3. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
4. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
5. Overload protected electronically throughout rotation.
6. Fail-Safe Operation: Mechanical, spring-return mechanism.
7. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 in.-lb. torque capacity shall have a manual crank.
8. Proportional Actuators shall be fully programmable through an EEPROM without the use of actuator mounted switches.
9. Proportional actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
10. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable. All actuators shall provide a 2 to 10 VDC position feedback signal.
11. Temperature Rating: -22 to +122ºF.
12. Housing: Minimum requirement NEMA type 2 mounted in any orientation.
13. Agency Listings: ISO 9001, cULus, CE or CSA
14. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.

C. Control Valves: Control valves shall be two-way or three-way type for two-position or modulating service as shown.

1. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

a. Two-way: 150% of total system (pump) head.
b. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

2. Water Valves: Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

a. Sizing Criteria:

1) Two-position service: Line size.
2) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
3) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load); 5 psi maximum.

b. Application:

1) VAV-reheat coils: two-way floating control, non-spring return.
2) CUH and Convectors: two-way two position, spring open 100%.
3) AHU main heating coils: two-way modulating control, spring open 100%.
4) Fintube radiation: zone valves. Zone valves shall have brass bodies with female NPT or sweat ends and a stainless-steel stem. Normally open zone valve actuators shall on/off and shall be available in 24VAC or 120VAC. Zone valves shall have push button for quick removal of actuator. Zone valves shall have a leakage rate of 0.1% or lower.

c. Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless-steel ball.
d. Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
e. Water valves shall fail normally open or closed, as specified.

D. Output Switches: Control Relays; Field installed and DDC panel relays shall be double pole, double throw, UL864 listed, with contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light shall be lit when the coil is energized and off when coil is not energized. Relays shall be the socket type, plug into a fixed base, and replaceable without tools or removing wiring. Encapsulated "PAM" type relays may be used for terminal control applications.

2.9 STATUS SENSORS

A. VFD Motor Current Switches: Veris Hawkeye H614, or equal; microprocessor based, self-learning, self-calibrating current-sensitive switching device designed for use with VFD systems. At initial power-up, the H614 automatically learns the average current on the line with no action required by the installer. Once a current is learned, the switch monitors for changes in current

greater than +/-20% of the learned load. When calibrated for a given VFD system, the H614 is tolerant of gradual drifts in frequency due to expected conditions, such as an accumulation of debris in a filter, while still detecting a sudden drop due to a potential abnormal system condition (e.g., belt loss or other mechanical failure).

1. Microcontroller based learning technology - automatically learns load upon initial power-up minimizes calibration labor.
2. Automatic trip point - automatic trip point (1.5 to 150 A, 12 to 115 Hz) detects abnormal events.
3. Under and over-load - microcontroller based learning technology automatically learns load.
4. Saves space - small size fits easily inside small starter enclosures.
5. 100% solid-state no. moving parts to fail.
6. LED status
7. Induced from monitored conductor sensor power.

B. ECM Motor Current Switch: Veris H6ECM, or equal: current-sensitive switching device that monitors current (amperage) in the conductor passing through it. A change in amperage in the monitored conductor that crosses the switch (setpoint) causes the resistance of the FET status output to change state, like the action of a mechanical switch. The status output is suitable for connection to building controllers or other appropriate data acquisition equipment operating at up to 30 V. The product requires no external power supply to generate its output. The ECM is a brushless DC motor that is supplied AC power, converts that power to DC current and uses electronic switching to control the motor rotation. The ECM motor shaft speed can be reduced to save energy, resulting in lower cost and less component wear. The H6ECM is optimized to provide meaningful proof of rotation which verifies that the ECM motor is operating as expected.

1. High performance device, split-core housing.
2. Precise current trip point setting.
3. Small size - fits easily inside small enclosures.
4. Self-gripping iris for easy installation.
5. Status LEDs - for easy setup and local indication.
6. Up to 1 A status output - increased application flexibility.
7. Induced from monitored conductor sensor power.

C. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

D. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.10 ELECTRICAL POWER AND DISTRIBUTION

A. Transformers: Transformers shall conform to UL 506. For control power other than terminal level equipment, provide a fuse or circuit breaker on the secondary side of each transformer.

B. Surge and Transient Protection

1. Provide each digital controller with surge and transient power protection. Surge and transient protection shall consist of the following devices, installed externally to the controllers.
2. Power Line Surge Protection: Provide surge suppressors on the incoming power at each controller or grouped terminal controllers. Surge suppressors shall be rated in accordance with UL 1449, have a fault indicating light, and conform to the following:

    a. The device shall be a transient voltage surge suppressor, hard-wire type individual equipment protector for 120 VAC/1 phase/2 wire plus ground.
    b. The device shall react within 5 nanoseconds and automatically reset.
    c. The voltage protection threshold, line to neutral, shall be no more than 211 volts.
    d. The device shall have an independent secondary stage equal to or greater than the primary stage joule rating.
    e. The primary suppression system components shall be pure silicon avalanche diodes.
    f. The secondary suppression system components shall be silicon avalanche diodes or metal oxide varistors.
    g. The device shall have an indication light to indicate the protection components are functioning.
    h. All system functions of the transient suppression system shall be individually fused and not short circuit the AC power line at any time.
    i. The device shall have an EMI/RFI noise filter with a minimum attenuation of 13 dB at 10 kHz to 300 MHz
    j. The device shall comply with IEEE C62.41.1 and IEEE C62.41.2, Class "B" requirements and be tested according to IEEE C62.45.
    k. The device shall be capable of operating between -20 °F and 122 °F.

3. Telephone and Communication Line Surge Protection: Provide surge and transient protection for DDC controllers and DDC network related devices connected to phone and network communication lines. The device shall provide continuous, non-interrupting protection, and shall automatically reset after safely eliminating transient surges. The protection shall react within 5 nanoseconds using only solid-state silicon avalanche technology. The device shall be installed at the distance recommended by its manufacturer.
4. Controller Input/Output Protection: Provide controller inputs and outputs with surge protection via optical isolation, metal oxide varistors (MOV), or silicon avalanche devices. Fuses are not permitted for surge protection.

C. Wiring: Provide complete electrical wiring for the DDC System, coordinate line of demarcation with Division 26. Unless indicated otherwise, provide all normally visible or otherwise exposed wiring in conduit. Where conduit is required, control circuit wiring shall not run in the same conduit as power wiring over 100 volts. Circuits operating at more than 100 volts shall be in accordance with Division 26. Run all circuits over 100 volts in conduit, metallic tubing, covered metal raceways, or armored cable. Use plenum-rated cable for circuits under 100 volts in enclosed spaces. Examples of these spaces include HVAC plenums, within walls, attics, or above suspended ceilings.

D. Power Wiring: The following requirements are for field-installed wiring:

1. Wiring for 24 V circuits shall be insulated copper 18 AWG minimum and rated for 300 VAC service.
2. Wiring for 120 V circuits shall be insulated copper 14 AWG minimum and rated for 600 VAC service.

E. Analog Signal Wiring: Field-installed analog signal wiring shall be 18 AWG single or multiple twisted pair. Each cable shall be 100 percent shielded and have a 20 AWG drain wire. Each wire shall have insulation rated for 300 VAC service. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started. Verify that duct-, pipe-, and equipment-mounted devices and wiring are installed before proceeding with installation.

C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be provided at the expense of this contractor.

3.2 INSTALLATION

A. Provide software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation. Connect and configure equipment and software to achieve sequence of operation specified.

B. Provide all components in accordance with the manufacturer's recommendations. Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems.

C. Provide equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

D. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices. Contractor shall continually monitor the field installation for code compliance and quality of workmanship. Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.

F. Temperature Sensors: Provide temperature sensors in locations that are accessible and provide a good representation of sensed media. Installations in dead spaces are not acceptable. Calibrate sensors according to manufacturer's instructions. Do not use sensors designed for one application in a different application.

G. Room Temperature Sensors: Verify location of thermostats and other exposed control sensors with plans and room details before installation. Mount the sensors on interior walls to sense the average room temperature at the locations indicated. Avoid locations near heat sources such as copy machines or locations by supply air outlet drafts. Mount the center of the sensor 48” above the floor to meet ADA requirements.

H. Duct Temperature Sensors

1. Probe Type: Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration airtight. Seal the duct insulation penetration vapor tight.
2. Averaging Type (and coil freeze protection thermostats): Weave the capillary tube sensing element in a serpentine fashion perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports. Prevent contact between the capillary and the duct or air handler internals. Provide a duct access door at the sensor location. The access door shall be hinged on the side, factory insulated, have cam type locks, and be as large as the duct will permit; maximum 18” x 18”. For sensors inside air handlers, the sensors shall be fully accessible through the air handler's access doors without removing any of the air handler's internals.

I. Outside Air Temperature Sensors: Provide outside air temperature sensors in weatherproof enclosures on the north side of the building, away from exhaust hoods and other areas that may affect the reading. Provide a shield to shade the sensor from direct sunlight.

J. Gas Monitor/Transmitters: Verify location of transmitter with room layout and details before installation. Do not exceed the manufactures’ recommended maximum surveillance radius. Provide proper quantity as required. Mounting height shall be at manufacturer recommended height for the gas being sensed.

K. Meters: Locate meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous and accumulated energy usage.

L. Provide automatic dampers according to Section 233113 "Ductwork."

M. Provide damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

N. Provide labels and nameplates to identify control components according to Section 230500 "Common Work Results".

O. Provide hydronic instrument wells, valves, and other accessories according to Section 232113 “Hydronic HVAC Piping". Provide thermowells for sensors measuring piping, tank, or pressure vessel temperatures. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells shall not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide thermal conductivity material within the well to fully coat the inserted sensor.

P. Provide duct volume-control dampers according to Section 233113 "Ductwork"

3.3 WIRING

A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification. Where the requirements of this section differ from Division 26, the requirements of Division 26 shall take precedence.

B. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements. Low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current limit.

C. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used if cables are UL listed for the intended application.

D. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

E. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 10 ft intervals.

F. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

G. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

H. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

I. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

J. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

K. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

L. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer’s recommendations and NEC requirements, except as noted elsewhere.

M. Include one pull string in each raceway in 1-inch or larger.

N. Use color-coded conductors throughout with conductors of different colors.

O. Control and status relays shall be in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

P. Conceal all raceways except within mechanical, electrical, or service rooms.

Q. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

R. Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.

S. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.

T. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

U. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3-feet in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

V. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes. Ends not terminating in boxes shall have bushings installed.

3.4 COMMUNICATION WIRING

A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

B. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

C. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

D. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each cable.

E. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to manufacturer’s instructions.

F. All runs of communication wiring shall be unspliced length when that length is commercially available.

G. All communication wiring shall be labeled to indicate origination and destination data.

H. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

I. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135.

J. Fiber Optic Cable: Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

B. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check flow instruments. Inspect tag number and line and bore size and verify that inlet side is identified and that meters are installed correctly.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.6 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Outdoor Air Dampers. Prior to occupancy, each ventilation system shall be tested to demonstrate that outdoor air dampers operate in accordance with the system design.
11. Provide diagnostic and test instruments for calibration and adjustment of system.
12. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Section 017900 "Demonstration and Training."

B. Provide a qualified instructor (or instructors) with five years minimum field experience with the installation and programming of similar BACnet DDC systems. Orient training to the specific systems installed. Coordinate training times with the Owner. Training shall take place at the job site.

C. This training shall last a minimum of four (4) hours and shall be conducted at the DDC system workstation, at a notebook computer connected to the DDC system in the field, and at other site locations as necessary. Upon completion of the Training, each trainee should fully understand the project's DDC system operation. The training session shall include the following:

D. Provide basic control system fundamentals training.

1. This project's list of control system components
2. This project's list of points and objects
3. This project's device and network communication architecture
4. This project's sequences of control, and:
5. Alarm capabilities
6. Trending capabilities
7. Troubleshooting communication errors
8. Troubleshooting hardware errors

E. Provide additional project-specific training:

1. A walk-through tour of the mechanical system and the installed DDC components (controllers, valves, dampers, surge protection, switches, thermostats, sensors, etc.)
2. A discussion of the components and functions at each DDC panel
3. Logging-in and navigating at each operator interface type.
4. Using each operator interface to find, read, and write to specific controllers and objects.
5. Modifying and downloading control program changes
6. Modifying setpoints
7. Creating, editing, and viewing trends
8. Creating, editing, and viewing alarms
9. Creating, editing, and viewing operating schedules and schedule objects
10. Backing-up and restoring programming and data bases
11. Modifying graphic text, backgrounds, dynamic data displays, and links to other graphics
12. Creating new graphics and adding new dynamic data displays and links.
13. Alarm and Event management
14. Adding and removing network devices

3.8 TEST AND BALANCE SUPPORT

A. The controls contractor shall coordinate with and provide on-site support to the test and balance (TAB) personnel This support shall include:

1. On-site operation and manipulation of control systems during the testing and balancing.
2. Control setpoint adjustments for balancing all relevant mechanical systems.
3. Tuning control loops with setpoints and adjustments determined by TAB personnel.

3.9 CONTROLS SYSTEM OPERATOR'S MANUALS

A. Provide three electronic and printed copies of a Controls System Operators Manual. The manual shall be specific to the project, written to actual project conditions, and provide a complete and concise depiction of the installed work. Provide information in detail to clearly explain all operation requirements for the control system.

B. Provide with each manual: CDs of the project's control system drawings, control programs, data bases, graphics, and all items listed below. Include gateway back-up data and configuration tools where applicable.

C. Provide printed manuals in sturdy 3-ring binders with a title sheet on the outside of each binder indicating the project title, project location, contract number, and the controls contractor name, address, and telephone number. Each binder shall include a table of contents and tabbed dividers, with all material neatly organized. Manuals shall include the following:

1. A copy of the as-built control system (shop) drawings set, with all items specified under the paragraph "Submittals." Indicate all field changes and modifications.
2. A copy of the project's mechanical design drawings, including any official modifications and revisions.
3. A copy of the project's approved Product Data submittals provided under the paragraph "Submittals."
4. A copy of the project's approved Performance Verification Testing Plan and Report.
5. A copy of the project's approved final TAB Report.
6. Printouts of all control system programs, including controller setup pages if used. Include plain-English narratives of application programs, flowcharts, and source code.
7. Printouts of all physical input and output object properties, including tuning values, alarm limits, calibration factors, and set points.
8. A table entitled "AC Power Table" listing the electrical power source for each controller. Include the building electrical panel number, panel location, and circuit breaker number.
9. The DDC manufacturer's hardware and software manuals in both print and CD format with printed project-specific labels. Include installation and technical manuals for all controller hardware, operator manuals for all controllers, programming manuals for all controllers, operator manuals for all workstation software, installation and technical manuals for the workstation and notebook, and programming manuals for the workstation and notebook software.
10. A list of qualified control system service organizations for the work provided under this contract. Include their addresses and telephone numbers.
11. A written statement entitled "Software Upgrades" stating software and firmware patches and updates will be provided upon request at no additional cost to the Owner for a minimum of two years from contract acceptance. Include a table of all DDC system software and firmware provided under this contract, listing the original release dates, version numbers, part numbers, and serial numbers.

3.10 CLEANING

A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be required to match the

adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

END OF SECTION 230900

SECTION 230993 - SEQUENCE OF OPERATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division 23 Section - Common Work Results
2. Division 23 Section – Direct Digital Control (DDC) System
3. Other Sections – Equipment with built in DDC controllers.
4. Division 23 Section - Testing, Adjusting, and Balancing

1.2 GENERAL

A. Control sequences are intended to be performance based. Implementations that provide the same functional result using different underlying detailed logic will be acceptable. As noted, control sequences shall be in accordance with ASHRAE Guideline 36-2021.

B. All points shown in the points list or described in the sequence shall be shown on the graphics.

C. All setpoints including setpoints internal to control algorithms shall be adjustable from all BAS operator interfaces. All commands shall be overridable from all BAS operator interfaces. All control points shall be adjustable or overridable from the same graphic page that displays the points.

D. All setpoints, timers, deadbands, PID gains, etc. listed in sequences shall be adjustable by the user with appropriate access level whether indicated as adjustable in sequences or not. Software points shall be used for these variables. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.

E. All points required by the sequence of operation including, but not limited to, the points listed in the sequences of operation below, as well as all the points' associated values, shall be connected to the BAS and available to the BAS operators on all operator workstations and all operator interface devices as part of a graphical display that depicts the mechanical system controlled.

F. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent windup.

G. When a control loop is enabled or reenabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a neutral value.

H. A control loop in neutral shall correspond to a condition that applies the minimum control effect, i.e., valves/dampers closed, VFDs at minimum speed, etc.

I. When there are multiple OA temperature sensors, the system shall use the valid sensor that most accurately represents the OA conditions at the equipment being controlled.

J. The term “control loop” or “loop” is used generically for all control loops. These will typically be PID loops, but proportional plus integral plus derivative gains are not required on all loops. Unless specifically indicated otherwise, the guidelines in the following subsections shall be followed.

1. Use proportional only (P-only) loops for limiting loops (such as zone CO2 control loops, etc.). Limiting loops are used to prevent controlled variables from rising above or dropping below setpoint (depending on the application) by defining a fixed threshold at which the loop output reaches 100%. Limiting loops shall use proportional-only control to prevent integral windup from causing the controlled sensor to overshoot setpoint due to the sensor generally being far from setpoint.
2. Do not use the derivative (D) term on any loops unless field tuning is not possible without it. Use of the derivative term makes loop tuning difficult in practice. It can make loops unstable because it increases as the rate of change of the error increases, amplifying the error signal. It is used in industrial process controls and systems that must react quickly but is rarely if ever needed in HVAC system.
3. Limit PID maximum change to 25%, make this a user modifiable variable.

K. When HVAC equipment or a sequence is specified to be started and stopped by a temperature, humidity, pressure setpoint or any other controlled variable, there shall be an adjustable differential setpoint that shall be set to prevent short cycling of the systems and equipment due to minor changes in the controlled variable. Temperature differential setpoints shall be set at 2°F and non-temperature setpoints shall be set at 10% of the controlled range unless otherwise specified. Setpoints shall indicate at when the process should be turned ON. Heating and cooling differentials shall be set for above setpoint and will be used to turn the process OFF. For example, an economizer sequence called to switch at 68ºF, would turn ON at 68°F and OFF at 70°F since it is a cooling function. A heating lockout setpoint of 50 ºF would turn ON heating control at 50°F and OFF at 52°F Non-temperature differentials shall be set above setpoint if the setpoint is indicating a minimum value or below setpoint if the setpoint is indicating a maximum value. Provide minimum runtime timers for loads that are cycled to prevent over-cycling. Timers shall be set as specified or as needed to prevent damage or excessive wear to the equipment. Unless otherwise specified in the individual control sequences, fans and pumps shall have a minimum runtime ON timers of 15 minutes (adj.) and OFF timers of 5 minutes (adj.). Safeties shall override runtime timers.

L. To avoid abrupt changes in equipment operation, the output of every control loop shall be capable of being limited by a user adjustable maximum rate of change, with a default of 25% per minute.

M. Provide minimum runtime timers for loads that are cycled to prevent over-cycling. Timers shall be set as specified or as needed to prevent damage or excessive wear to the equipment. Safeties shall override runtime timers.

N. All setpoints, timers, deadbands, PID gains, etc. listed in sequences shall be adjustable by the user with appropriate access level whether indicated as adjustable in sequences or not. Software points shall be used for these variables. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.

O. The BAS contractor is responsible for utilizing the functional performance test procedures developed by the commissioning agent in accordance with the procedures defined for functional performance test procedures.

P. Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user with appropriate access level (e.g., for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point, and the software point shall be used in all sequences. Exceptions shall be made for machine or life safety.

1. All hardware points, not just inputs, shall be capable of being overridden for purposes of testing and commissioning. For example, the commissioning agent shall be able to command damper positions, valve positions, fan speeds, etc. directly through BAS overrides.
2. The requirement to equate hardware points to software points is necessary for systems that do not allow overriding real input points.
3. The user interface shall allow the user to set an expiration period that automatically releases the override after the period has expired. The system shall also keep track of who initiates each override and when.

Q. Provide Sequenced starting of HVAC equipment at initial startup, whether specifically mentioned in each Sequence of Operation.

R. All setpoints indicated in the control specification are to be adjustable. The setpoints indicated herein are only specified as a calculated starting point (or initial system operation). It is expected that setpoint adjustments and control loop tuning shall be required to provide optimum system operation based on the requirements of the building. The control contractor shall work with the TAB contractor (230593) and the Owner to provide the final system setpoint adjustments and control loop tuning after the system is in operation and building is in use.

S. BACnet

1. All controllers with BACnet cards shall be integrated into the DDC system via BACnet. Provide DDC programming to define input and output information available through the boiler manufacturer’s integration data port.
2. All hardwired points and any setpoints, timers, or other control elements that are specified to be adjustable (adj.) shall be mapped as BACnet objects and be available on the user interface to be adjusted.

T. Trends shall be provided for all hardware I/O points and integrated points listed as having trending and for analog and binary data points mapped to the user interface. Interval trending with sample intervals of 10 minutes shall be provided on analog process variables (this includes both analog inputs and calculated process variables) and process outputs. Data shall be stored at the supervisory controller or in the field controller and uploaded to the DDC system server when

archiving is desired. Consult with the Owner to determine which trends should be archived. Trending shall be in place for a minimum of 24 hours prior to functional testing by the commissioning provider. The BAS shall sample and store trend data and shall be able to archive data to the hard disk.

U. Variable Frequency Drives (VFD) Speed Points per ASHRAE Guideline 36-2021:

1. The speed AO sent to VFDs shall be configured such that 0% speed corresponds to 0 Hz, and 100% speed corresponds to maximum speed configured in the VFD.
2. For each piece of equipment, the minimum speed shall be stored in a single software point; in the case of a hard-wired VFD interface, the minimum speed shall be the lowest speed command sent to the drive by the BAS. The active minimum speed parameter shall be read every 60 minutes via the drive's network interface. When a mismatch between the drive's active minimum speed and the minimum speed stored in the software point is detected, the minimum speed stored in the software point shall be written to the VFD via the network interface to restore the active minimum speed parameter to its default value and generate a Level 4 alarm.
3. The VFD start-up technician shall work with the BAS Contractor to determine the minimum speed required for the motor controlled by the VFD to provide cooling of the motor as installed to prevent heat related problems. This minimum speed shall be set in the VFD controller.

V. Point Types

1. AO = analog output
2. DO = digital output (also, BO = binary output)
3. AI = analog input
4. DI = digital input (aka BI = Binary Input)

1.3 ALARMS

A. Provide alarms per ASHRAE Guideline 36, Paragraph 5.1.12: "Alarms".

B. Provide at least the following requirements in the specification for the BAS graphical user interface:

1. All alarms shall include a time/date stamp using the standalone control module time and date.
2. Each alarm can be configured in terms of level, latching (Requires Acknowledgment of a Return to
3. Normal/Does Not Require Acknowledgment of a Return to Normal), entry delay, exit deadband, and post-suppression period.
4. An operator shall be able to sort alarms based on level, time/date, and current status. Alarms should be reported with the following information:

a. Date and time of the alarm
b. Level of the alarm
c. Description of the alarm
d. Equipment tags for the units in alarm.
e. Possible causes of the alarm if provided by the fault detection routines.
f. The source that serves the equipment in alarm, per ASHRAE Guideline 36, Paragraph 5.1.19 “Hierarchical Alarm Suppression”.

C. As per ASHRAE Guideline 36, there shall be 4 levels of alarm:

1. Level 1: Life-safety message
2. Level 2: Critical equipment message
3. Level 3: Urgent message
4. Level 4: Normal message

D. Alarms shall be reset during a power failure; the controls shall be programmed to ignore alarms that will occur upon loss of power. For example, a pump status alarm is not necessary, since it’s obvious that the pump will fail upon loss of power.

E. Alarms associated with equipment that is disabled shall be inhibited.

F. Current status-switches shall prove the operation of fans and pumps. Level 2 Alarm, Fans & pumps: Status point not matching it’s ON/OFF point for 3 seconds after a time delay of 15 seconds while the equipment is commanded ON. The term “proven” (i.e., “prove ON”/ “prove OFF”) shall mean that the equipment’s DI status point (current switch) matches the state set by the equipment’s DO command point.

G. If an operating equipment has any fault condition, a Level 2 alarm shall be generated, and a response shall be triggered as defined in ASHRAE Guideline 36.

1.4 TRIM & RESPOND (T&R) SET-POINT RESET LOGIC

A. Provide T&R logic per ASHRAE Guideline 36, Paragraph 5.1.14: “Trim & Respond Set-Point Reset Logic”.

B. Trim & Respond logic shall reset the setpoint within the range minimum (SPmin) to maximum (SPmax) setpoint. When the associated device is OFF, the setpoint shall be SP0.

C. T&R logic resets a setpoint for pressure, temperature, or other variables. It reduces the setpoint at a fixed rate until a downstream zone is no longer satisfied and generates a request. When enough requests are present, the setpoint is increased in response. The importance of each zone’s requests can be adjusted to ensure that critical zones are always satisfied. When enough requests no longer exist, the setpoint resumes decreasing at its fixed rate. A running total of the requests generated by each zone is kept identifying zones that are driving the reset logic.

D. Damper/Valve Position: Knowledge of damper and valve position are required for proper generation of T&R reset requests. The following are acceptable methods for determining position:

1. Analog actuator. Position may be assumed to be equal to analog signal to actuator.
2. Floating actuator. Provide either:

    a. Position feedback AI
    b. Position estimated by timing pulse-open and pulse-closed commands with autozeroing whenever zone is in Unoccupied Mode and damper is driven full closed. This option is not acceptable for 24/7 applications.

PART 2 - SEQUENCES

PART 3 - VENTILATION SEQUENCES

3.1 Tunnel Ventilation

A. In normal occupied mode, Tunnel Exhaust Fans and make-up air unit shall be energized, OA and EA dampers open, and both shall operate continuously at low speed, as scheduled to provide space ventilation. Supply fan speed is controlled via 4-20 input from BAS to MUA controller. Exhaust fan speed is controlled via 4-20 signal from BAS to the exhaust fan VFD.

B. Gas furnace modulates to maintain discharge air temperature at setpoint (as scheduled through BAS).

C. Emergency Ventilation Sequence

1. Emergency Ventilation Sequence: Exhaust Fans and Makeup Air Unit: CO and NOx sensors located in the space, provided and installed under this section, shall enable MUA and EF's to operate in Emergency Ventilation Mode, at which point, both the supply and general exhaust fans operate at scheduled maximum flow. Emergency ventilation shall be triggered upon detection of 3 ppm NOx and/or 25 ppm CO. The sensors shall further activate an audible alarm upon rise of NOx to 5 ppm and/or CO to 35 ppm. All associated control wiring and interlock shall be by this division. Coordinate with Division 26 for installation of combination starters to manually energize the exhaust fan and associated supply air fan. Provide time delay relays for each EF set at 15 minutes (adj) to prevent short cycling of operation by CO/NOx sensors. EFs/SFs shall be interlocked for simultaneous operation as dictated by sensors and switches serving specific area monitored.
2. Fans start only after MOD's have opened fully where applicable.
3. Provide adequate quantity of sensors to detect gases for specific floor areas per approved manufacturer's recommendations.

D. In unoccupied mode, unless emergency ventilation sequence is triggered, exhaust fans and make-up air unit shall be off, MOD's closed.

E. Display the following thru BAS for the above:

1. Fan/MUA status and command ON/OFF.
2. DAT setpoint and actual
3. VFD speed-all fans.
4. Emergency Ventilation Mode Status/Alarm.
5. MOD positions.

3.2 EXHAUST FANS

A. Interlock: Fan operates continuously with operation of its Associated MUA.

1. EF-1 and EF-2 are interlocked with MUA-1.

2. EF-3 and EF-4 are interlocked with MUA-2.

3.3 TERMINAL UNITS – SPECIFIC REQUIREMENTS

A. Unit Heaters – Hydronic

1. Input Device: Electronic temperature sensor.
2. Upon a drop-in space temperature below the heating setpoint, the fan shall start, and the HW 2-position valve shall open. When the temperature rises above the setpoint, the fan shall stop, and the valve shall close. Minimum run time: 1 minute.

B. Dehumidifiers

1. Units shall operate through package unit controls – refer to Section 238416.

END OF SECTION 230993

SECTION 232113 – HYDRONIC HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division 23 Section "Common Work Results"

1.2 SUMMARY

A. This Section includes piping and specialties for hydronic HVAC piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Piping
2. Hydronic specialties
3. Chemical treatment.

B. Delegated-Design Submittal: Braided Expansion Loops

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.

1.4 INFORMATIONAL SUBMITTALS

A. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Qualify soldering processes, procedures, and solderers for copper and copper alloy pipe and tube in accordance with ASTM B 828.

C. Qualify brazing processes for copper and copper alloy pipe and tube according to ANSI/AWS C3.4.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

E. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.7 COORDINATION

A. Drawings show the general layout of piping and accessories but do not show all required fittings and offsets that may be necessary to connect piping to equipment and to coordinate with other trades. Fabricate piping based on field measurements. Provide all necessary fittings and offsets.

B. Coordinate layout and installation of hydronic piping and suspension system components with other construction.

C. Coordinate pipe sleeve installations and penetrations with other trades.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Balancing Valves:

    a. Griswold Controls.
    b. ITT Bell & Gossett
    c. Taco, Inc.
    d. Tour & Anderson
    e. IMI Flow Design
    f. Griswold Controls
    g. Watts Industries Inc.
    h. Caleffi
    i. Nexus

2. Air Vents and Vacuum Breakers:

    a. Armstrong International, Inc.
    b. Barnes & Jones, Inc.
    c. ITT Hoffman
    d. Caleffi
    e. Spirotherm
    f. Spirax Sarco, Inc.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. DWV Copper Tubing: ASTM B 306, Type DWV.

C. Fitting Standard: Copper fittings shall conform to ASME B16.18, ASME B16.22 or ASME B16.26.

D. Press Fitting: Viega Pro Press - Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed, or an alternative supplied by fitting manufacturer. Press ends shall have SC (Smart Connect) feature design (leakage path). Provide a smart connect feature to assure leakage of liquids and/or gases from inside the system past the sealing element of an un-pressed connection. The function of this feature shall be to provide the installer quick and easy identification of connections which have not been pressed prior to putting the system into operation.

E. Wrought-Copper Unions: ASME B16.22.

F. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2 and Smaller: ASTM A-53, Type S (seamless) or Type F (furnace-butt welded), Grade B, Schedule 40 and 80, black steel, plain ends.

B. Steel Pipe, NPS 2-1/2 and larger: ASTM A-53, Type E (electric-resistance welded), Grade B, Schedule 40 and 80, black steel, plain ends.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A-234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings: Material Group: 1.1. End Connections: Butt-welding. Facings: Raised face.

H. Mechanically formed copper or steel tee connections are not acceptable.

I. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ANSI B16.11 may be used for drain, vent and gage connections.

J. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

K. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.5 HYDRONIC VALVES

A. Ball Valves

1. Threaded Ends 4" and Smaller: 150 psi WP and 600 psi non-shock CWP, forged brass full-port or cast bronze two-piece body, hard chrome plated forged brass ball, true adjustable packing nut ("O"-ring only type stem seal not acceptable), blow-out proof stem: Watts FBV-3C series/B6080 series, Hammond 8501, Nibco T-585-70, Milwaukee BA100, Apollo 70-Series, or approved equal.
2. Soldered Ends 3" and Smaller: 150 psi WP and 600psi non-shock CWP, full-port cast bronze or forged brass two-piece body, hard chrome plated forged brass ball, true adjustable packing nut ("O"-ring only type stem seal not acceptable), blow-out proof stem: Watts FBVS-3C series/B6081 series, Hammond 8511, Nibco S-585-70, Milwaukee BA150, Apollo 70-Series, approved or equal.

3. Comply with MSS SP-110.

B. Butterfly Valves

1. Basis of Design: Center Line Series 200; Lug Type, cast iron, drilled and tapped lug body, ductile iron disc, 416SS shaft, bronze bushing, EPDM seat.
2. Valve bodies shall have extended necks to provide for 2-1/4" insulation as needed.
3. Comply with MSS SP-67.
4. Compatible with ANSI 125/150 flanges. Dead-end capacity to 200 psi.
5. Operators: 6” and smaller: handle with infinite adjustment; 8” and larger: gear w/balance-stop hand wheel. Valves located 7 feet or higher: provide gear/chain wheel.
6. Approved Manufacturers: Watts, Hammond, Nibco, Milwaukee, or approved equal.

C. Bronze Globe Valves, Class 125:

1. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron.

D. Bronze Globe Valves, Class 150:

1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

E. Iron Globe Valves, Class 125:

1. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

F. Iron Globe Valves, Class 250:

1. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 500 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

G. Wafer Check valves: Provide wafer style, butterfly type, spring actuated check valves designed to be installed with gaskets between two standard Class 125 flanges. Construct iron body valves with pressure containing parts of valves with materials conforming to ANSI/ASTM A 126, Grade B. Support hanger pin by removable side plug; Class 125, cast iron body, stainless steel trim, bronze disc, Buna-N seal:, Watts BF/DBF series, Metraflex 700 Series, Nibco W920-W, Stockham WG970, Hammond 9253, Milwaukee 1400, or approved or equal.

H. Swing check valves:

1. Construct pressure containing parts of Valves as follows: Bronze Valves: 125 or 150 psi: ANSI/ASTM B 62; Iron Body Valves: ANSI/ASTM A-126, Grade B. Comply with the following standards for design, workmanship, material and testing: Bronze Valves: MSS SP – 80; Cast Iron Valves: MSS SP – 71.
2. Construct valves of pressure casting free of any impregnating materials. Construct disc and hanger as one piece. Support hanger pins by removable side plug.
3. Threaded Ends 2" and Smaller: Class 125, bronze body, screwed cap, Teflon disc: Hammond IB904, Nibco T-413Y, Stockham B320T, Milwaukee 509 or approved equal.
4. Soldered Ends 2" and Smaller: Class 125, bronze body, screwed cap, Teflon disc: Hammond IB912, Nibco S-413-Y, Stockham B310T, Milwaukee 511 or approved equal.
5. Flanged Ends 2-1/2" and Larger: Class 125, iron body, bronze mounted, horizontal swing, cast-iron disc: Hammond IR1124, Nibco F918-B, Stockham G931, Milwaukee F2974 or approved equal.

2.6 HOOKUPS AND BALANCING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Nexus (Basis of Design)
2. IMI Flow Design
3. HCI
4. Hays
5. Griswold
6. Victaulic
7. Taco
8. Bell & Gossett

B. Minimum Requirements Per Coil Installation:

1. Manual Flow Control Valve (MFCV)
2. Y-strainer.
3. Temperature Control Valve (TCV) – see 230900.
4. Union connections at coil and TCV.
5. Air vent on return side.
6. Blowdown/drain valve on supply side.
7. Pressure/temperature test plugs across coil and TCV.
8. Full port, union end ball valves or butterfly valves for shutoff.

C. Materials Of Construction (2½" and smaller, except as noted)

1. Brass or stainless-steel metals.
2. Teflon, EPDM or FKM seals.

D. Installation

1. Installation shall conform to basic piping methods specifications.
2. All components shall be isolated by shutoff valves.
3. Flexible hoses shall be installed at coil connections as shown in the plans or at the option of the mechanical contractor.
4. Union tailpieces may be used to reduce pipe sizes to match coil and TCV valve sizes.
5. Pressure/Temperature test plugs shall be installed across coil.
6. A Y-strainer or combination strainer and valve shall be installed on the supply side.
7. Unions shall be used to isolate the coil, AFCV and TCV.

E. Shutoff Valves (2½" and smaller) shall be forged brass ball valves, Nexus Model UX:

1. A one-piece body rated at 250 psi WP, 325° F.
2. Interchangeable union ends with FKM O-ring seal (ground joint is not acceptable).
3. Multiple ¼" tapped ports for test plugs, vent, and/or drain.
4. Blowout-proof stem with dual KFM O-ring seals.
5. Hard chrome plated stainless steel ball with Teflon seats.

F. Shutoff Valves (2½" and larger) shall be lug pattern butterfly valves, Nexus Model BV:

1. A minimum of 225 psi WP, 250° F.
2. 125# Class lug pattern cast or ductile iron body.
3. EPDM cartridge seat, 416 stainless steel one-piece shaft, and 304 stainless steel disc.
4. Top and bottom shaft bushings.
5. Provide an infinite position chrome plated steel top plate for balancing purposes.
6. Epoxy coated body.

G. Manual Flow Control Valves (2½" and smaller) shall be a combination of metering/balance type of forged brass construction, Nexus Model XB:

1. A modified venturi equipped with (2) pressure/temperature ports and an ID tag.
2. A combination shutoff and memory stop device-indicating degree of opening.

3. A rating of 250 WOG, 325°F.
4. An interchangeable union ends with FKM O-ring type seal.
5. Blowout proof stem with dual FKM O-ring seals.
6. Hard chrome plated stainless steel ball with Teflon seats.

H. Manual Flow Control Valves (2½" and larger) shall be an instrument and metering station with integral Pitot Tube, multiple ports for instruments, accessories and drains, a butterfly throttling valve; Nexus Model NXFB:

1. The Pitot tube shall be twin tube design, of 316 stainless steel with blowout proof attachment to station body.
2. Ports shall include ¾" port for thermometer well, ¼" ports for pressure gauge, air vent, transmitter or other accessories, and a ½" drain port.
3. The instrument station shall be 125# Class flanged (mates to 150# Class flanges) construction.
4. The butterfly valve shall be lug pattern with a rating 225 PSIG, 250°F.
   The butterfly valve shall have an infinite position operator with memory stop (6" and smaller), worm gear with memory stop (6" and larger).

I. Temperature Control Valves, ref. Section 230900 & 230993.

J. Combination Strainer/Ball Valves (2½" and smaller) used for supply side shutoff and strainer requirements shall be forged brass construction, Nexus Model UY:

1. A minimum rating of 250 WOG, 325° F.
2. Interchangeable union end with FKM O-ring seal.
3. Multiple ¼" tapped ports for test plugs, vent, or other accessories.
4. Blowout proof stem with dual FKM O-ring seals.
5. Hard chrome plated stainless steel ball with Teflon seats.
6. A 20 mesh 304 stainless steel filter screen, accessible without affecting the valve piping.
7. A port in the filter cap for a blowdown/drain valve.

K. Combination Strainer/Butterfly Valves (2½" and larger) used for supply side shutoff and strainer requirements shall be cast or gray iron construction, Nexus Model SXFV:

1. A minimum rating of 175 psi WP, 250° F.
2. 125# Class flanges (mates to 150# Class flanges) and lug pattern butterfly valve.
3. Multiple ¼" tapped accessory ports across the filter screen.
4. A flanged end cap with a ¾" port for a blowdown/drain valve standard thru 8" size.
5. A ¾" port for thermometer well.
6. A 304 stainless steel screen, with perforations 0.045" thru 3", and 0.125" thru 8".

L. Y-Strainers (2½" and smaller) shall be forged brass body, Nexus Model UYX:

1. ¼" tapped accessory ports.
2. A rating of 250 WOG, 325° F.
3. A 20 mesh 304 stainless steel filter screen, removable without affecting the strainer piping.
4. A port in the filter cap for a blowdown/drain valve.

M. Y-Strainers (2½" and larger) shall be 125# Class flanged cast or ductile iron body, Nexus Model SXF:

1. Multiple ¼" tapped accessory ports across the filter screen.
2. A flanged end cap with a ¾" port for a blowdown valve standard thru 8" size.
3. A ¾" port for thermometer well.
4. A 304 stainless steel screen, with perforations 0.045" thru 3", and 0.125" thru 8".

N. Blowdown/Drain Valves shall be forged brass ball valve construction, Nexus Model BD:

1. A minimum rating of 250 WOG, 325° F.
2. Blowout proof stem with dual FKM O-ring seals.
3. Hard chrome plated brass ball with Teflon seats.
4. A ¾" hose end and nylon / brass cap with retainer to protect threads.

O. Unions (2" and smaller) shall be forged brass, Nexus Model UU:

1. A minimum of 250 psi WP, 325° F.
2. Multiple ¼" tapped ports for test plugs, vent and/or drain valves.
3. FKM O-ring seal.

P. Accessories to coil piping components shall conform to the following:

1. Nexus PT Pressure/Temperature test plugs shall be rated for 1000 psi, 325° F, with brass body, Nordel check plugs, and sealed cap.
2. Flexible hoses shall be designed for water, and fire retarding conform to ASTM codes E84-00, with stainless steel outer braid.
3. Hoses (½" thru 1"), Nexus UFHF.

    a. Shall have a Kevlar reinforced EPDM tube core, brass end fittings, and designed for a working pressure of 400 psi, 248°F.
    b. Provide dual union or swivel end fittings.

4. Hoses (1¼" thru 2"), Nexus UFHM:

    a. Shall have Rayon reinforced EPDM tube core, brass end fittings, and designed for a working pressure of 300 psi, 248° F. The (2½") hose shall have stainless steel outer braid and carbon steel Sch. 40 fittings, and designed for a working pressure of 400 psi, 70º F.
    b. Provide least one union or swivel end fitting

5. Nexus MV Manual air vents shall be of brass construction and rated at 250 psi, 450° F.
6. Shaft extensions (2" and smaller) for insulated pipe shall be at least 2¼" tall and constructed of brass
7. Provide a temperature and pressure test/meter kit (Nexus #MKA) for use by MC during start-up, turn-over to Owner at project completion.

2.7 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.

B. Automatic Air Vent: Spirotherm Spirotop, or equal; maintenance-free, designed to vent automatically with float principle; solid-brass body and nonferrous internal parts; 150-psig working pressure; 270°F maximum temperature; NPS 1/2 inlet connection; ½" male thread at vent point for pressure-testing or remote venting of unwanted gases. The Spirotop has a unique "dry" vent design that helps prevent the system fluid from reaching the spring actuated Viton seat and seal assembly, which is the cause of most conventional air vent failures. Air vent shall be dry: release air, not water.

1. The unique valve mechanism is guaranteed not to leak and cannot be shut off.
2. Specially constructed air chamber to protect the valve mechanism from dirt.
3. Sufficient volume to handle pressure fluctuations.
4. A reliable vacuum breaker for system draining.
5. Leak and dirt resistant.

C. Y-Pattern Strainers: Strainers shall be Y-type with removable basket. Body shall have cast-in arrows to indicate direction of flow. Strainer screens shall have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material shall be AISI Type 304 corrosion-resistant steel. Provide fine-mesh start-up strainers. Strainers in sizes 3-inch and smaller shall have screwed ends; Hammond 3010 or approved equal. Body material shall be cast bronze conforming to ASTM B584-C84400. Strainer bodies fitted with screwed screen retainers shall have straight threads and shall be gasketed with nonferrous metal. Strainer screens shall have perforations not to exceed 1/32". In sizes 4 and larger, strainers shall have flanged ends; Hammond 3030 or approved equal. Body material shall be cast iron conforming to ASTM A126 Class B. Strainer bodies fitted with bolted-on screen retainers shall have offset blowdown holes. Strainer screens shall have perforations not to exceed 1/16" (4" size); 1/8" (5" size and larger).

2.8 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Peterson Equipment Co., Inc.
2. Flow Design, Inc.
3. Trerice, H. O. Co.
4. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
5. Weiss Instruments, Inc.

B. Description: "Pete's Plug II", a ¼" fitting to receive either a temperature or pressure probe 1.8" OD.

C. Body: Solid brass with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping. Core Inserts: Nordel, an ethylene-propylene based synthetic rubber.

D. Minimum Pressure and Temperature Rating: 500 PSIG at 275 deg F.

2.9 WATER TREATMENT FOR CLOSED LOOP HYDRONIC SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Sentinel
2. Anderson Chemical Company.
3. Aqua-Chem, Inc.
4. Barclay Water Management, Inc.
5. General Electric Company; GE Water & Process Technologies.
6. H-O-H Water Technology, Inc.
7. Metro Group, Inc. (The); Metropolitan Refining Div.
8. Nalco; an Ecolab company.
9. Watcon, Inc.

B. Performance Requirements

1. Provide water treatment for closed-loop hydronic systems.
2. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.
3. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
4. Closed hydronic systems, including shall have the following water qualities:

    a. pH: Maintain a value within 8.2 to 9.5.
    b. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
    c. Total Hardness : <150 ppm as $caCO_3$.
    d. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
    e. Soluble Copper: Maintain a maximum value of 0.20 ppm.
    f. TSS: Maintain a maximum value of 10 ppm.
    g. Ammonia: Maintain a maximum value of 20 ppm.
    h. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
    i. Microbiological Limits:

        1) Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
        2) Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
        3) Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
        4) Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
        5) Iron Bacteria: Maintain a maximum value of zero organisms/mL.

C. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 HYDRONIC PIPING APPLICATIONS – ABOVE GROUND

A. Hot Water, NPS 3 and Smaller: Type L drawn-temper copper tubing with pressed or soldered joints; Schedule 40 steel pipe with threaded joints; polypropylene; PEX-a piping.

3.2 VALVE APPLICATIONS

A. Hydronic Valve Applications: Shutoff Duty: Ball and butterfly valves. Throttling Duty: Globe, ball, and butterfly valves.

B. Provide shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line.

C. Provide calibrated balancing valves in the return water line of terminal units, as indicated, and ass required to facilitate system balancing.

D. Provide pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.3 HYDRONIC PIPING INSTALLATIONS

A. Refer to Division 23 Section "Common Work Results" for installation of:

1. Basic piping requirements.
2. Joint construction requirements.
3. Hanger, support, and anchor devices.
4. Firestopping
5. Sleeves and Escutcheons
6. Dielectric fittings
7. Valves
8. Mechanical Identification

B. Hydronic piping systems shall be provided to permit the system to be drained. Provide drains, consisting of a tee fitting, NPS 3/4 ball valve, and hose-end fitting with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Provide piping at a uniform grade of 0.2 percent upward in direction of flow. Pipe size at connections to equipment shall be distribution main size, not connection size. Reduce pipe sizes using eccentric reducer fitting installed with level side up. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out

the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

D. Provide safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Provide safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements. Check the settings and operation of each safety valve, including valves furnished by heater manufacturer. Record settings.

E. Swing Connections for Expansion: Connect risers and branch connections to mains with at least five pipe fittings, including tee in main. Connect mains and branch connections to terminal units with flexible hoses at least four pipe fittings, including tee in main.

F. Terminal Equipment Connections

1. Size for supply and return piping connections shall be same as for equipment connections.
2. Provide control valves in accessible locations close to connected equipment.
3. Arrange piping with offsets to allow for expansion, as well as terminal unit removal.

3.4 HYDRONIC SPECIALTIES INSTALLATION

A. Provide air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

3.5 CONTROL VALVE INSTALLATION

A. Perform the following as directed by the BAS contractor:

1. Provide modulating control valves with minimum of 10 pipe diameters straight pipe at inlet and 5 pipe diameters straight pipe at outlet.
2. Installation of immersion wells and pressure tappings, along with associated shut-off cocks.
3. Installation of flow switches.
4. Setting of automatic control valves or other control devices.

B. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.

C. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.

3.6 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the water characteristics described in Part 2.

B. Provide bypass chemical feeders in each hydronic system.

1. Provide in upright position with top of funnel not more than 48 inches above the floor.
2. Provide feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Provide NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

C. Initial flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided, and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 6 feet per second, if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Provide temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean as approved by the commissioning agent.

D. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water. Circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system, if possible, to circulate at velocities not less than 6 feet per second. Circulate each section for not less than four hours. Blow-down all strainers or remove and clean as frequently as necessary. Drain and prepare for final flushing.

E. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.

F. Close and fill system as soon as possible after final flushing to minimize corrosion. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

G. Fill systems that glycol solutions to the concentrations indicated in the equipment schedules.

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Provide blinds in flanged joints to isolate equipment.
5. Provide safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 233113 - DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division 23 Section "Common Work Results"
2. Division 23 Section "Diffusers, Registers, and Grilles."
3. Division 23 Control Section
4. Division 23 Section "Testing, Adjusting, and Balancing".

1.2 SUMMARY

A. This Section includes ductwork and accessories.

1.3 SYSTEM DESCRIPTION

A. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide necessary fittings and offsets. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions, which may be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.

B. The contractor must comply with the enclosed specification in its entirety. If on inspections, the engineer finds changes have been made without prior written approval, the contractor will make the applicable changes to comply with this specification, at the contractor’s expense.

C. At the discretion of the engineer, sheet metal gauges, and reinforcing may be randomly checked to verify duct construction is in compliance.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible", 4th Editon (SMACNA); and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1. Exception: Sheet metal surfaces and fasteners.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Fittings.
4. Reinforcement and spacing.
5. Seam and joint construction.
6. Penetrations through fire-rated and other partitions.
7. Equipment installation based on equipment being used on Project.
8. Hangers and supports, including methods for duct and building attachment.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.

D. Ductwork Specialties Product Data; provide for the following:

1. Sealant
2. Duct-mounted access doors and panels.
3. Manual-volume dampers: Damper manufacturer's printed application and performance data including pressure, velocity and temperature limitations shall be submitted for approval.
4. Life Safety dampers: Provide complete submittal information (including installation instructions) and the manufacturer's certification of compliance with these specifications for approval prior to bidding. Contractor shall include damper manufacturer’s Installation Instructions as part of the submittal. These instructions shall describe the applicable requirements for damper sleeve thickness, retaining angles, and methods of attachment, duct-to-sleeve connections, preparation of wall or floor openings, and all other requirements to provide an installation equivalent to that tested by the damper manufacturer during the UL Standard 555 qualification procedures. Contractor shall detail any proposed installations that deviate from these manufacturer’s instructions and explain the needed deviations.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling – examples: lighting fixtures, sprinklers, etc.
7. Areas of building where coordination drawings are required:

a. All Mechanical Rooms
b. All ductwork 24” wide and larger.
c. Congested areas

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

C. Record Drawings: Indicate actual routing, fitting details, reinforcement, support, and installed accessories and devices.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.8 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. IMC-2021

D. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. 4th Edition: 2020 HVAC Duct Construction Standards, Metal and Flexible (SMACNA)
2. 1st Edition: 2012 ANSI/SMACNA 016-2012 HVAC Air Duct Leakage Test Manual

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver sealant and fire stopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

B. Deliver, store and handle materials according to manufacturer's written recommendations.

C. All ductwork, equipment, and fittings delivered and stored on the job site must be capped to prevent the entry of moisture, construction dust or other debris.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M. Galvanized Coating Designation: G60 or G90 as indicated. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A-1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A-480/A-480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A-36/A-36M, steel plates, shapes, and bars; black and galvanized.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of un-braced panel area, unless ducts are lined. All large ducts must be braced as required to prevent drumming.

E. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.

1. Fig. 2-3 Rectangular Elbows: Type RE2 square throat with vanes, Type RE1 radius (1.5W minimum), or Type RE5 dual radius. Square throat is not allowed.
2. Vane support in elbows: Fig 2-4. Turning vanes shall be double wall turning vanes fabricated from the same material as the duct. Mounting rails shall have friction insert tabs that align the vanes automatically. Tab spacing shall be as specified in Figure 2-3 of SMACNA Rail systems with non-standard tab spacing shall not be accepted. Due to tensile loading, vanes shall be capable of supporting 250 pounds when secured according to the manufacturer’s instructions.
3. Fig. 2-5 Rectangular Divided Flow Branches: Type 1, Type 2, Type 4A, or 4B.
4. Fig. 2-6 Branch Connections: 45-degree entry, 45-degree lead-in, bell-mouth or spin-in (single diffuser supply only).
5. Fig. 2-7 Offsets and Transitions. Use gradual offsets as shown, 90-degree offsets shall be avoided.
6. Fig 2-9 Duct Coils: Duct coils with transitions and upstream access door.

2.3 ROUND DUCT FABRICATION

A. Fabricate supply ducts of galvanized steel according to SMACNA.

B. Longitudinal Seams: Select seam types and fabricate according to SMACNA Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.

1. Exposed Round Ducts: Shall be Spiral Seam (RL-1 seam) at 2-inch wg construction.
2. Concealed Round Ducts: Shall be longitudinal Grooved Seam Flat lock (RL-5 seam) at 2-inch wg construction.
3. Snap lock seams shall not be used for this project.

C. Transverse Joints: Select joint types and fabricate according to SMACNA Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.

2.4 HANGERS AND SUPPORTS

A. Hanger Rods: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Outdoor Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A-603. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

G. Supports For Roof Mounted Items:

1. Equipment rails shall be galvanized steel, minimum 18-gauge, with integral baseplate, continuous welded corner seams, factory installed 2x4 treated wood nailer, 18-gauge galvanized steel counter flashing cap with screws, built-in cant-strip; minimum height 11 inches. Provide raised cant strip to start at the upper surface of the insulation.
2. Roof Duct Supports: Portable Pipe Hanger Model number PPH-D - Enclosed style.

    a. Engineered, portable system specifically designed for installation without the need for roof penetrations or flashings, and without causing damage to the roofing membrane.
    b. Hot dip galvanize in accordance with ASTM A 123 after fabrication.
    c. Factory fabricated to support exact duct sizes and equipment to be installed.
    d. Provide SS or galvanized clamps, bolts, nuts, washers, and other devices as required for a complete system.

2.5 SEALANT MATERIALS

A. Joint Sealant/Mastic: Shall be flexible, water-based, adhesive sealant designed for use in all pressure duct systems. After curing, it shall be resistant to ultraviolet light and shall prevent the entry of water, air and moisture into the duct system. Sealer shall be UL 723 listed; UL 181A-M or 181B-M listed; and meet NFPA 90A requirements. Pressure sensitive tape shall not be used as a sealing mechanism.

1. Maximum 5 flame spread and 0 smoke-developed (ASTM E-84 Tunnel Test).
2. Generally, provide liquid sealant for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger.
3. Resistance to mold, mildew and water: Excellent
4. Color: Gray
5. Duct sealant/mastic shall meet requirements for LEED. ITW TACC Miracle Kingco water-based sealants, or approved equal.

B. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

C. Round Duct Joint O-Ring Seals: Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch w.g. and shall be rated for 10-inch w.g. static-pressure class, positive or negative. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 FITTINGS

A. Tees, Laterals, and Conical Tees: Use 45 degree; fabricate to comply with SMACNA with metal thicknesses specified for longitudinal seam straight duct.

B. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

C. Elbows: Diameters 3 through 8 inches shall be two-section die stamped; all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.

D. Low-point drains: Ductmate moisture drain with funnel collection design; ¾” connection with drain fitting and cap.

2.7 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Greenheck Fan Corporation.
3. McGill Air Flow LLC.
4. Nailor Industries Inc.
5. Durodyne
6. Cesco
7. Buckley

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

1. Door: Double wall, rated for up to 4.5” static pressure. Door panel filled with 1" fiberglass insulation; ¾ lb. density. Hinges and Latches: 1-by-1-inch continuous piano hinge and cam latches. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs.
3. Provide 1/8” thick neoprene gaskets.
4. Locks: Access doors less than 12 sq. inches: One cam lock. Doors over 12 sq. inches shall have two locks.

2.8 FLEXIBLE CONNECTORS

A. Provide for all air moving equipment. General: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with NFPA 90A. Factory fabricated with a strip of fabric 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized, sheet steel or 0.032-inch aluminum sheets. Select metal compatible with connected ducts. Duro-Dyne, Ductmate, Hardcast, or approved equal.

B. Indoor Flexible Connector Fabric: Glass fabric double coated with polychloroprene or neoprene. Minimum Weight: 26 oz. /sq. yd. Tensile Strength: 480 lbf/inch in the warp, and 360 lbf/inch in the filling.

C. Outdoor Flexible Connector Fabric: Glass fabric double coated with a synthetic-rubber or hypalon, white color; weatherproof coating resistant to the sun's ultraviolet rays and ozone environment. Minimum Weight: 24 oz. /sq. yd. Tensile Strength: 530 lbf/inch in the warp, and 440 lbf/inch in the filling.

2.9 MANUAL-VOLUME DAMPERS

A. Manual balancing dampers meeting the following specifications shall be furnished and installed on all branch ducts and where shown on plans. Testing and ratings to be in accordance with AMCA Standard 500-D.

B. Single-Blade Rectangular Dampers shall consist of: an 18 ga. galvanized steel frame with 3-1/2 in. depth; blades fabricated from 20 ga. galvanized steel; integral 1/2 in. diameter axles. Damper suitable for pressures to 1.0 in. wg, velocities to 2000 fpm and temperatures to 180°F. Basis of design is Greenheck model MBD-10.

C. Multi-Blade Rectangular Dampers shall consist of: a 16 ga. galvanized steel hat channel frame with 5 in. depth; triple V type blades fabricated from 16 ga. galvanized steel; ½ in. dia. plated steel axles; external (out of the airstream) blade-to-blade linkage. Damper suitable for pressures to 4.0 in. w.g. (996 Pa), velocities to 2000 fpm and temperatures to 180°F. Basis of design is Greenheck model MBD15.

D. Round dampers shall consist of: a 20 ga. galvanized steel frame with 6 in. depth; blades fabricated from 20 ga. galvanized steel; 3/8 in. square plated steel axles turning in acetal bearings. Damper suitable for pressures to 1.0 in. wg, velocities to 2000 fpm and temperatures to 180°F. Basis of design is Greenheck model MBDR50.

2.10 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.
2. Cesco Products
3. Greenheck Fan Corporation.
4. Metalaire, Inc.
5. Nailor Industries Inc.
6. Prefco
7. NCA
8. Ruskin Company.

B. Type: Static; rated and labeled according to UL 555S by an NRTL.

C. Fire Rating: 3 hours.

D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory-provided.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Heat-Responsive Device: Provide replaceable fusible links with a temperature approximately 50°F above the maximum temperature that would normally be encountered within the system, but not less than 165°F.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION, GENERAL

A. Provide volume dampers at branch ducts to RGD’s. If volume dampers are inadvertently not shown, contractor shall provide, the intent is to provide volume dampers at branches.

B. Provide ducts and accessories according to SMACNA unless otherwise indicated.

C. Construct and install each duct system for the specific duct pressure classification indicated.

D. Properly seam, brace, stiffen, support and render ducts mechanically airtight. Adjust ducts to suit job conditions. Dimensions may be changed as approved, if cross sectional area is maintained.

E. Provide ducts in lengths not less than 12 feet, unless interrupted by fittings. Provide ducts with fewest possible joints.

F. Provide fabricated fittings for changes in directions, changes in size and shape, and connections.

G. Provide couplings tight to duct wall surface with a minimum of projections into duct.

H. Provide ductwork to allow maximum headroom. Provide ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Provide ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Provide ducts with a clearance of 1 inch, plus allowance for insulation thickness.

J. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

K. Coordinate layout with suspended ceiling, lighting layouts, and similar finished work.

L. Electrical Equipment Spaces: Ductwork not allowed.

M. Exterior ductwork shall have a pitch of at least 3 degrees on the top, to allow water runoff, prevent ice buildup.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Hangers Exposed to View: Threaded rod and angle or channel supports.

C. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system. Seal duct joints to prevent dirt marks.

D. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

E. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

F. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 MATERIALS

A. Hangers, accessories, and dampers shall be same material as parent duct.

B. Ducts shall be G60 galvanized steel except as follows:

1. Un-insulated exterior ductwork: G90 galvanized steel.
2. Exterior ductwork: Hangers and attachments shall be electro-galvanized, all-thread rod or galvanized rods with threads painted after installation. Refer to SMACNA Fig. 5-3. Ductwork shall be pitched or sloped to prevent “ponding” of water.

3.4 DUCT CLASSIFICATIONS AND SEALING

A. Static-Pressure Classifications: Unless otherwise indicated, construct ducts to the following:

1. Supply Ducts: 2-inch w.g.
2. Exhaust Ducts: 2-inch w.g, negative pressure.

B. Seam And Joint Sealing:

1. Ductwork and plenums with pressure class ratings shall be constructed to Seal Class A. Openings for rotating shafts shall be sealed with bushings or other devices that seal off air leakage.
2. Pressure-sensitive tape shall not be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory, and the tape is used in accordance with that certification.
3. Connections shall be sealed, including but not limited to spin-ins, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required.
4. Spiral lock seams need not be sealed.
5. Seal externally insulated ducts before insulation installation.

3.5 DUCT PENETRATIONS

A. Fire or Smoke Rated Penetrations not requiring a fire and/or smoke damper: Where ducts pass through walls, floors, or partitions that are required to have a fire resistance rating and fire dampers are not required, the opening in the construction around the duct shall be provided in accordance with the UL listing of the penetration. Provide firestopping per Section 230500.

B. Fire or Smoke Rated Penetrations: Provide fire and/or smoke damper.

C. Non-Fire-Rated Exposed Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.

D. Non-Fire-Rated Concealed Penetrations: Provide insulation infill and acoustical sealant around gaps. Tightly seal to prevent sound transmission. Neatly finish.

E. Mechanical room floor penetrations: Provide 4-inch high concrete curbs or other sealing method to prevent leakage from mechanical room into floor penetration.

F. Roof penetrations by ducts shall use counter-flashed curbs.

G. Flexible air ducts or connectors shall not pass through any wall, floor, or ceiling.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA Chapter 5, "Hangers and Supports."

B. Building Attachments: Comply with SMACNA Chapter 5, "Hangers and Supports". Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

C. Hanger Spacing: Comply with SMACNA Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

E. Provide upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.7 DUCT ACCESSORIES INSTALLATION

A. Provide duct accessories according to applicable details shown in SMACNA.

B. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards

C. Each register, grille, or diffuser shall have a means of air flow adjustment. Provide volume damper in branch duct if not furnished with the RGD.

D. Adjust operable devices for proper action.

E. Manual dampers shall be visible outside the insulation and marked with a 12" orange ribbon.

F. Locate each duct smoke detector in a serviceable location, in accordance with its listing.

G. Perform the following as directed by the controls contractor: Installation of control devices. Access doors where indicated and as required.

H. Provide duct access panels for access components that require servicing.

1. Provide duct access panels to allow access to interior of ducts for cleaning, inspecting, adjusting, and maintaining per equipment manufacturers' requirements.
2. Provide access panels on side of duct where adequate clearance is available.
3. Locate panel upstream and/or downstream as recommended by manufacturer.
4. Locations:

    a. Upstream side of duct coils.
    b. At outdoor-air intakes.
    c. Adjacent to and close enough to life safety dampers, to reset or reinstall fusible links.
    d. Control devices requiring inspection.
    e. Elsewhere as indicated or required by duct accessory manufacturer

5. Inspect locations of access doors and verify that purpose of access door can be performed.

I. Control Damper Installation

1. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
2. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.
3. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 1/8 in. of each other.
4. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
5. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, sections must open and close simultaneously.
6. Provide a visible and accessible indication of damper position on the drive shaft end.
7. Support ductwork in area of damper when required to prevent sagging due to damper weight.
8. After installation of low-leakage dampers with seals, caulk between frame and duct opening to prevent leakage around perimeter of damper.

J. Fire Damper Installation

1. Examine areas to receive dampers. Notify the Engineer of conditions that would adversely affect installation or subsequent utilization of dampers. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Provide dampers in accordance with manufacturer's UL Installation Instructions, labeling, and NFPA 90A at locations indicated on the drawings. Any damper installation that is not

in accordance with the manufacturer's UL Installation Instructions must be approved prior to installation.

3. Dampers must be accessible to allow inspection, adjustment, and replacement of components. The sheet metal contractor shall furnish any access doors in ductwork or plenums required to provide this access. The general contractor shall furnish any access doors required in walls, ceilings, or other general building construction.
4. Provide dampers square and free from racking.
5. The installing contractor shall provide and install bracing for multiple section assemblies to support assembly weight and to hold against system pressure.
6. Do not compress or stretch the damper frame into the duct or opening.
7. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Provide support mullions as reinforcement between assemblies as required.
8. Handle dampers using the frame or sleeve. Do not lift or move dampers using blades, actuator, or jackshaft.
9. Provide access door, properly located for serving.
10. Tests and Inspections: Operate dampers to verify full range of movement and verify that proper heat-response device is installed.

3.8 PROTECTION

A. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

1. The HVAC system and ductwork shall be provided with protective coverings. The HVAC system includes any interior surface of the facility's air distribution system for conditioned spaces and/or occupied zones. This includes the entire duct from the points where the air enters the system to the points where the air is discharged from the system.
2. The duct system shall be free of construction debris.
3. The working area shall be clean, dry and the ductwork protected from dust.
4. Protective coverings shall only be removed immediately before installation and inspected to determine if additional wipe down is necessary.

B. Upon completion of installation duct systems and before HVAC system start-up, visually inspect the ductwork proper installation

C. Cover supply openings with filter media prior to system start-up to catch any loose material that may remain inside the ductwork. Turn the HVAC system on and allow it to run until steady state operation is reached. Remove the temporary filter media from supply openings and, along with it, any loose material blown downstream and caught by the filter media.

3.9 DUCT CLEANING

A. Ducts shall be kept clean. If the contractor fails to maintain cleanliness, duct cleaning will be required, using duct cleaning methodology as indicated in NADCA ACR.

B. If the contractor fails to maintain cleanliness, duct system cleanliness tests shall be performed:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.

3. Duct system will be considered defective if it does not pass tests and inspections.

4. Prepare test and inspection reports.

END OF SECTION 233113

SECTION 233423 - POWER AND GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division 23 Section "Common Work Results"

1.2 SUMMARY

A. This Section includes fans and ventilators.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material gages and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Wiring Diagrams: Power, signal, and control wiring.
7. Vibration Isolation

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal for sound and air performance.

1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standards: Power ventilators shall comply with UL 705.

E. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

F. Each fan and fan array shall have a fan energy index (FEI) of not less than 1.00 at the design point of operation, as determined in accordance with AMCA 208 by an approved independent testing laboratory and labeled by the manufacturer. Each fan and fan array used for a variable-air- volume system shall have an FEI of not less than 0.95 at the design point of operation, as determined in accordance with AMCA 208 by an approved independent testing laboratory and labeled by the manufacturer. The FEI for fan arrays shall be calculated in accordance with AMCA 208 Annex C. Exceptions: The following fans are not required to have a fan energy index:

1. Fans that are not embedded fans with motor name- plate horsepower of less than 1 HP or with a nameplate electrical input power of less than 0.89 kW.
2. Embedded fans that have a motor nameplate horse- power of 5 HP or less, or with a fan system electrical input power of 4.1 kW or less.
3. Multiple fans operated in series or parallel as the functional equivalent of a single fan that have a combined motor nameplate horsepower of 5 HP or less or with a fan system electrical input power of 4.1 kW or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Refer to Division 23 Section "Common Work Results for Mechanical"

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

C. Coordinate size and location of structural-steel support members.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cook
2. Penn Ventilation Companies, Inc.
3. Acme Engineering & Mfg. Corp.
4. Greenheck Fan Corp.

2.2 GENERAL FAN REQUIREMENTS

A. Motors: Include built-in, thermal-overload protection and grease-lubricated ball bearings. Select each motor to be non-overloading over full range of pump performance curve. Comply with NEMA MG 1 requirements for thermally protected motors.

B. Motors Indicated to be premium efficiency, and shall meet or exceed all NEMA Standards Publication MG1 requirements and comply with NEMA premium efficiency levels Class B temperature rise; Class F insulation.

C. Motors used with VFD's: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Provide AEGIS® Shaft Grounding Ring (SGR) on either DE or NDE of motor to divert current away from the bearings and protect bearings in attached equipment.
2. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.

D. ECM Motors: Motor to be an open type, DC electronic commutation type motor (ECM) specifically designed for fan applications. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase. Internal motor circuitry to convert AC power supplied to the fan to DC power operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

E. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.

F. Total efficiency of fans at point of operation shall be within 10% of the fan's maximum total efficiency.

2.3 ROOF OR WALL POWER VENTILATOR

A. Description: centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Construction: Aluminum, completely weatherproof, for curb or wall mounting, exhaust cowl or entire drive assembly readily removable for servicing.

C. Provide a factory disconnect Switch: NEMA-3R non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

D. Provide ECM motor with a Vari-Green Variable-Speed Controller: Solid-state control to adjust speed.

1. Control by 0-10VDC signal
2. Provide adjustable dial mounted on fan for use during balancing.
3. Provide adjustable dial remote-mounted (above ceiling of _____ in an accessible location) for use during balancing.

E. Accessories:

1. Automatic belt tensioner to maintain constant tension on the belt-drive.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum wire.
3. Gravity Back-draft Dampers: Counterbalanced, parallel-blade, mounted in curb base; factory set to close when fan stops.
4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
5. Extended lube lines to allow bearing lubrication while the fan is running.
6. Provide roof curb as specified hereinafter.

2.4 UTILITY SET FANS

A. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The scroll wrapper shall be minimum 14-gauge steel and the scroll side panels shall be a minimum 12-gauge steel. The entire fan housing shall have continuously welded seams for leak proof operation. A performance cut-off shall be furnished to prevent the recirculation of air in the fan housing. The fan housing shall be field rotatable to any one of eight discharge positions and shall have a minimum 1-1/2 inch outlet discharge flange. Bearing support shall be minimum 10-gauge welded steel. Side access inspection ports shall be provided with quick release latches for access to the motor compartment without removing the weather cover. Lifting lugs shall be provided for ease of installation. Unit shall bear an engraved aluminum nameplate and shall be shipped in ISTA certified transit-tested packaging.

C. Provide seismic spring vibration isolators.

D. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.

1. Blade Materials: Steel.
2. Blade Type: Airfoil

E. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

F. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{50} of 200,000 hours.

G. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor: 1.5.
2. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
4. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

H. Accessories:

1. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades and felt edges in steel frame installed on fan discharge.
2. Access Doors: Gasketed doors with latch-type handles.
3. Automatic belt tensioner to maintain constant tension on the belt-drive.
4. Inlet Screens: Removable wire mesh.
5. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
6. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
7. Seismically-housed spring isolators.

I. Coatings:

1. All steel fan components shall be finished with an electrostatically applied, baked polyester powder coating. Each component shall be subject to a five stage environmentally friendly wash system, followed by a minimum 2 mil thick baked powder finish. Paint must exceed 1,000 hour salt spray under ASTM B117 test method.
2. Hot-dip galvanized.

2.5 ROOF CURBS

A. Ducts from fans shall be connected to fan with a flex connector, below roofline.

B. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and less wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: per roofing manufacturer's requirements. Coordinate with roofing contractor.
2. Provide a neoprene seal between the fan and the curb cap to help prevent insects and moisture from entering and vibration transmission in the ductwork.
3. Pitch Mounting: Manufacture curb for roof slope.
4. Metal Liner: Galvanized steel.
5. Overall Height: 14 inches.
6. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide power ventilators level and plumb.

B. Provide vibration isolation as specified.

C. Provide floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 23 "Common Work Results".

D. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 for installation of roof curbs.

E. Support suspended units from structure using threaded steel rods and spring hangers.

F. Provide units with clearances for service and maintenance.

G. Label units according to requirements specified in the Division 23 Common Work Results.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Ductwork."

B. Provide ducts adjacent to power ventilators to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks and Adjustments:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices. Verify that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Inspect and tighten fasteners and setscrews, particularly fan mounting and bearing fasteners.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Verify lubrication for bearings and other moving parts.
7. Verify that dampers in connected ductwork systems are in fully open position.
8. Lubricate bearings.

B. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

3.4 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

END OF SECTION 233423

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division 23 Section "Common Work Results"
2. Division 23 Section "Ductwork"
3. Division 23 Section "Testing, Adjusting, and Balancing"

1.2 SUMMARY

A. This Section includes diffusers, registers (combination grille & damper), and grilles.

1.3 SUBMITTALS

A. Each manufacturer shall check noise level ratings for registers and diffusers to insure that the sizes selected will not produce noise to exceed 30 db, "A" scale, measured at occupant level; notify Owner’s representative of problems prior to shop drawing submittal.

B. Pressure drop, airflow and noise criteria selection are based on design equipment. Manufacturers not submitting design makes must provide written certification in front of submittal that equipment submitted has been checked against and performs equal to the design make.

C. Product Data: For each model indicated, include the following:

1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished.
4. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.

D. Coordinate locations with reflected ceiling plans and wall elevations as applicable.

E. Coordinate mounting frame with associated mounting surface.

1.4 QUALITY ASSURANCE

A. NFPA Compliance: Install diffusers, registers, and grilles according to NFPA 90A.

B. Sound pressure levels shall be determined by using AHRI Standard 885-2008 “Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Outlets”.

C. Testing: Test performance according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 2 - PRODUCTS

2.1 GENERAL

A. Diffusers, registers, and grilles are scheduled on Drawings.

B. Border and mounting type shall match the mounting surface. Coordinate with mounting conditions.

C. Material shall match the specified ductwork. Coordinate with Section 233113 “Ductwork”.

D. Provide with a White Powder Coat finish, unless noted otherwise.

E. Grille blade orientation: Vertical rectangle (wall grille with height longer than width): The blades shall run parallel to the short dimension of the grille. Horizontal rectangle: The blades shall run parallel to the long dimension of the grille.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Price
2. Titus
3. Metal-Aire
4. Anemostat
5. Nailor
6. Grilles shall be 45 degree deflection fixed louver type with blades spaced 3/4" on center.

2.3 SUPPLY

A. Double-deflection Supply Register

1. Material: steel (Price 520D Series) or aluminum (Price 620D Series)

2. Registers shall be double deflection type with two sets of fully adjustable deflection blades spaced ¾" on center.
3. The integral volume control damper shall be of the opposed blade type. Material shall match the register material. The damper shall be operable from the register face.

B. High Capacity Drum Louver with Pattern Control

1. Description:

   a. Furnish and install Price Model AHCD2 high capacity drum louver supply outlets of sizes and mounting types indicated on the plans and air distribution schedule.

2. Construction:

   a. The outlets shall have aluminum AHCD2 frame construction, and extruded aluminum drum and vanes.
   b. The outlets shall consist of individually adjustable spread control vanes housed within a rotatable drum.
   c. The vanes shall be bisected by a center divider, allowing separate adjustment of top and bottom blades.
   d. The end panels of the drum shall incorporate spread control members to enhance pattern control.
   e. The drum pivot mechanism shall incorporate a positive positioning detent device to hold field adjusted drum angles of up to thirty degrees off-center. Adjustable vanes shall pivot and maintain blade setting.
   f. The outlet mounting frame shall be constructed of formed steel with welded, reinforced corners for added strength.
   g. The mounting frame shall be supplied with countersunk screw holes for aesthetic appeal.

3. Paint Specification:

   a. Paint finish shall be a baked-on powder coat finish. The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests. The paint film thickness shall be a minimum of 2.0 mils. The finish shall have a hardness of 2H. The finish shall withstand a minimum salt spray exposure of 500 hours with no measurable creep in accordance with ASTM D1654, and 1000 hours of exposure with no rusting or blistering as per ASTM D610 and ASTM D714. The finish shall have an impact resistance of 80 inch-pounds.

4. Options:

   a. Opposed Blade Damper: The heavy duty, opposed blade balancing damper shall be constructed of a minimum 18 gauge coated, cold rolled steel. The damper frame corners shall overlap and be of welded construction for added strength. The damper shall be operable from the register face. The damper shall be supplied fitted with a face accessible screw-type blade locking mechanism.

b. Spiral Duct Mounting Frame: The outlet shall be suitable for spiral duct mounting. The spiral duct frame shall be galvanized steel or aluminum construction.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Provide diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

C. Drawings indicate general arrangement of ducts, fittings, and accessories. Make final locations where indicated, as much as practicable.

1. For units installed in lay-in ceiling panels, locate units in the center of the panel.
2. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

D. Provide diffusers, registers, and grilles with airtight connection to ducts.

E. Provide 18” minimum of vertical straight ductwork at the entrance to ceiling diffusers.

F. Plenum boxes on grilles/registers shall be 8” minimum height.

3.2 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

B. Adjustable outlets: adjust pattern for draft-free air distribution.

3.3 CLEANING

A. Protect unit interiors from moisture, construction debris and dust, and other foreign materials. Comply with Section 233113 “Ductwork” Paragraph: Field Quality Control.

B. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION 233713

SECTION 237333 - DIRECT-FIRED H&V UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Division 23 Section: Basic Mechanical Materials and Methods.

1.2 SUMMARY

A. This Section includes indirect-fired gas fired H&V units.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. The supplier shall furnish gas piping schematics, as built wiring connection and control-circuit diagrams, dimension sheets and a full description of the unit(s).

C. Service manuals, showing service and maintenance requirements.

D. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, and methods of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:

E. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

F. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of indirect-fired H&V units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

D. Unit(s) assembly shall be tested in accordance with UL Standard UL 795, and shall bear the ETL label. The duct furnace shall be certified by the American Gas Association and approved by the Canadian Gas Association.

1.5 COORDINATION

A. Coordinate size, location and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below of indirect-fired H&V units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each unit.
2. Fan Belts: One set(s) for each unit.

PART 2 - PRODUCTS

2.1 DIRECT FIRED MAKEUP AIR UNITS

A. Manufacturers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Captive-Air Systems, Inc. (Ruppair)
b. Greenheck.
c. Reznor-Thomas & Betts Corporation; Mechanical Products Division.
d. Sterling Gas; Mestek, Inc.
e. Trane Company (The); Unitary Products Group.

B. Manufactured Units

1. Units with Integral Heating shall be fully assembled at the factory and consist of an insulated metal cabinet, an outdoor air intake weatherhood with bird screen, supply air blower assembly, electrical control center. All specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection.

C. CABINET

1. Size 1 Unit(s) shall be constructed of minimum 24 gauge G-90 galvanized steel riveted together via structural pop-rivets. All metal shall be CNC bent for precise assembly.

    a. Rigging Provisions: Size 1 unit(s) shall have a structural base constructed of minimum 18 gauge G-90 galvanized steel. Include full-sized fork pockets and lifting points on all four sides.
    b. Roof Construction: The lids shall be fabricated by forming a double-standing, self-locking seam that requires no additional support. Roof shall be pitched to allow for proper drainage.
    c. Exterior Wall Construction: All exterior walls shall consist of a double wall, G-90 galvanized steel construction. Cabinet size 1 shall be insulated with 1in. thick, R4.3 fiber glass duct board insulation.
    d. Service Access Doors: All door jambs shall be gasketed around their perimeter, and allow for doors to be mounted via removable, spring actuated, stainless steel hinges with stainless steel rivets, and self-compressing latches. Each compartment shall have removable access panels to allow for ease of service and maintainability. Electrical cabinet access doors shall have a door hold installed to prop doors open. All doors shall have stainless steel latches which are pad lockable. Electrical cabinet doors shall be outfitted with schematic/manual pouches formed into the door, along with wiring diagram attached to the indoor of the door from the factory.

2. Entire interior and exterior casing shall be constructed of minimum G90 galvanized steel. The unit casing will not be painted. Unit shall have undergone a salt spray corrosion test as per ASTM B 117.

D. AIRFLOW CONFIGURATIONS

1. Fans: Discharge: Unit shall be configurable for Side (Horizontal) Discharge through the cabinet.

E. SUPPLY AIR BLOWER AND MOTOR

1. All supply fans shall be direct drive (belt-drive not acceptable) variable speed plenum fans.
2. Blower Motor: Motor shall be a premium efficiency motor available as:

    a. Fans : Electronically Commutated Motor (ECM).

3. Fans to be selected at or near efficiency peak. (Submit fan curves)
4. Blower and motor assembly shall be dynamically balanced. The entire blower and motor assembly shall be mounted on rubber vibration isolators. Wheels balanced as per AMCA 204-96, Balance Quality and Vibration Levels for fans.
5. Unit equipped with total CFM monitoring to measure airflow across supply discharge.

F. HEATING SYSTEM

1. The gas burner shall be an indirect-fired, push-through type, using natural gas or liquid propane gas. The inlet-supply pressure to the unit for natural gas must be 7” w.c. minimum. For liquid propane gas, the minimum inlet supply pressure to the unit must be 11" w.c.
2. Burner shall be a tubular in-shot fired design capable of using natural or LP type gas. Each burner ignition shall be of the direct-spark design with remote flame sensing at inlet of the last firing tube of the gas manifold.
3. Direct-sparking sequence shall last through the complete duration of the trial for ignition period for guaranteed light-off. Burner shall always be lit at maximum gas flow and combustion airflow for guaranteed light-off. Each burner ignition module shall have LED indicators for troubleshooting and a set of exposed prongs for testing flame indication signal.
4. All furnaces shall be controlled by an electronic Vernier-type fully modulating control system capable of achieving 80% combustion efficiency over the entire gas firing range of the unit.
5. Each furnace shall have:

    a. A minimum turndown ratio of 6:1 for natural gas and 5:1 for LP gas while maintaining a constant 80% efficiency (90% for high efficiency furnace option). No cold air bypass of the heat exchanger.
    b. Each furnace heat exchanger shall be a bent-tube style design made entirely of stainless steel.
    c. Stainless steel Quick Seal Connection for gas connection.
    d. Manifold and Input gas pressure gauges.
    e. Factory piped condensate drain to exterior of cabinet.
    f. A combustion flue to be installed on adjacent side as combustion intake with integrated high velocity wind cap.
    g. A blocked vent safety airflow switch with high temperature silicone tubing operating off of absolute pressure measured inside of the power-vent blower housing.
    h. A high temperature auto-recycling limit with a maximum non-adjustable set point.
    i. A manual reset high temperature flame rollout switch with a non-adjustable set point.
    j. Each furnace compartment shall have a removable post and panel that allows the furnace to be easily removed for service and maintainability.
    k. A power-vent assembly for exhausting flue gases with a PSC or ECM type motor that is securely mounted and easily accessible/removable for service.
    l. A 0-10”w.c. gas pressure gauge installed on the gas manifold.

G. FILTERS

1. Provide filters as part of unit. All filters shall be furnished and installed to meet the performance requirements set forth in the schedule and as specified under another section of this work.
2. All filters shall be installed on tracks for easy removal from the unit.
3. Unit shall ship incorporate 2” MERV-8 filters.
4. Unit shall have an optional adjustable pressure differential sensor for the filter bank to alert in the event of a clogged filter.

H. ELECTRICAL

1. All controls shall be pre-wired and housed in an insulated electrical cabinet within the unit to protect against risk of condensation.
2. Fans #1, 2: Units shall be provided with single point electrical connection.
3. Unit shall be provided with a door safety switch that de-energizes the supply fan when the door is opened.
4. Unit shall be provided with a factory mounted averaging supply air temperature sensor to allow for accurate discharge temperature readings within unit when a downstream sensor is not installed. Field mounted and wired discharge air sensors will not be accepted.
5. Unit shall be provided with a factory mounted averaging intake air temperature sensor to allow for accurate intake temperature reading regardless of how the OA/RA dampers are positioned.
6. The electrical cabinet shall be outfitted with the following:

    a. Disconnect for power to fully de-energize the electrical cabinet.
    b. LED electrical cabinet service light with automatic activation upon door switch.
    c. Color wiring schematics, laminated to the interior wall of the cabinet doors.
    d. Factory mounted disconnect with unit bottom knockouts.
    e. A LED backlit, LCD Human-Machine Interface (HMI) shall be mounted within the unit’s control cabinet to allow for all set points configuration and refrigeration system monitoring at the unit.
    f. Optional 120V, 15A unit powered or unpowered convenience outlet.

7. All sensors shall be wired back to the main control board that continuously monitors all critical components and makes decisions based on pre-determined logic to accurately control the following:

    a. PID logic to control heater modulation ensuring precise discharge/space temperature control.
    b. PID logic to control compressor speed to provide precise control over evaporative coil temperatures, leaving dew point, and discharge/space temperatures.
    c. PID logic for Outdoor fan modulation to maintain an optimal outdoor coil temperature.
    d. PID logic for Electronic Expansion Valve (EEV) position to maintain a precise superheat temperature.

I. CONTROLS

1. Unit shall be outfitted with a control board to allow for full control of the entire unit.
2. Provide air flow switch on the supply fan system to sense air flow with available set of contacts for connection to BMS for airflow alerts.
3. All unit controls shall be compatible with BACnet and LonWorks based building management systems.
4. All units shall be outfitted with CASLink cloud based monitoring, which monitors every point of operation. Provides configurable automated fault alert e-mails, and remote control capabilities.
5. Integrated cellular module to provide remote connection to monitoring services to view both real time and historical unit operation. Data shall be stored a minimum of 3 years on the cloud. Data sample rate shall be a maximum of 60 seconds.
6. Temperature Control System

    a. Discharge Temp Control (Heating)
    Unit modulates the burner flame (current supply in the case of electric heating) to accurately maintain the desired discharge temperature set point and compensate for fluctuations in entering air temperature, air volume and % of OA.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation of indirect-fired H&V units.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where rooftop replacement-air units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

B. Install and secure indirect-fired H&V units on curbs, and coordinate roof penetrations and flashing with roof construction.

C. Install controls and equipment shipped by manufacturer for field installation with indirect-fired H&V units.

3.3 CONNECTIONS

A. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.

1. Gas Piping: Comply with requirements in Division 15 Section "Fuel Gas Piping." Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.

B. Duct Connections: Duct installation requirements are specified in Division 15 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to indirect-fired H&V units with flexible duct connectors. Flexible duct connectors are specified in Division 15 Section "Duct Accessories."

C. Ground equipment according to Division 16 Section "Grounding and Bonding."

D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Inspect for visible damage to furnace combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.
7. Inspect and adjust vibration isolators.
8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
10. Adjust fan belts to proper alignment and tension.
11. Start unit according to manufacturer's written instructions.
12. Complete startup sheets and attach copy with Contractor's startup report.
13. Inspect and record performance of interlocks and protective devices; verify sequences.
14. Operate unit for run-in period recommended by manufacturer.
15. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

    a. Gas Burner:

        1) Measure gas pressure at manifold.
        2) Measure combustion-air temperature at inlet to combustion chamber.

3) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

16. Calibrate thermostats.
17. Adjust and inspect high-temperature limits.
18. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
19. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

20. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.

D. Prepare written report of the results of startup services.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain indirect-fired H&V units. Refer to Division 1 Section.

END OF SECTION 237333

SECTION 238239 - UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following: Division 23 Section “Common Work Results”

1.2 SUMMARY

A. This Section includes hydronic unit heaters.

1.3 SUBMITTALS

A. Product Data: Include specialties and accessories for each unit type and configuration.

1. Plans, elevations, sections, and details.
2. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
3. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

B. Maintenance Data: For unit heaters to include in maintenance manuals specified in Division 1. Include maintenance schedules and repair parts lists for motors, coils, integral controls, and filters.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Test unit heater coils according to ASHRAE 33.

1.5 COORDINATION

A. Coordinate layout and installation of unit heaters and suspension system components

B. Coordinate wall construction and conditions with recessed or semi-recessed cabinet unit heater installation requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier Corp.
2. Trane
3. McQuay
4. Sterling
5. Vulcan
6. Modine
7. Rittling

2.2 COMMON ELEMENTS

A. Motors shall be brushless DC (BLDC)/electronically commutated motors (ECM) factory-programmed and run-tested in assembled units. The motor controller shall be mounted in a touch-safe control box with a built-in integrated user interface and LED tachometer. If adjustments are needed, motor parameters can be adjusted through momentary contact switches accessible without factory service personnel on the motor control board. Motors shall soft-ramp between speeds to lessen the acoustics due to sudden speed changes. Motors shall be operated at three speeds. The motor will choose the highest speed if there are simultaneous/conflicting speed requests. Motors shall have integral thermal overload protection with a maximum ambient operating temperature of 104°F and shall be permanently lubricated. Motors shall be capable of starting at 50 percent of rated voltage and operating at 90 percent of rated voltage on all speed settings. Motors shall operate up to 10 percent over voltage.

B. Provide a unit-mounted disconnect switch.

2.3 UNIT HEATERS

A. Description: An assembly including casing, coil, fan, and motor; provide horizontal or vertical configuration as scheduled.

B. Casing: Galvanized steel, with removable panels.

C. Cabinet Finish: Bonderize, phosphatized, and flow-coat with baked-on primer and manufacturer's standard paint applied to factory-assembled and -tested propeller unit heater before shipping.

D. Hot-Water Coil: Copper tube, 0.031-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering water temperature of 325°F, with manual air vent. Test for leaks to 375 psig underwater.

E. Propeller with aluminum blades directly connected to motor.

F. Units mounted shall be equipped with an OSHA fan guard. Fan guards shall be welded steel, zinc plated or painted.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before cabinet unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Provide unit heaters level and plumb.

B. Provide unit heaters to comply with NFPA 90A.

C. Hung unit heaters shall be suspended from structure with rubber-in-shear vibration isolators.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.

C. Provide piping adjacent to machine to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing and report results in writing:

1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. After installing units, clean unit heaters internally according to manufacturers written instructions.

C. Provide new filters in each cabinet unit heater within two weeks after Substantial Completion.

END OF SECTION 238239

SECTION 238416.16 - INDOOR, MECHANICAL DEHUMIDIFICATION UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor, mechanical dehumidification units.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For dehumidification units to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 INDOOR, MECHANICAL DEHUMIDIFICATION UNITS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. DriSteem
2. Santa Fe
3. Quest

B. Dehumidifier shall be DRI-STEEM RL Dehumidification System or engineer-approved equal. Fabrication requirements:

1. RL enclosure shall be constructed with 20-gauge painted galvannealed steel cabinet, polyester powder coat finish.
2. Enclosure shall have separate compartments: one for refrigeration components and one for electrical components. Enclosure shall be designed and secured to prevent accidental contact with electrical components. The front or top exterior of the cabinet shall contain the controller’s touch keypad.
3. The dehumidifier enclosure shall have pre-punched mounting holes for hanging.
4. Drain: PVC tubing.

C. Fan/Motor

1. Unit shall include a single inlet centrifugal impeller (backward curved).
2. Material shall be molded polymer.
3. Motor shall include be ECM or PSC

D. Filter Section: Pleated, disposable pre-filters in supply-air. Filter shall be 1-inch thick, easily replaceable, with a minimum efficiency report value (MERV) of 11.

E. Cooling

1. Refrigeration Package: Comply with UL 60335-2-40 “Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers”.

   a. Refrigerant Coils: aluminum tubes with mechanically bonded aluminum fins; factory fabricated and tested; multiple evaporator & condenser circuits, copper headers with brazed connections, and aluminum frame. Coils shall have an 800-psig pressure rating and be factory tested to 450 psig.
   b. Compressors: Hermetic, rotary compressor with integral vibration isolators with capillary tubes, filter-dryers, and accumulator.
   c. Refrigerant: R-454B.
   d. Capacity Control: Cycled compressor.

2. Safety Devices:

   a. Compressor Motor Overload Protection:

      1) Thermal Overload Switch integral to compressor.
      2) High temperature sensor protection: high temperature thermistor cuts off the compressor when the discharge temperature reaches 190°F.
      3) Compressor drive-board built-in current, voltage, and temperature protection.

   b. Antirecycling Timing Device: Prevent compressor restart for three minutes after shutdown.

F. Electrical: Corded device with 8-foot cord.

G. RL Dehumidifier Controls

1. Adjustable set point control of dehumidifier.
2. Humidistat, D77 controller, room: The control allows the user to set and adjust the humidity setting and turn dehumidification on or off from a convenient location . In this application, the Model D77 uses an onboard sensor to monitor the relative humidity (%RH) in the space in which it is located and displays the measured relative humidity on the digital display. Control range 35-80%, accuracy of +- 5%, deferential 3%RH Low limit 40°F dew point and high limit is 99°F dry bulb.
3. Microprocessor controller with the following features or functions:

a. Keypad/display operable within a temperature range of 32 to 158°F, and that provides backlighting for viewing in low light.
b. Alarms, unit configuration values shall remain in nonvolatile memory indefinitely during a power outage.
c. The capability to monitor, control, and/or adjust the following parameters:

1) Relative humidity (RH) set point, space temperature.
2) System alarms and system messages
3) Outputs for remote signaling of alarms, or for
4) System diagnostics that include:

a) Test outputs function to verify component operation.
b) Test dehumidifier function, by simulating demand to validate performance.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine for suitable conditions where dehumidification units will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Connect condensate drain pan, extend to nearest equipment, or floor drain. Construct deep trap at connection to drain pan and install cleanout at changes in direction.

B. Connect and ground wiring according to Division 26.

C. Install wall mounted controller and wire to the dehumidifier.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Dehumidification unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 CLEANING

A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.

B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust initial temperature and humidity set points.

3.6 STARTUP SERVICE

A. Perform startup service. Complete installation and startup checks according to manufacturer's written instructions.

B. Perform the following final checks before startup:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations.
5. Check lubrication of bearings and other moving parts.
6. Install clean filters.

C. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain dehumidification units.

END OF SECTION 238416.16

SECTION 261000 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. If the Contractor discovers any ambiguity, error, omission, conflict, or discrepancy, General Conditions Section 101.3.6 Priority of Conflicting Contract Documents shall control.

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

2. State of Maine Department of Transportation, “Standard Specifications,” Revision December 2014, and any revisions thereto, apply to this Section.

1.2 SUMMARY

A. The electrical requirements included herein apply to the necessary installation provisions required for the heating, ventilation and dehumidification equipment and other associated electrical scope related to this project.

B. Alternates: Refer to Division 01 to determine extent of, if any, work of this section that will be affected by any alternates if accepted.

C. Furnish all materials, equipment, labor, and supplies and perform all operations necessary to complete the electrical work in accordance with the intent of the drawings and these specifications.

1.3 QUALITY ASSURANCE

A. All wiring shall be in accordance with the state adopted issue of the National Electrical Code that is in effect at the time of the contract.

B. Ground Resistance Testing:

1. Measure ground resistance with bridge type meter designed for testing grounds.

2. Record readings, conditions of soil, model of meter, date, and name of tester.

3. Conduct test in presence of Owner or his Representative. The test shall be made no less than 48 hours after a rain.

C. The Contractor shall show evidence, upon request, of having successfully completed at least five similar projects. Installation of each system shall be under the supervision of a factory-authorized organization.

D. The Contractor shall show evidence, upon request, that he maintains a fully equipped service organization capable of furnishing adequate inspection and service to the system. The Contractor must have a service contract program for the maintenance of the system after the guarantee period.

E. All electrical equipment shall be listed by Underwriters Laboratories, Inc. Each system shall be products of a single manufacturer of established reputation and experience. The Contractor shall have supplied similar apparatus to comparable installations rendering satisfactory service for at least three years.

F. For each system, the manufacturer shall furnish "gratis" to the Owner a one-year contract effective from the date of installation for maintenance and inspection services of the manufacturer's equipment with a minimum of two inspections during the contract year.

1.4 SUBMITTALS

A. In accordance with Division 01, furnish the following:

1. Manufacturer's descriptive literature: For each type of product indicated.

2. Submit shop drawings which include engineering drawings of the system with specification sheets covering all component parts of the system and interconnection diagrams.

3. Certification:

a. Prior to final inspection, deliver to the Owner's Representative certification that the material is in accordance with the drawings and specifications and has been properly installed.

b. Submit certification of system operating test.

4. Manuals: Submit copies of complete set of operating instructions including circuit diagrams and other information of system components.

1.5 PROJECT CONDITIONS

A. Regulatory Requirements:

1. Conform to the requirements of all laws and regulations applicable to the work.

2. Cooperate with all authorities having jurisdiction.

3. Compliance with laws and regulations governing the work on this project does not relieve the Contractor from compliance with more restrictive requirements contained in these specifications.

4. If the Contract Documents are found to be at variance with any law or regulation, the Contractor shall notify the Architect/Engineer promptly in writing. The Contractor shall assume full responsibility for any work contrary to law or regulation, and shall bear all costs for the corrections thereof.

5. Minimum Requirements: The National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL), the National Fire Codes, and National Fire Protection Association (NFPA) are a minimum requirement for work under this section. Design drawings and other specification sections shall govern in those instances where requirements are greater than those required by code.

B. Permits, Fees, and Inspections:

1. Secure and pay for all permits, fees, licenses, inspections, etc., required for the work under Division 26.

2. Schedule and pay for all legally required inspections and cooperate with inspecting officers.

3. Provide Certificates of Inspection and Approval from all regulatory authorities having jurisdiction over the work in Division 26.

C. Drawings:

1. Do not scale the drawings. The general location of the apparatus and the details of the work are shown on the drawings, which form a part of this specification. Exact locations are to be determined at the building as the work progresses, and shall be subject to the Architect/Engineer's approval. Actual field conditions shall govern all dimensions.

2. Anything shown on the drawings and not mentioned in the specifications or vice versa shall be provided as if it were both shown and specified.

3. It is not intended that the drawings shall show every wire, device, fitting, conduit or appliance, but it shall be a requirement to furnish without additional expense, all material and labor necessary to complete the systems in accordance with applicable codes and the best practice of the trade.

1.6 WARRANTY

A. The Contractor shall guarantee all equipment and wiring free from inherent mechanical or electrical defects for one year from date of acceptance.

1.7 RELATED WORK

A. Division 23 - Mechanical

PART 2 - PRODUCTS

2.1 MATERIALS

A. Receptacles shall be specification grade, mounted 18" above finished floor unless otherwise noted.

1. Provide type TR tamper-resistant where required by code.

2. Provide type WR weather-resistant where required by code.

B. Duplex Receptacles With Ground-Fault Interrupter shall be an integral unit suitable for mounting in a standard outlet box.

1. Ground-Fault Interrupter shall consist of a differential current transformer, solid state sensing circuitry and a circuit interrupter switch. It shall be rated for operation on a 60 Hz, 120-volt, 20-ampere branch circuit. Device shall have nominal sensitivity to ground leakage current of five milliamperes and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes on the load side of the device. Device shall have a minimum nominal tripping time of 1/30th of a second.

2. Receptacle shall be rated 20 amperes, 125 volts for indoor use and shall be the standard duplex, three-wire, grounding type.

3. Provide type WR weather-resistant where required by code.

C. Weatherproof Receptacles shall consist of a duplex GFI receptacle, as specified, mounted in a weatherproof box with a gasketed, weatherproof, cast metal cover plate. The weatherproof integrity shall not be affected when heavy duty specification or hospital grade attachment plug caps are inserted. Cover plates on outlet boxes mounted flush in the wall shall be gasketed to the wall in a watertight manner.

D. Plates shall be 302 stainless steel or PVC with tamper-proof screws.

E. Boxes shall be 302 stainless steel or PVC; minimum 2-1/2" deep.

F. Light Fixtures: The light fixtures shall be as described on the drawings or approved equal.

G. Disconnect Switches shall be heavy-duty type, horsepower rated.

H. Motor Starters:

1. Manual motor starters shall be toggle-switch type with melting alloy thermal overload relay. Thermal units shall be one-piece construction and interchangeable. Starter shall be inoperative with thermal unit removed. Contacts shall be double break, silver alloy. Starters in finished areas shall be flush mounted over the light switch at 60" above finished floor. Starters shall be mounted behind stainless steel device plate and shall have adjacent pilot lights. Square D Class 2510 Type FS-1P-FL1 or approved equal. Starters in unfinished areas shall be surface mounted 60" above finished floor. Square D Class 2510 Type FG-5P or approved equal.

2. Magnetic motor starters shall be combination circuit breaker or fused disconnect switch type, mounted in a common enclosure. Starters shall be three-pole with three melting alloy overload relays. Overload heaters shall be coordinated with Division 23. Thermal units shall be of one-piece construction and interchangeable. Starter shall be inoperative with any thermal unit removed. The disconnect operating handle shall be position indicating.

    a. Provide a control device and pilot light on the cover of each combination starter. Control devices for motors with remote manual or automatic control shall be "hand-off-auto" switches. Control devices for locally controlled motors shall be "start-stop" pushbuttons.

    b. 120-volt magnetic motor starters may consist of a circuit breaker or fused disconnect switch and a magnetic starter in separate enclosures mounted next to each other.

    c. Control circuits shall operate at a maximum of 120 volts. Provide control transformers as required.

3. Starters shall be mounted within NEMA-1 enclosures unless specified otherwise.

4. All starters shall be lockable in the "off" position.

5. Overload heaters shall be sized for the motor nameplate full-load amperes per the manufacturer's recommendations.

I. Wiring Materials:

1. Wiring shall be enclosed in electrical conduit (non-metallic when inside the tunnel) sized in accordance with code requirements for the conductors. Types MC or NM cable may be used where concealed in walls or ceilings and allowed by code.

    a. Conduit fittings shall be non-metallic type (when inside the tunnel).

    b. Terminations for all conduit shall have insulated bushings or insulated throat connectors in accordance with code requirements.

    c. All conduits shall be substantially supported with approved clips or hangers spaced not to exceed ten feet on center. Minimum conduit size shall be 1/2".

2. Interior Surface Metal Raceway (where permitted by the NEC for areas outside the tunnel): UL 5 listed.

a. Not permitted inside the tunnel locations; PVC only in tunnel area.

b. Boxes and fittings for surface metal raceways shall be as recommended by the manufacturer.

c. Support clips for surface metal raceways shall be the concealed type, with attachment screws concealed behind the raceway.

3. Flexible Metal Conduit shall be used for all connections to motors and vibrating equipment and shall comply with Fed. Spec. WW-C-566.

4. Liquid-Tight Flexible Metal Conduit shall consist of flexible steel conduit with a liquid-tight PVC jacket over the conduit.

a. Fittings shall incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening.

b. Liquid-tight flexible metal conduit shall be used in damp or wet locations when flexible metal conduit would otherwise be used.

c. Liquid-tight flexible metal conduit shall not penetrate the roof or exterior walls, and shall not be installed in lengths exceeding 72” except where necessary for flexibility.

5. Nonmetallic Conduit: Fed. Spec. W-C-1094, Type II or Type III shall apply. Conduit shall be Schedule 40 heavy wall PVC or high density PE. Conduit shall be UL listed for use above ground and direct burial underground and be sunlight resistant.

6. All Wiring shall be type THW, XHHW, or THWN, UL labeled, copper conductors with 600-volt insulation, except as otherwise noted. Minimum size wire shall be No. 12 AWG.

7. Type MC Cable shall have minimum No. 12 AWG type THWN or XHHW insulated copper conductors with an internal bare or insulated copper ground wire.

J. Fire-Stop Material:

1. Fire-stopping material shall maintain its dimension and integrity while preventing the passage of flame, smoke, and gases under conditions of installation and use when exposed to the ASTM E 119 time-temperature curve for a time period equivalent to the rating of the assembly penetrated. Cotton waste shall not ignite when placed in contact with the non-fire side during the test. Fire-stopping material shall be noncombustible as defined by ASTM E 136; and in addition for insulation materials, melt point shall be a minimum of 1700^{o}F for one-hour protection and 1850^{o}F for two-hour protection.

2. Seals for floor, exterior wall, and roof shall also be watertight.

K. Circuit Breakers: Circuit breakers to be added to existing panelboards shall match existing circuit breakers.

L. Grounding Conductors:

1. Grounding conductors shall be soft-drawn bare copper.

2. Insulated grounding wires shall be UL and NEC approved types, copper, with THWN or XHHW insulation color identified green, except where otherwise shown on the drawings or specified.

3. Wire shall not be less than shown on the drawings and not less than required by the NEC.

M. Equipment Grounding Connections: Connections shall be of the compression type solderless connectors.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. All work shall be in accordance with the National Electrical Code's requirements as amended to date, with the local electric utility company's rules, the Fire Underwriter's requirements, and all local, state and federal laws and regulations.

2. In general, all wiring in finished areas shall be concealed in walls or above ceilings. Where wiring cannot be concealed due to existing construction, exposed wiring shall be installed in conduit or surface metal raceway as indicated on the drawings. Exposed wiring shall not be installed in finished areas without prior written authorization from the Engineer.

3. Conduits shall be of sizes required by the National Electrical Code. Exposed conduits shall be installed with runs parallel or perpendicular to walls and ceiling, with right-angle turns consisting of bends, fittings, or outlet boxes. No wire shall be installed until work that might cause damage to wires or conduits has been completed. Conduits shall be thoroughly cleaned of water or other foreign matter before wire is installed.

4. Where conduits, wireways and other electrical raceways pass through fire partitions, fire walls, or floor, install a fire-stop that provides an effective barrier against the spread of fire, smoke and gases. Fire-stop material shall be packed tight and completely fill clearances between raceways and openings. Floor, exterior wall, and roof seals shall also be made watertight.

5. Where raceways puncture roof, coordinate with Division 07.

6. Raceway penetrations through roof and exterior walls shall be made with rigid metal conduit, intermediate metal conduit, or EMT with compression fittings.

7. Surface metal raceways shall be sized as required by the National Electrical code and as recommended by the manufacturer. Surface metal raceways shall be installed with runs parallel or perpendicular to walls and ceiling. Changes in direction shall only be made at

device box locations or with fittings designed for the particular application. Installation shall be as visually unobtrusive as possible:

a. Surface metal raceways shall be painted to match wall finishes.

8. All splices shall be mechanically and electrically perfect, using crimp type wire connectors.

9. Provide all disconnect switches required by the N.E.C.

10. Locate motor starters as shown on drawings.

11. Mount disconnect switches and starters at a height of 60" above finished floor unless otherwise noted.

12. Provide all necessary hardware for mounting motor starters.

13. A typewritten schedule of circuits, approved by the Owner's Representative shall be on the panel directory cards. Type the room numbers and items served on the cards. Three-complete separate copies of all directories, neatly bound, shall be delivered to the Owner's Representative.

14. Revise existing panelboard directories. Furnish new cards as needed. Directories shall be typewritten or printed using a computer.

15. Circuit numbers indicated on the drawings are the actual numbers assigned to the circuit in the panelboard and shall not be varied without the consent of the Architect/Engineer.

16. Branch circuit wiring may be nonmetallic-sheathed cable where concealed and allowed by Code, Type NM. NOTE: All romex shall be Properly Supported. (Provide continuous ground wire.)

17. Underground wiring may be installed in rigid nonmetallic conduit. In locations where nonmetallic conduits are used, change to heavy wall metallic conduit of the same internal diameter before rising out of ground. Provide metallic conduit elbows.

    a. Pitch conduits a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

    b. Provide a means for drainage, such a hole drilled in the bottom of the conduit, at low point of underground conduits. Coordinate drainage with Divisions 31 and 33.

18. Feeder circuit wiring shall be in conduit or EMT.

19. All wiring in outside walls shall be in conduit or EMT.

20. All wiring in masonry walls shall be in conduit or EMT.

21. In general, conductors shall be the same size from the last protective device to the load and shall have an ampacity the same as or greater than the ampacity of the protective device where the wire size is not shown on the drawings. Use the 60°C ampacity rating for wire sizes No. 12 through No. 1. For 120V circuits, home runs longer than 100 feet shall be minimum No. 10 AWG, longer than 200 feet shall be minimum No. 8 AWG.

B. Grounding:

1. The entire electrical system shall be permanently and effectively grounded in accordance with Code requirements. Maintain the existing grounding systema and verify its performance and integrity.

2. Connections to junction boxes, equipment frames, etc., shall be bolted.

3. Conduit Systems:

a. Ground all metallic conduit systems.

b. Conduit systems shall contain a grounding conductor sized per NEC Table 250-122 or as shown on the drawings. Increase conduit size where necessary to accommodate the grounding conductor.

4. Feeders and Branch Circuits: Install green grounding conductors with all feeders and branch circuits.

5. Bare copper ground conductors shall be painted with bitumastic paint where they enter and leave concrete structures.

6. Bare copper ground conductors shall be a minimum of 30" below finished grade.

7. Lighting Fixtures: Conduits shall not be used for grounding fixtures. Green equipment grounding conductor must be bonded to all fixtures.

C. Alterations:

1. The Contractor shall study all drawings and specifications, visit the site, and acquaint himself with the existing conditions and the requirements of the plans and specifications. No claim will be recognized for extra compensation due to the failure of the Contractor to familiarize himself with the conditions and extent of the proposed work.

2. The Contractor shall execute all alterations, additions, removals, relocations or new work, etc., as indicated or required to provide a complete installation in accordance with the intent of the drawing and specifications.

3. Reconnect existing circuits to remain. Remove existing equipment to be discontinued.

4. Any existing work disturbed or damaged by the alterations or new work shall be repaired or replaced to the Engineer's satisfaction.

5. Equipment relocated or removed and reinstalled shall be cleaned and repaired to a first-class condition before reinstallation.

D. Continuity of Services: Arrange to execute work at such times and in such locations to provide uninterrupted service to the building or any of its sections. If necessary, temporary power shall be installed to provide for this condition. Authorization for interrupting service shall be obtained in writing from the Owner. Any interruption of normal supply shall be performed during an overtime period to be scheduled with the Owner. Cost for overtime work shall be included in the bid.

E. Identification:

1. Provide tags on each end of all pulled wires giving location of other end.

2. Provide phenolic nameplates for all panelboards, motor starters, disconnect switches (except switches located at motors), and duct smoke detector remote test/alarm-indicating stations.

3. Label each receptacle faceplate and equipment disconnect using machine-printed thermal adhesive labels to indicate source panel and branch circuit. For receptacles connected to normal power, labels shall be white with black letters. For receptacles connected to circuits from operational standby (OS) panels, labels shall be red with white letters.

F. Record Drawings: The Contractor shall keep on the job a set of prints showing any changes to the installation. These shall be given to the Engineer at the completion of the work.

G. Testing and Adjusting:

1. The entire installation shall be free from short-circuits and improper grounds. Tests shall be made in the presence of the Engineer or his representatives.

2. Each individual lighting circuit shall be tested at the panel; and in testing for insulation resistance to ground, the lighting equipment shall be connected for proper operation. In no case shall the insulation resistance be less than that required by the National Electrical Code. Failures shall be corrected in a manner satisfactory to the Architect/Engineer.

3. Each system shall be completely tested and shall be adjusted for proper operation as required by the Engineer.

END OF SECTION 261000