

RFP 825984/KM - ADDENDUM 1

Bid Closing: **May 20, 2019** at **2:00 PM** (Local

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Time) Bid Number: **825984/KM**

Date: **April 22, 2019**

BID MUST BE SUBMITTED ON OR ATTACHED TO THIS SIGNED FORM

RETURN BIDS AS SHOWN BELOW

Copies of bid, descriptive literature or supplemental materials required:

Seven (7) Copies

FAX or TELEX Bids Permitted: ☐ YES ☒ NO

U.S. Mail /Hand Delivery/Express Mail/Courier Service

Address: (Including Federal Express, UPS, etc.)

The University of Texas MD Anderson Cancer Center
Attn: Supply Chain Management
7007 Bertner, Suite 10.3212
Houston, Texas 77030

BIDS MUST BE SUBMITTED IN A SEALED ENVELOPE IDENTIFIED BY THE COMPANY NAME. BID NUMBER MUST BE SHOWN ON THE LOWER LEFT HAND CORNER OF THE ENVELOPE.

BIDS MAY BE SUBMITTED AT ANY TIME UNTIL BID CLOSING DATE.

THE UNIVERSITY OF TEXAS MD ANDERSON CANCER CENTER RESERVES THE RIGHT TO REJECT ANY AND ALL BIDS OR ANY PART THEREOF.

BIDDER MUST COMPLETE AND SIGN BELOW

Company Name: _____

Mailing Address: _____

(STREET OR BOX #)

(CITY) (STATE) (ZIP)

Telephone No.: _____ / _____

AC

Email Address: _____

(Authorized Signature)

(DATE)

(Typed or Printed Name and Title)

THIS RFP ADDENDUM IS A FURTHERANCE OF A SOLICITATION FOR PROPOSALS AND IS NOT A CONTRACT OR OFFER TO CONTRACT.

Griffin Animal Building Crawlspace Improvements

1. Project Manual is attached.
2. Project Drawings are attached.

Karrie McKeown (Sourcing Specialist)
E-Mail address: kmckeown@mdanderson.org

GRIFFIN ANIMAL BUILDING CRAWLSPACE IMPROVEMENTS

THE UNIVERSITY OF TEXAS

MD Anderson
Cancer Center

Making Cancer History®

SCIENCE PARK - DEPARTMENT OF
EPIGENETICS AND MOLECULAR CARCINOGENESIS
SMITHVILLE, TEXAS

MD ANDERSON PROJECT NO. 15-0005
100% CONSTRUCTION DOCUMENTS

OCTOBER 12, 2018



MD ANDERSON PROJECT MANAGER

CODY CHRISTIAN
M.D. ANDERSON CANCER CENTER
RESEARCH & EDUCATION FACILITIES
1808 PARK ROAD 1C
SMITHVILLE, TEXAS 78957
512-237-6483

PRIME CONSULTANT / MEP ENGINEER

Tom Green & Company
Engineers, Inc.
© 2018 Tom Green & Co. Engineers, Inc.
Texas Firm Registration No. F-2929 TGCE NO. 1311.00
3701 EXECUTIVE CENTER DRIVE SUITE 258
AUSTIN, TEXAS 78731 (512)345-7793

CIVIL ENGINEER

STANSBERRY ENGINEERING CO.
P.O. BOX 309
MANCHACA, TX 78662
512-292-8000
WWW.STANSBERRYENGINEERING.COM
TEXAS REGISTERED ENGINEERING FIRM F-8276

ARCHITECT/STRUCTURAL ENGINEER

WJE
ENGINEERS
ARCHITECTS
MATERIALS SCIENTISTS
Wiss, Janney, Elstner Associates, Inc.
9511 NORTH LAKE CREEK PARKWAY
AUSTIN, TX 78717
512-257-4800
WWW.WJE.COM
TEXAS REGISTERED ENGINEERING FIRM F-0093

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Project Manual

for

The University of Texas MD Anderson Cancer Center
Houston, Texas

Griffin Animal Building Crawl Space Improvements

MD ANDERSON PROJECT : 15-0005

A/E PROJECT : 1311.00

PROJECT DELIVERY METHOD : Competitive Sealed Proposal (CSP)

100% Construction Documents – October 12, 2018

Project Manual

for

The University of Texas MD Anderson Cancer Center
Houston, Texas

Griffin Animal Building Crawl Space Improvements

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PROJECT DELIVERY METHOD : Competitive Sealed Proposal (CSP)

100% Construction Documents – October 12, 2018

OWNER'S REPRESENTATIVE

Cody Christian - FPDC

MD Anderson Cancer Center

1808 Park Road 1C
Smithville, Texas 78957
(512) 237-6483 (phone); (512) 237-9408 (fax)

PROJECT ENGINEER

Tod Thompson, P.E.
Tom Green and Company Engineers, Inc.
3701 Executive Center Drive, Suite 258
Austin, Texas 78731
(512) 345-7793 (phone); (512) 345-7201 (fax)

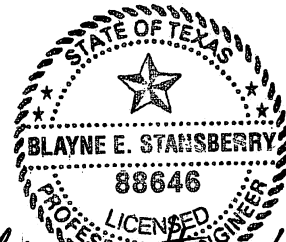


10/12/18

PROJECT ENGINEER'S CONSULTANTS

Civil Engineer:

Blayne Stansberry, P.E.
Stansberry Engineering Company, Inc.
P.O. Box 309
Manchaca, Texas 78652
(512) 292-8000 (phone); (512) 292-7270 (fax)



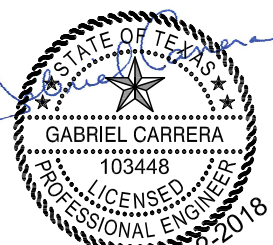
10/12/18

Architect / Structural Engineer:

Jeff Russell, A.I.A. / Gabriel Carrera, P.E.
Wiss, Janney, Elstner Associates, Inc.
9511 North Lake Creek Parkway
Austin, TX 78717
Tel: (512) 257-4800 Fax: (512) 219-9883



10/12/18



10-12-2018

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The Uniform General Conditions for University of Texas System Building Construction Contracts and the Division 00 and Division 01 Specification Sections have been Issued Under Separate Cover (IUSC) as Exhibits to the Agreement Between Owner and Contractor.

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DIVISION 00	PROCUREMENT AND CONTRACTING REQUIREMENTS	
	2013 Uniform General Conditions for University of Texas System Building Construction Contracts	IUSC
00 25 00	Owners Special Conditions	IUSC
00 25 00 A	Attachment “A” - Minimum Wage Rate Determination	IUSC
00 25 00 B	Attachment “B” - Facilities Planned Utility Outages Policy	IUSC

B - SPECIFICATIONS GROUP

DIVISION 01	GENERAL REQUIREMENTS	
01 31 00	Project Administration	IUSC
01 32 00	Project Planning and Scheduling	IUSC
01 35 16	Alteration Project Procedures	IUSC
01 35 25	Owner Safety Requirements	IUSC
01 35 25 A	Attachment “A” - Maintaining Indoor Air Quality During Construction And Maintenance Activities Policy	IUSC
01 45 00	Project Quality Control	IUSC
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01 91 00	General Commissioning Requirements	IUSC

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03 30 00	Cast-In-Place Concrete	

DIVISION 07	THERMAL AND MOISTURE PROTECTION	REVISION
07 13 10	Self-Adhering Sheet Water Proofing	
07 21 19	Foamed-in-Place Insulation	
07 62 00	Sheet Metal Work	

DIVISION 20	COMMON FIRE SUPPRESSION, PLUMBING AND HVAC REQUIREMENTS	REVISION
20 01 00	Basic, Plumbing and HVAC Requirements	
20 05 13	Motors	
20 05 53	Piping and Equipment Identification	
20 08 00	HVAC Systems Commissioning	
20 08 13	HVAC Systems Prefunctional Checklists and Start-Ups	
20 08 16	HVAC Systems Functional Performance Tests	

DIVISION 22	PLUMBING	REVISION
22 10 00	Plumbing Piping	
22 10 30	Plumbing Specialties	

DIVISION 23	HEATING, VENTILATING, AND AIR CONDITIONING	REVISION
23 05 90	Contractor Coordination with Testing, Adjusting and Balancing	
23 05 93	System Testing, Adjusting and Balancing	
23 31 00	Ductwork	
23 33 00	Ductwork Accessories	
23 34 23	Power Ventilators	

DIVISION 25	INTEGRATED AUTOMATION	REVISION
25 00 10	Building Automation Systems (BAS) General - Retrofit	
25 08 00	BAS Commissioning	
25 11 10	BAS Basic Materials, Interface Devices, and Sensors (Retrofit)	
25 14 10	BAS Field Panels - Retrofit	
25 15 10	BAS Software And Programming - Retrofit	

DIVISION 26	ELECTRICAL	REVISION
26 01 00	Basic Electrical Requirements	
26 05 19	Cable, Wire and Connectors, 600 Volt	
26 05 26	Grounding	
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DIVISION 26	ELECTRICAL	REVISION
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26 29 14	Motor Starters	

DIVISION 31	EARTHWORK	REVISION
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31 40 00	Hydraulic Cement Concrete	
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31 40 12	Sidewalks	
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32 10 00	Sodding	
32 29 11	Topsoil	

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33 23 20	Utility Backfill Materials	
33 25 06	Polyvinyl Chloride Pipe	

END OF SECTION 00 01 10

SECTION 03 30 00 – CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.03 QUALITY ASSURANCE

- A. Codes and Standards: Comply with provisions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified:
 - 1. American Concrete Institute (ACI):
 - a. 117: Specification for Tolerances for Concrete Construction and Materials and Commentary.
 - b. 301: Specifications for Structural Concrete for Buildings.
 - c. 305R: Guide to Hot Weather Concreting.
 - d. 306R: Guide to Cold Weather Concreting.
 - e. 347: Guide to Formwork for Concrete.
 - 2. Concrete Reinforcing Steel Institute (CRSI) "Manual of Standard Practice."
 - 3. ASTM International:
 - a. C31: Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - b. C33: Standard Specification for Concrete Aggregates.
 - c. C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

- d. C42: Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
 - e. C94: Standard Specification for Ready-Mixed Concrete.
 - f. C143: Standard Test Method for Slump of Hydraulic-Cement Concrete.
 - g. C150: Standard Specification for Portland Cement.
 - h. C171: Standard Specification for Sheet Materials for Curing Concrete.
 - i. C172: Standard Practice for Sampling Freshly Mixed Concrete.
 - j. C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
 - k. C260M: Standard Specification for Air-Entraining Admixtures for Concrete.
 - l. C309: Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - m. C494: Standard Specification for Chemical Admixtures for Concrete.
 - n. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - o. C856: Standard Practice for Petrographic Examination of Hardened Concrete.
 - p. C1064: Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
- B. Contractor Qualifications: Experienced firm that has successfully completed concrete work similar in material, design, and extent to that indicated for Project. Must have successful construction with specified materials in local area in use for minimum of 5 years.
- 1. Employ foreman with minimum 5 years of experience as foreman on similar projects, who is fluent in English, to be on Site at all times during Work. Do not change foremen during course of Project except for reasons beyond control of Contractor; inform Engineer in advance of any changes.
 - 2. Provide at least one individual who is certified by ACI as Finisher/Technician for type of work being performed, during concrete pours.
- C. Ready-Mix Supplier Qualifications: ASTM C94/C94M; Certification of Production Facilities and Delivery Vehicles by National Ready Mixed Concrete Association.
- D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and all admixtures from the same manufacturer.
- E. Mockup: Cast mockup of size indicated or as required to demonstrate typical joints, form tie spacing, and proposed surface finish, texture, and color. Maintain sample panel exposed to view for duration of Project, after Owner's acceptance of visual qualities.

1. Demolish mockup and remove from Site when directed by Owner.

1.04 OWNER/CONTRACTOR RESPONSIBILITIES

- A. Owner will retain a qualified testing agency to provide Field Quality Control Testing. Testing agency to submit field quality control test reports within 3 days of results and include the following in addition to ASTM reporting requirements:
 1. Name of project, Contractor, and supplier
 2. Proprietary product name and required strength
 3. Placement location of concrete
 4. Description of weather and air temperature at time of placement
 5. Compressive strength (ASTM C109)
 6. Date tested
 7. Type of curing
 8. Compliance with specifications
- B. Contractor is responsible for properly scheduling the testing agency retained by the Owner, for obtaining and distributing test reports in a timely manner, and for coordinating as required.

1.05 SUBMITTALS

- A. Product Data:
 1. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, waterstops, joint systems, curing compounds, dry shake finish materials, and others if requested by Owner.
 - a. Include Material Safety Data Sheets
 2. Design Mixes: For each concrete mixture, include:
 - a. Proportions of materials.
 - b. Mill test certificate for cement and report of fly ash.
 - c. Sieve analysis for fine and coarse aggregate.
 - d. Test results for deleterious substances in aggregates and potential aggregate reactivity.
 - e. Slump during laboratory tests.
 - f. Air content during laboratory tests.
 - g. 3-, 7-, and 28-day laboratory compression test results. Minimum 3 cylinders at each test age.

h. Indicate:

- 1) Maximum amount of water that may be added at site. Mix must still satisfy specified water-cementitious content after addition. No water addition will be permitted if not indicated on batch ticket.
- 2) Range of high-range, water-reducing admixture dosage that may be added at Site without adversely affecting hardened concrete.

B. Samples:

1. Samples of materials including names, sources, and descriptions, as follows:

- a. Normal weight aggregates.
- b. Reglets.
- c. Waterstops.
- d. Vapor retarder/barrier.
- e. Form liners.

C. Shop Drawings:

1. Shop Drawings for formwork indicating fabrication and erection of forms for specific finished concrete surfaces. Show form construction including jointing, special form joints or reveals, location and pattern of form tie placement, and other items that affect exposed concrete visually.
2. Shop Drawings for reinforcement detailing fabricating, bending, and placing concrete reinforcement. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures" showing bar schedules, stirrup spacing, bent bar diagrams, and arrangement of concrete reinforcement. Include special reinforcing required for openings through concrete structures.
3. Review is for general architectural applications and features only. Designing formwork for structural stability and efficiency is Contractor's responsibility.

D. Record Documents:

1. Laboratory test reports for concrete materials and mix design test.
2. Material certificates in lieu of material laboratory test reports when permitted by Owner. Material certificates shall be signed by manufacturer and Contractor, certifying that each material item complies with or exceeds specified requirements. Provide certification from admixture manufacturers that chloride content complies with specification requirements.
3. Batch tickets for ready mix concrete.

1.06 WARRANTY

1. Written warranty signed by Contractor, including

- a. Repair or replace concrete repairs that show evidence of material degradation (except for minor weathering), cracking (other than isolated hairline drying shrinkage cracks), delamination, spalling or corrosion (other than continuing corrosion beyond the limits of the repair).
 - b. Upon notification of such defects, make necessary repairs or replacement, including necessary repairs at no cost to Owner and at convenience of the Owner. Repair work shall be in accordance with the requirements of these Contract Documents.
 - c. Repair or replacement work shall include necessary repairs to affected concrete coatings.
2. Warranty Period: 3 years after Substantial Completion date.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 FORM MATERIALS

- A. Forms for Exposed Finish Concrete: Plywood, metal, metal framed plywood faced, or other acceptable panel type materials to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on Drawings.
1. Use overlaid plywood complying with U.S. Product Standard PS 1 "A C or B B High Density Overlaid Concrete Form," Class I.
 2. Use plywood complying with U.S. Product Standard PS 1 "B B (Concrete Form) Plywood," Class I, Exterior Grade or better, mill oiled and edge sealed, with each piece bearing legible inspection trademark.
- B. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or another acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration to match Owner's control sample. Provide solid backing and form supports to ensure stability of textured form liners.
- D. Forms for Cylindrical Columns and Supports: Metal, glass fiber reinforced plastic, or paper or fiber tubes that will produce smooth surfaces without joint indications. Provide units with sufficient wall thickness to resist wet concrete loads without deformation.
- E. Carton Forms (optional): Sure Void or equal. Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

- F. Form Release Agent: Provide commercial formulation form release agent with a maximum of 350 g/L volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
- G. Form Ties: Factory fabricated, adjustable length, removable or snap off metal form ties designed to prevent form deflection and to prevent spalling of concrete upon removal. Provide units that will leave no metal closer than 1-1/2 inches to the plane of the exposed concrete surface.
 - 1. Provide ties that, when removed, will leave holes not larger than 1 inch in diameter in the concrete surface.

2.03 REINFORCING MATERIALS

- A. Reinforcing Bars: ASTM A 615, Grade 60, deformed
- B. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI specifications.
 - 1. For slabs on grade, use supports with sand plates or horizontal runners where base material will not support chair legs.
 - 2. For exposed to view concrete surfaces where legs of supports are in contact with forms, provide supports with legs that are protected by plastic (CRSI, Class 1) or stainless steel (CRSI, Class 2).

2.04 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Type I/II.
 - 1. Use one brand of cement throughout Project unless otherwise acceptable to Owner.
- B. Fly Ash: ASTM C 618, Type F or C.
- C. Silica Fume: ASTM C 1240.
- D. Normal Weight Aggregates: ASTM C33/C33M or ASTM C330; from single source with documented record of at least 10 years of satisfactory service using similar aggregates and cementitious materials in similar applications and service conditions.
 - 1. Coarse Aggregates: 3/4-inch maximum size.
 - 2. Alkali Reactivity: Coarse and fine aggregates shall have expansion indicative of innocuous behavior; that is, less than 0.10 percent expansion after 16 days; with tested according to ASTM C1260, or mitigating measures shall be included in concrete mix.
 - a. Provide ASTM C1260 test results for aggregates proposed for use, performed within last year.

- b. If reported expansion is 0.10% or more at 16 days after casting, use mitigation measures shown to render innocuous results when tested according to ASTM C1260 or provide coarse and fine aggregates from remote source, with expansion indicative of innocuous behavior with tested according to ASTM C1260. ASTM C1293 procedure may be substituted for ASTM C1260.

E. Water: Potable

- F. Admixtures, General: Provide concrete admixtures that contain not more than 0.1 percent chloride ions. Do not use admixtures containing calcium chloride.

- G. Air Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures. Subject to compliance with requirements, provide one of the following:

- 1. Air Tite, Cormix Construction Chemicals
- 2. Air Mix or Perma Air, Euclid Chemical Co.
- 3. Darex AEA or Daravair, W.R. Grace & Co.
- 4. MB VR or Micro Air, Master Builders, Inc.
- 5. Sealtight AEA, W.R. Meadows, Inc.
- 6. Sika AER, Sika Corp.

- H. Water Reducing Admixture: ASTM C 494, Type A. Subject to compliance with requirements, provide one of the following:

- 1. Chemtard, ChemMasters Corp.
- 2. PSI N, Cormix Construction Chemicals
- 3. Eucon WR 75, Euclid Chemical Co.
- 4. WRDA, W.R. Grace & Co.
- 5. Pozzolith Normal or Polyheed, Master Builders, Inc.
- 6. Metco W.R., Metalcrete Industries
- 7. Prokcrete N, Prokcrete Industries
- 8. Plastocrete 161, Sika Corp.

- I. High Range Water Reducing Admixture: ASTM C 494, Type F or Type G. Subject to compliance with requirements, provide one of the following:

- 1. Super P, Anti Hydro Co., Inc.
- 2. Cormix 200, Cormix Construction Chemicals
- 3. Eucon 37, Euclid Chemical Co.

4. WRDA 19 or Daracem, W.R. Grace & Co.
 5. Rheobuild or Polyheed, Master Builders, Inc.
 6. Superslump, Metalcrete Industries
 7. PSPL, Prokrete Industries
 8. Sikament 300, Sika Corp.
- J. Water Reducing, Accelerating Admixture: ASTM C 494, Type E. Subject to compliance with requirements, provide one of the following:
1. Q Set, Conspec Marketing & Manufacturing Co.
 2. Lubricon NCA, Cormix Construction Chemicals
 3. Accelguard 80, Euclid Chemical Co.
 4. Daraset, W.R. Grace & Co.
 5. Pozzutec 20, Master Builders, Inc.
 6. Accel Set, Metalcrete Industries
- K. Water Reducing, Retarding Admixture: ASTM C 494, Type D. Subject to compliance with requirements, provide one of the following:
1. PSI R Plus, Cormix Construction Chemicals
 2. Eucon Retarder 75, Euclid Chemical Co.
 3. Daratard 17, W.R. Grace & Co.
 4. Pozzolite R, Master Builders, Inc.
 5. Protard, Prokrete Industries
 6. Plastiment, Sika Corp.

2.05 RELATED MATERIALS

- A. Reglets: Where sheet flashing or bituminous membranes are terminated in reglets, provide reglets of not less than 0.0217 inch thick (26 gage) galvanized sheet steel. Fill reglet or cover face opening to prevent intrusion of concrete or debris.
- B. Dovetail Anchor Slots: Hot dip galvanized sheet steel, not less than 0.0336 inch thick (22 gage) with bent tab anchors. Fill slot with temporary filler or cover face opening to prevent intrusion of concrete or debris.
- C. Waterstops: Provide bentonite strip type waterstops; "Volclay Waterstop RX" by American Colloid Co.

- D. Waterstops: Provide flat, dumbbell type or centerbulb type waterstops at construction joints and other joints as indicated. Size to suit joints.
- E. Rubber Waterstops: Corps of Engineers CRD C 513. Subject to compliance with requirements, provide products of one of the following:
 - 1. The Burke Co.
 - 2. Progress Unlimited
 - 3. Williams Products, Inc.
- F. Polyvinyl Chloride Waterstops: Corps of Engineers CRD C 572. Subject to compliance with requirements, provide products of one of the following:
 - 1. The Burke Co.
 - 2. Greenstreak Plastic Products Co.
 - 3. W.R. Meadows, Inc.
 - 4. Progress Unlimited
 - 5. Schlegel Corp.
 - 6. Vinylex Corp.
- G. Sand Cushion: Clean, manufactured or natural sand
- H. Vapor Retarder: Provide vapor retarder that is resistant to deterioration when tested according to ASTM E 154, as follows:
 - 1. Polyethylene sheet not less than 8 mils thick.
 - 2. Water resistant barrier consisting of heavy kraft papers laminated together with glass fiber reinforcement and overcoated with black polyethylene on each side.
 - a. Product: Subject to compliance with requirements, provide Moistop by Fortifiber Corporation.
- I. Vapor Barrier: Premolded seven ply membrane consisting of reinforced core and carrier sheet with fortified bitumen layers, protective weathercoating, and plastic antistick sheet. Water vapor transmission rate of 0.00 grains per square foot per hour when tested according to ASTM E 96, Method B. Provide manufacturer's recommended mastics and gusset tape.
 - 1. Product: Subject to compliance with requirements, provide Sealtight Premoulded Membrane by W.R. Meadows, Inc.
- J. Nonslip Aggregate Finish: Provide fused aluminum oxide granules or crushed emery as the abrasive aggregate for a nonslip finish, with emery aggregate containing not less than 50 percent aluminum oxide and not less than 25 percent ferric oxide. Use material that is factory graded, packaged, rustproof, nonglazing, and unaffected by freezing, moisture, and cleaning materials.

- K. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.
- L. Moisture Retaining Cover: One of the following, complying with ASTM C 171.
1. Waterproof paper
 2. Polyethylene film
 3. Polyethylene coated burlap (white)
- M. Liquid Membrane Forming Curing Compound: Liquid type membrane forming curing compound complying with ASTM C 309, Type I, Class A. Moisture loss not more than 0.55 kilograms per square meter when applied at 200 square feet per gallon.
1. Provide material that has a maximum volatile organic compound (VOC) rating of 350 millograms per liter.
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. A H 3 Way Sealer, Anti Hydro Co., Inc.
 - b. Spartan Cote, The Burke Co.
 - c. Conspec #1, Conspec Marketing & Mfg. Co.
 - d. Sealco 309, Cormix Construction Chemicals
 - e. Day Chem Cure and Seal, Dayton Superior Corp.
 - f. Eucocure, Euclid Chemical Co.
 - g. Horn Clear Seal, A.C. Horn, Inc.
 - h. L&M Cure R, L&M Construction Chemicals, Inc.
 - i. Masterkure, Master Builders, Inc.
 - j. CS 309, W.R. Meadows, Inc.
 - k. Seal N Kure, Metalcrete Industries
 - l. Kure N Seal, Sonneborn Chemrex
 - m. Stontop CS2, Stonhard, Inc.
- N. Water Based Acrylic Membrane Curing and Sealing Compound: ASTM C 309, Type I, Class B. Subject to compliance with requirements, provide one of the following:
1. Highseal, Conspec Marketing and Mfg. Co.
 2. Sealco VOC, Cormix Construction Chemicals
 3. Safe Cure and Seal, Dayton Superior Corp.

4. Aqua Cure, Euclid Chemical Co.
 5. Dress & Seal WB, L&M Construction Chemicals, Inc.
 6. Masterkure 100W, Master Builders, Inc.
 7. Vocomp 20, W.R. Meadows, Inc.
 8. Metcure, Metalcrete Industries
 9. Stontop CS1, Stonhard, Inc.
- O. Evaporation Control: Monomolecular film forming compound applied to exposed concrete slab surfaces for temporary protection from rapid moisture loss. Subject to compliance with requirements, provide one of the following:
1. Aquafilm, Conspec Marketing and Mfg. Co.
 2. Eucobar, Euclid Chemical Co.
 3. E Con, L&M Construction Chemicals, Inc.
 4. Confilm, Master Builders, Inc.
 5. Waterhold, Metalcrete Industries

2.06 PROPORTIONING AND DESIGNING MIXES

- A. Prepare design mixes for each type and strength of concrete determined by either laboratory trial mixes or field-test data, according to ACI 301.
1. Use qualified independent testing agency for preparing and reporting proposed mix designs for laboratory trial mix basis.
- B. Proportion normal-weight concrete mix as follows:
1. 28-day Compressive Strength: 4,000 pounds per square inch.
 2. Maximum Water-Cementitious Materials Ratio, by weight: 0.45.
 3. Slump: 3 to 5 inches maximum.
 - a. With High-Range, Water-Reducing Admixture:
 - 1) 7 to 9 inches maximum slump.
 4. Air Content: Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having air content of 4.5 +/- 1.5 percent, unless otherwise indicated.
 5. Admixtures: Use admixtures according to manufacturer's written instructions.
 - a. Use water-reducing admixture. Alternately use high-range, water-reducing admixture (superplasticizer), as required, for placement and workability.

- b. Use retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
- 6. No chlorides shall be intentionally introduced into concrete mix.
 - a. In hardened concrete, limit acid-soluble chloride ion content to 0.10 percent by weight of cement when tested according to ASTM C1152/C1152M, or water-soluble chloride ion content to 0.08 percent by weight of cement when tested according to ASTM C1218/C1218M.
 - b. If hardened concrete exceeds chloride ion limits above, limit water-extractable chloride ion content to 0.08 percent by weight of cement when tested according to ASTM C1524.
 - c. Provide test results necessary to demonstrate concrete or aggregates do not exceed chloride ion limits, unless waived by Engineer.
- C. Submit written reports to Owner of each proposed mix for each class of concrete at least 15 days prior to start of Work. Do not begin concrete production until proposed mix designs have been reviewed by Owner.
- D. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, as accepted by Owner. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Owner before using in Work.

2.07 ADMIXTURES

- A. Use water reducing admixture or high range water reducing admixture (superplasticizer) in concrete, as required, for placement and workability.
- B. Use accelerating admixture in concrete slabs placed at ambient temperatures below 50 degrees F (10 degrees C).
- C. Use high range water reducing admixture in pumped concrete, concrete for heavy use industrial slabs, architectural concrete, parking structure slabs, concrete required to be watertight, and concrete with water cement ratios below 0.50.
- D. Use air entraining admixture in exterior exposed concrete unless otherwise indicated. Add air entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having total air content with a tolerance of plus or minus 1½ percent within the following limits:
 - 1. Concrete structures and slabs exposed to freezing and thawing, deicer chemicals, or hydraulic pressure:
 - a. 4.5 percent (moderate exposure); 5.5 percent (severe exposure) for 1½ inch maximum aggregate.
 - b. 4.5 percent (moderate exposure); 6.0 percent (severe exposure) for 1 inch maximum aggregate.

- c. 5.0 percent (moderate exposure); 6.0 percent (severe exposure) for $\frac{3}{4}$ inch maximum aggregate.
 - d. 5.5 percent (moderate exposure); 7.0 percent (severe exposure) for $\frac{1}{2}$ inch maximum aggregate.
- 2. Other concrete not exposed to freezing, thawing, or hydraulic pressure, or to receive a surface hardener: 2 to 4 percent air.
- E. Use admixtures for water reduction and set accelerating or retarding in strict compliance with manufacturer's directions.

2.08 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94/C94M, and furnish batch ticket information.
 - 1. Deliver concrete to Site and discharge within 90 minutes after introduction of mix water. When air temperature is between 85 and 90 degrees F, reduce mixing and delivery time to 75 minutes; when air temperature is above 90 degrees F, reduce mixing and delivery time to 60 minutes. Due to nature of Work, trucks with short loads may be required. Concrete that exceeds specified time limit may be rejected at Testing Agency, Engineer, or Owner's Representative's discretion.
 - 2. Do not add water-reducing or high-range, water-reducing admixture indiscriminately to increase slump.
 - 3. Introduce high-range, water-reducing admixture at Site with additional mixing per manufacturer's recommendations.
 - 4. Reject concrete that arrives at Site with slump exceeding maximum specified slump.
- B. Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M.
 - 1. Develop batching and mixing operations so that quality control is assured.
 - 2. Designate 1 or 2 individuals to batch and mix concrete. Fully instruct these individuals on batching and mixing procedures. No other persons shall batch or mix concrete without prior notification to Engineer.
 - 3. Maintain accurate mix proportions. Batch materials by weight on basis of whole bags of cement. Maintain calibrated scale at Site during concrete placement operations. Batching by volume is permitted if weight-volume relationship for each material is verified on daily basis.
 - 4. Incorporate admixtures into mix in manner recommended by manufacturer and approved by Engineer. Measure with accuracy of ± 3 percent. Add each admixture separately.
 - 5. Combine and mix ingredients to uniform consistency.
 - 6. Mix concrete materials in appropriate drum-type batch machine mixer.

- a. For mixer capacity of 1 cubic yard or smaller, mix at least 1 1/2 minutes, but not more than 5 minutes after ingredients are in mixer.
- b. For mixer capacity larger than 1 cubic yard, increase mixing time by 15 seconds for each additional 1 cubic yard.
- c. Provide sufficient number of mixers, including reserve mixers, so that concrete placement operations will proceed uninterrupted and each patch is completely cast before patch concrete achieves initial set.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Coordinate the installation of joint materials, vapor retarder/barrier, and other related materials with placement of forms and reinforcing steel.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.

3.03 FORMS

- A. General: Design, erect, support, brace, and maintain formwork to support vertical, lateral, static, and dynamic loads that might be applied until concrete structure can support such loads. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position. Maintain formwork construction tolerances and surface irregularities complying with the following ACI 347 limits:
 1. Provide Class A tolerances for concrete surfaces exposed to view.
 2. Provide Class C tolerances for other concrete surfaces.
- B. Construct forms to sizes, shapes, lines, and dimensions shown and to obtain accurate alignment, location, grades, level, and plumb work in finished structures. Provide for openings, offsets, sinkages, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in the Work. Use selected materials to obtain required finishes. Solidly butt joints and provide backup at joints to prevent cement paste from leaking.
- C. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like for easy removal.

- D. Provide temporary openings for clean outs and inspections where interior area of formwork is inaccessible before and during concrete placement. Securely brace temporary openings and set tightly to forms to prevent losing concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- E. Chamfer exposed corners and edges as indicated, using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.
- F. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses, and chases from trades providing such items. Accurately place and securely support items built into forms.
- G. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before placing concrete. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

3.04 VAPOR RETARDER/BARRIER INSTALLATION

- A. General: Place vapor retarder/barrier sheeting in position with longest dimension parallel with direction of pour.
- B. Lap joints 6 inches and seal with manufacturer's recommended mastic or pressure sensitive tape.
 - 1. Cover vapor retarder/barrier with sand cushion and compact to depth indicated.

3.05 PLACING REINFORCEMENT

- A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports and as specified.
 - 1. Avoiding cutting or puncturing vapor retarder/barrier during reinforcement placement and concreting operations. Repair damages before placing concrete.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.
- C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as approved by Owner.
- D. Place reinforcement to maintain minimum coverages as indicated for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.
- E. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.06 JOINTS

- A. Construction Joints: Locate and install construction joints so they do not impair strength or appearance of the structure, as acceptable to Owner.
- B. Provide keyways at least 1½ inches deep in construction joints in walls and slabs and between walls and footings. Bulkheads designed and accepted for this purpose may be used for slabs.
- C. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints except as indicated otherwise. Do not continue reinforcement through sides of strip placements.
- D. Use bonding agent on existing concrete surfaces that will be joined with fresh concrete.
- E. Waterstops: Provide waterstops in construction joints as indicated. Install waterstops to form continuous diaphragm in each joint. Support and protect exposed waterstops during progress of Work. Field fabricate joints in waterstops according to manufacturer's printed instructions.
- F. Isolation Joints in Slabs on Grade: Construct isolation joints in slabs on grade at points of contact between slabs on grade and vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
- G. Contraction (Control) Joints in Slabs on Grade: Construct contraction joints in slabs on grade to form panels of patterns as shown. Use saw cuts 1/8 inch wide by one fourth of slab depth or inserts 1/4 inch wide by one fourth of slab depth, unless otherwise indicated.
 - 1. Form contraction joints by inserting premolded plastic, hardboard, or fiberboard strip into fresh concrete until top surface of strip is flush with slab surface. Tool slab edges round on each side of insert. After concrete has cured, remove inserts and clean groove of loose debris.
 - 2. Contraction joints in unexposed floor slabs may be formed by saw cuts as soon as possible after slab finishing as may be safely done without dislodging aggregate.
 - 3. If joint pattern is not shown, provide joints not exceeding 15 feet in either direction and located to conform to bay spacing wherever possible (at column centerlines, half bays, third bays).
 - 4. Joint fillers and sealants are specified in Division 07 Section "Joint Sealants."

3.07 INSTALLING EMBEDDED ITEMS

- A. General: Set and build into formwork anchorage devices and other embedded items required for other work that is attached to or supported by cast in place concrete. Use setting Drawings, diagrams, instructions, and directions provided by suppliers of items to be attached.
- B. Install reglets to receive top edge of foundation sheet waterproofing and to receive through wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, relieving angles, and other conditions.
- C. Install dovetail anchor slots in concrete structures as indicated on Drawings.

- D. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and contours in finished surfaces. Provide and secure units to support screed strips using strike off templates or compacting type screeds.

3.08 PREPARING FORM SURFACES

- A. General: Coat contact surfaces of forms with an approved, nonresidual, low VOC, form coating compound before placing reinforcement.
- B. Do not allow excess form coating material to accumulate in forms or come into contact with in place concrete surfaces against which fresh concrete will be placed. Apply according to manufacturer's instructions.
 - 1. Coat steel forms with a nonstaining, rust preventative material. Rust stained steel formwork is not acceptable.

3.09 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. General: Comply with ACI 304, "Guide for Measuring, Mixing, Transporting, and Placing Concrete," and as specified.
- C. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened sufficiently to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation at its final location.
- D. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers no deeper than 24 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.
 - 1. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete complying with ACI 309.
 - 2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mix to segregate.
- E. Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until completing placement of a panel or section.
 - 1. Consolidate concrete during placement operations so that concrete is thoroughly worked around reinforcement, other embedded items and into corners.

2. Bring slab surfaces to correct level with a straightedge and strike off. Use bull floats or darbies to smooth surface free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations.
 3. Maintain reinforcing in proper position on chairs during concrete placement.
- F. Cold Weather Placement: Comply with provisions of ACI 306 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
- G. When air temperature has fallen to or is expected to fall below 40 degrees F (4 degrees C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 degrees F (10 degrees C) and not more than 80 degrees F (27 degrees C) at point of placement.
1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 2. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.
- H. Hot Weather Placement: When hot weather conditions exist that would impair quality and strength of concrete, place concrete complying with ACI 305 and as specified.
1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 90 degrees F (32 degrees C). Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover reinforcing steel with water soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.
 3. Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without puddles or dry areas.
 4. Use water reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, as acceptable to Owner.

3.10 FINISHING FORMED SURFACES

- A. Rough Formed Finish: Provide a rough formed finish on formed concrete surfaces not exposed to view in the finished Work or concealed by other construction. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched, and fins and other projections exceeding 1/4 inch in height rubbed down or chipped off.

- B. Smooth Formed Finish: Provide a smooth formed finish on formed concrete surfaces exposed to view or to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such as waterproofing, dampproofing, veneer plaster, painting, or another similar system. This is an as cast concrete surface obtained with selected form facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch defective areas with fins and other projections completely removed and smoothed.
- C. Smooth Rubbed Finish: Provide smooth rubbed finish on scheduled concrete surfaces that have received smooth formed finish treatment not later than 1 day after form removal.
 - 1. Moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
- D. Grout Cleaned Finish: Provide grout cleaned finish on scheduled concrete surfaces that have received smooth formed finish treatment.
 - 1. Combine one part portland cement to one and one half parts fine sand by volume, and a 50:50 mixture of acrylic or styrene butadiene based bonding admixture and water to form the consistency of thick paint. Blend standard portland cement and white portland cement in amounts determined by trial patches so that final color of dry grout will match adjacent surfaces.
 - 2. Thoroughly wet concrete surfaces, apply grout to coat surfaces, and fill small holes. Remove excess grout by scraping and rubbing with clean burlap. Keep damp by fog spray for at least 36 hours after rubbing.
- E. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.11 MONOLITHIC SLAB FINISHES

- A. Scratch Finish: Apply scratch finish to monolithic slab surfaces to receive concrete floor topping or mortar setting beds for tile, portland cement terrazzo, and other bonded applied cementitious finish flooring material, and where indicated.
 - 1. After placing slabs, finish surface to tolerances of F(F) 20 (floor flatness) and F(L) 15 (floor levelness) measured according to ASTM E 1155. Slope surfaces uniformly to drains where indicated. After leveling, roughen surface before final set with stiff brushes, brooms, or rakes.
- B. Float Finish: Apply float finish to monolithic slab surfaces to receive trowel finish and other finishes as specified; slab surfaces to be covered with membrane or elastic waterproofing, membrane or elastic roofing, or sand bed terrazzo; and where indicated.

1. After screeding, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating, using float blades or float shoes only, when surface water has disappeared, or when concrete has stiffened sufficiently to permit operation of power driven floats, or both. Consolidate surface with power driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to tolerances of F(F) 18 (floor flatness) and F(L) 15 (floor levelness) measured according to ASTM E 1155. Cut down high spots and fill low spots. Uniformly slope surfaces to drains where indicated. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.
- C. Trowel Finish: Apply a trowel finish to monolithic slab surfaces exposed to view and slab surfaces to be covered with resilient flooring, carpet, ceramic or quarry tile, paint, or another thin film finish coating system.
 1. Uniformly slope surfaces to drains where indicated. After floating, begin first trowel finish operation using a power driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand troweling operation, free of trowel marks, uniform in texture and appearance, and finish surfaces to tolerances of F(F) 20 (floor flatness) and F(L) 17 (floor levelness) measured according to ASTM E 1155. Grind smooth any surface defects that would telegraph through applied floor covering system.
- D. Trowel and Fine Broom Finish: Where ceramic or quarry tile is to be installed with thin set mortar, apply a trowel finish as specified, then immediately follow by slightly scarifying the surface with a fine broom.
- E. Nonslip Broom Finish: Apply a nonslip broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated.
 1. Immediately after float finishing, slightly roughen concrete surface by brooming with fiber bristle broom perpendicular to main traffic route. Coordinate required final finish with Owner before application.
- F. Nonslip Aggregate Finish: Apply nonslip aggregate finish to concrete stair treads, platforms, ramps, sloped walks, and where indicated.
 1. After completing float finishing and before starting trowel finish, uniformly spread 25 pounds of dampened nonslip aggregate per 100 square feet of surface. Tamp aggregate flush with surface using a steel trowel, but do not force below surface. After broadcasting and tamping, apply trowel finishing as specified.
 2. After curing, lightly work surface with a steel wire brush or an abrasive stone, and water to expose nonslip aggregate.

3.12 MISCELLANEOUS CONCRETE ITEMS

- A. Filling In: Fill in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as specified to blend with in place construction. Provide other miscellaneous concrete filling shown or required to complete Work.

- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Floor Drains: At all interior floor drain locations, where the entire floor is not indicated to slope to drain, provide a depressed sump approximately 1 inch deep and 12 inches to 18 inches in diameter in the surface of the concrete to facilitate drainage.
- D. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with diagrams or templates of manufacturer furnishing machines and equipment.

3.13 CONCRETE CURING AND PROTECTION

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. In hot, dry, and windy weather protect concrete from rapid moisture loss before and during finishing operations with an evaporation control material. Apply according to manufacturer's instructions after screeding and bull floating, but before power floating and troweling.
- B. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.
- C. Curing Methods: Cure concrete by curing compound, by moist curing, by moisture retaining cover curing, or by combining these methods, as specified.
- D. Provide moisture curing by the following methods:
 - 1. Keep concrete surface continuously wet by covering with water.
 - 2. Use continuous water fog spray.
 - 3. Cover concrete surface with specified absorptive cover, thoroughly saturate cover with water, and keep continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with a 4 inch lap over adjacent absorptive covers.
- E. Provide moisture retaining cover curing as follows:
 - 1. Cover concrete surfaces with moisture retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
- F. Apply curing compound on exposed interior slabs and on exterior slabs, walks, and curbs as follows:
 - 1. Apply curing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly in continuous operation by power spray or roller according to manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.

2. Use membrane curing compounds that will not affect surfaces to be covered with finish materials applied directly to concrete.
- G. Curing Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces, by moist curing with forms in place for the full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.
- H. Curing Unformed Surfaces: Cure unformed surfaces, including slabs, floor topping, and other flat surfaces, by applying the appropriate curing method.
 1. Final cure concrete surfaces to receive finish flooring with a moisture retaining cover, unless otherwise directed.

3.14 SHORES AND SUPPORTS

- A. General: Comply with ACI 347 for shoring and reshoring in multistory construction, and as specified.
- B. Extend shoring from ground to roof for structures four stories or less, unless otherwise permitted.
- C. Extend shoring at least three floors under floor or roof being placed for structures over four stories. Shore floor directly under floor or roof being placed, so that loads from construction above will transfer directly to these shores. Space shoring in stories below this level in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members where no reinforcing steel is provided. Extend shores beyond minimums to ensure proper distribution of loads throughout structure.
- D. Remove shores and reshore in a planned sequence to avoid damage to partially cured concrete. Locate and provide adequate reshoring to support work without excessive stress or deflection.
- E. Keep reshores in place a minimum of 15 days after placing upper tier, or longer, if required, until concrete has attained its required 28 day strength and heavy loads due to construction operations have been removed.

3.15 REMOVING FORMS

- A. General: Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may be removed after cumulatively curing at not less than 50 degrees F (10 degrees C) for 24 hours after placing concrete, provided concrete is sufficiently hard to not be damaged by form removal operations, and provided curing and protection operations are maintained.
- B. Formwork supporting weight of concrete, such as beam soffits, joists, slabs, and other structural elements, may not be removed in less than 14 days or until concrete has attained at least 75 percent of design minimum compressive strength at 28 days. Determine potential compressive strength of in place concrete by testing field cured specimens representative of concrete location or members.

- C. Form facing material may be removed 4 days after placement only if shores and other vertical supports have been arranged to permit removal of form facing material without loosening or disturbing shores and supports.

3.16 REUSING FORMS

- A. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form facing material will not be acceptable for exposed surfaces. Apply new form coating compound as specified for new formwork.
- B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joint to avoid offsets. Do not use patched forms for exposed concrete surfaces except as acceptable to Owner.

3.17 CONCRETE SURFACE REPAIRS

- A. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removing forms, when acceptable to Owner.
- B. Mix dry pack mortar, consisting of one part portland cement to 2½ parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing.
 - 1. Cut out honeycombs, rock pockets, voids over ¼ inch in any dimension, and holes left by tie rods and bolts down to solid concrete but in no case to a depth less than 1 inch. Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush coat the area to be patched with bonding agent. Place patching mortar before bonding agent has dried.
 - 2. For surfaces exposed to view, blend white portland cement and standard portland cement so that, when dry, patching mortar will match surrounding color. Provide test areas at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
- C. Repairing Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of Owner. Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes and fill with dry pack mortar or precast cement cone plugs secured in place with bonding agent.
 - 1. Repair concealed formed surfaces, where possible, containing defects that affect the concrete's durability. If defects cannot be repaired, remove and replace the concrete.
- D. Repairing Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface tolerances specified for each surface and finish. Correct low and high areas as specified. Test unformed surfaces sloped to drain for trueness of slope and smoothness by using a template having the required slope.

1. Repair finished unformed surfaces containing defects that affect the concrete's durability. Surface defects include crazing and cracks in excess of 0.01 inch wide or that penetrate to the reinforcement or completely through nonreinforced sections regardless of width, spalling, popouts, honeycombs, rock pockets, and other objectionable conditions.
 2. Correct high areas in unformed surfaces by grinding after concrete has cured at least 14 days.
 3. Correct low areas in unformed surfaces during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete. Proprietary underlayment compounds may be used when acceptable to Owner.
 4. Repair defective areas, except random cracks and single holes not exceeding 1 inch in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose reinforcing steel with at least $\frac{3}{4}$ inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials to provide concrete of same type or class as original concrete. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
- E. Repair isolated random cracks and single holes 1 inch or less in diameter by dry pack method. Groove top of cracks and cut out holes to sound concrete and clean of dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding compound. Place dry pack before bonding agent has dried. Compact dry pack mixture in place and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.
- F. Perform structural repairs with prior approval of Owner for method and procedure, using specified epoxy adhesive and mortar.
- G. Repair methods not specified above may be used, subject to acceptance of Owner.

3.18 QUALITY CONTROL TESTING DURING CONSTRUCTION

- A. The Owner will employ a testing agency to perform tests and to submit test reports.
- B. Sampling and testing for quality control during concrete placement may include the following, as directed by Owner.
1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
 - a. Slump: ASTM C 143; one test at point of discharge for each day's pour of each type of concrete; additional tests when concrete consistency seems to have changed.
 - b. Air Content: ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231, pressure method for normal weight concrete; one for each day's pour of each type of air entrained concrete.
 - c. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4 deg C) and below, when 80 deg F (27 deg C) and above, and one test for each set of compressive strength specimens.

- d. Compression Test Specimen: ASTM C 31; one set of four standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens except when field cured test specimens are required.
 - e. Compressive Strength Tests: ASTM C 39; one set for each day's pour exceeding 5 cu. yd. plus additional sets for each 50 cubic yards more than the first 25 cubic yards of each concrete class placed in any one day; one specimen tested at 7 days, two specimens tested at 28 days, and one specimen retained in reserve for later testing if required.
- 2. When frequency of testing will provide fewer than five strength tests for a given class of concrete, conduct testing from at least five randomly selected batches or from each batch if fewer than five are used.
 - 3. When total quantity of a given class of concrete is less than 50 cubic yards, Owner may waive strength testing if adequate evidence of satisfactory strength is provided.
 - 4. When strength of field cured cylinders is less than 85 percent of companion laboratory cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in place concrete.
 - 5. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test result falls below specified compressive strength by more than 500 psi.
- C. Test results will be reported in writing to Owner, Structural Engineer, ready mix producer, and Contractor within 24 hours after tests. Reports of compressive strength tests shall contain the Project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7 day tests and 28 day tests.
 - D. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.
 - E. Additional Tests: The testing agency will make additional tests of in place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by Owner. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

3.19 CLEANING

- A. After completing concrete Work:
 - 1. Clean soiling from adjacent surfaces. Exercise care to avoid scratching or damage to surfaces.
 - 2. Repair surfaces stained, marred, or otherwise damaged during concrete Work.

3. Clean up debris and surplus materials and remove from Site.

END OF SECTION 03 30 00

SECTION 07 13 10 SELF-ADHERING SHEET WATERPROOFING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Self-adhering, rubberized-asphalt system for installation on below-grade walls, including primers, mastics, and termination bars. Protection course materials, drainage panels, and filter fabric are also included.

1.02 REFERENCES

- A. American Society for Testing and Materials International (ASTM)
 - 1. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
 - 2. ASTM C836 - Standard Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course.
 - 3. ASTM D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
 - 4. ASTM D570 - Standard Test Method for Water Absorption of Plastics.
 - 5. ASTM D1079 - Standard Terminology Relating to Roofing, Waterproofing, and Bituminous Materials.
 - 6. ASTM D1621 - Standard Test Method for Compressive Properties of Rigid Cellular Plastics.
 - 7. ASTM D1970 - Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection.
 - 8. ASTM D4258 - Standard Practice for Surface Cleaning Concrete for Coatings.
 - 9. ASTM D4259 - Standard Practice for Abrading Concrete.
 - 10. ASTM D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
 - 11. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
 - 12. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

13. ASTM D4716 - Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
14. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
15. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
16. ASTM D5295 - Standard Guide for Preparation of Concrete Surfaces for Adhered (Bonded) Membrane Waterproofing Systems.
17. ASTM D5385 - Standard Test Method for Hydrostatic Pressure Resistance of Waterproofing Membranes.
18. ASTM D5957 - Standard Guide for Flood Testing Horizontal Waterproofing Installations.
19. ASTM D6135 - Standard Practice for Applications of Self-Adhering Modified Bituminous Waterproofing.
20. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
21. ASTM E154 - Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover.

B. International Concrete Repair Institute (ICRI)

1. ICRI No. 03732 - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.

1.03 SUBMITTALS

- A. Product Data: Waterproofing manufacturer's literature including written instructions for evaluating, preparing, and treating substrate; technical data including tested physical and performance properties; and application instructions. Include VOC content of components.
- B. Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.
- C. Samples:
 1. 8-inch by 8-inch square of rubberized asphalt sheet membrane waterproofing.
 2. 4-inch by 4-inch square of drainage mat.
 3. 6-inch long section of termination bar and anchors.

D. Product Test Reports: From qualified independent testing agency indicating and interpreting test results of waterproofing for compliance with requirements, based on comprehensive testing of current waterproofing formulations.

E. Installer Qualifications:

1. Certification signed by waterproofing manufacturer, certifying that Installer complies with manufacturer's requirements to install specified, warranted, waterproofing system.
2. Submit evidence that Installer's existing company has minimum of five years continuous experience in application of specified materials. Submit list of at least five completed projects of similar scope and size, including:

Project name.

Owner's name.

Owner's Representative name, address, and telephone number.

Description of work.

Self-adhering sheet materials used.

Project supervisor.

Total cost of waterproofing work and total cost of project.

Completion date.

F. Sample Warranties: Copies of waterproofing manufacturer's warranty and Installer's warranty, both stating obligations, remedies, limitations, and exclusions. Submitted with bid.

G. Prior to installation of waterproofing system, submit to waterproofing manufacturer's technical services department for review and approval:

1. Manufacturer's Project Registration Form, with information filled out completely and accurately, including deviations from Specification.
2. Complete set of drawings of waterproofing system installation showing substrate limits, outline, dimensions, transitions, and types and locations of penetrations.
3. Atypical or special condition details which are to be used.

H. Following completion of Work, submit waterproofing manufacturer's warranty inspection report(s) and completed warranty; submit completed Installer's warranty.

1.04 QUALITY ASSURANCE

- A. Installer Qualifications: Qualified firm that is approved, authorized, or licensed by waterproofing manufacturer to install waterproofing and that is eligible to receive waterproofing manufacturer's warranty. Must have installations of specified materials in local area in use for minimum of five years.
 - 1. Employ foreman trained by waterproofing manufacturer and with minimum of five years experience as foreman on similar projects, who is fluent in English, to be on site at all times during Work.
- B. Mockups: Construct a mockup for subgrade wall waterproofing. Apply waterproofing to 10 square feet of substrate to demonstrate surface preparation, crack and joint treatment, corner treatment, and execution quality.
 - 1. If Engineer determines mockup does not comply with requirements, modify mockup or construct new mockup until mockup is approved.
 - 2. Approved mockups may become part of completed Work if undisturbed at time of Substantial Completion.
 - 3. Contractor's site foreman, waterproofing membrane manufacturer's technical representative, waterproofing Installer, Owner's Representative, THC Project Reviewer, and Engineer shall attend.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Project site in original packages with seals unbroken, labeled with waterproofing manufacturer's name, product brand name and type, date of manufacture, lot number, and directions for storing and mixing with other components.
- B. Keep materials dry and do not allow materials to be exposed to moisture during transportation, storage, handling, and installation. Reject and remove from Site new materials which exhibit evidence of moisture during application, or have been exposed to moisture.
- C. Store materials in original, undamaged containers in clean, dry, protected location on raised platforms with weather-protective coverings, within temperature range required by waterproofing manufacturer. Protect stored materials from direct sunlight. Waterproofing manufacturer's standard packaging and covering is **not** considered adequate weather protection.
- D. Store rolled goods on ends only, unless otherwise required by waterproofing manufacturer's written instructions. Discard rolls that have been flattened, creased, or otherwise damaged.
- E. Limit stored materials on structures to safe loading of structure at time materials are stored, and to avoid permanent deck deflection.
- F. Handle materials to avoid damage.

- G. Conspicuously mark damaged or opened containers or containers with contaminated materials, and remove from site as soon as possible.
- H. Remove and replace materials that cannot be applied within stated shelf life.

1.06 PROJECT CONDITIONS

- A. Verify existing dimensions and details prior to installation of materials. Notify Engineer of conditions found to be different than those indicated in Contract Documents. Engineer will review situation and inform Contractor and Installer of changes.
- B. Comply with Owner's limitations and restrictions for site use and accessibility.
- C. Environmental Limitations: Apply waterproofing when existing and forecast weather conditions permit waterproofing to be installed according to waterproofing manufacturer's written instructions and warranty requirements.
 - 1. Do not apply when substrate or ambient temperature is below 0 degrees F, or outside of range recommended by waterproofing manufacturer.
 - 2. Do not apply to damp or wet substrate.
- D. Install materials in strict accordance with safety requirements required by waterproofing manufacturer, Material Safety Data Sheets, and local, state, and federal rules and regulations.
- E. Maintain adequate ventilation during preparation and application of waterproofing materials.

1.07 WARRANTY

A. Manufacturer's Warranty:

- 1. Written warranty, signed by waterproofing manufacturer and Installer, including

Repair or replace waterproofing or sheet flashings that do not comply with requirements; that do not remain watertight; that fail in adhesion, cohesion, or general durability; or that deteriorate in manner not clearly specified by submitted waterproofing manufacturer's data as inherent quality of material for application indicated.

Removal and reinstallation of protection board, drainage panels, and insulation. Warranty includes replacing materials as necessary.

Warranty does not include removal or reinstallation of plantings, soil overburden or backfill, concrete or asphalt topping, or paver systems.

- 2. Warranty Period: five years after Substantial Completion date.

B. Installer's Warranty:

- 1. Written warranty, signed by Installer and Contractor, including

Repair or replace waterproofing or sheet flashings that do not comply with requirements; that do not remain watertight; that fail in adhesion, cohesion, or general durability; or that deteriorate in manner not clearly specified by submitted waterproofing manufacturer's data as inherent quality of material for application indicated.

Removal and reinstallation of protection board, drainage panels, and insulation. Warranty includes replacing materials as necessary.

Removal and reinstallation of plantings, soil overburden and backfill, concrete and asphalt topping, and paver systems. Provide new materials to replace materials that are not suitable for reuse, in opinion of Engineer.

Repair or replacement, to satisfaction of Owner, of other work or items which may have been displaced or damaged as consequence of defective work.

Make immediate emergency repairs within forty-eight (48) hours of notice of leakage.

2. Warranty Period: two years after Substantial Completion date.

PART 2 - PRODUCTS

2.01 RUBBERIZED-ASPHALT SHEET

- A. Source Limitations: Obtain materials through one source from single waterproofing manufacturer, or from sources approved by waterproofing manufacturer.
- B. General: 60-mil-(0.060-inch) thick, self-adhering sheet; consisting of 56 mils of rubberized asphalt laminated to 4-mil-thick, polyethylene film with release liner on adhesive side; with following properties measured per test methods referenced.
 - 1. Tensile Strength: ASTM D412, Die C, modified - 250 pounds per square inch minimum.
 - 2. Ultimate Elongation: ASTM D412, Die C, modified - 300 percent minimum.
 - 3. Low-Temperature Flexibility: ASTM D1970 - Pass at minus 20 degrees F.
 - 4. Crack Cycling: ASTM C836 - Unaffected after 100 cycles of 1/8-inch movement.
 - 5. Puncture Resistance: ASTM E154 - 40 pounds-force minimum.
 - 6. Hydrostatic-Head Resistance: ASTM D5385 - 150 feet minimum.
 - 7. Water Absorption: ASTM D570 - 0.15 percent weight-gain maximum after 48-hour immersion at 70 degrees F.
 - 8. Vapor Permeance: ASTM E96, Water Method - 0.05 perms.
- C. Use one of following products or approved equal.

1. Bituthene 3000, manufactured by W. R. Grace & Co.
2. CCW MiraDRI 860, manufactured by Carlisle Coatings & Waterproofing Inc.

2.02 AUXILIARY MATERIALS

- A. General: Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with sheet waterproofing.
 1. Furnish liquid-type auxiliary materials that comply with VOC limits of authorities having jurisdiction.
- B. Primer: Liquid solvent-borne primer recommended for substrate by waterproofing manufacturer of sheet waterproofing material.
- C. Sheet Strips: Self-adhering, rubberized-asphalt composite sheet strips of same material and thickness as sheet waterproofing.
- D. Liquid Membrane: Elastomeric, two-component liquid; cold-fluid-applied, trowel-grade, or low viscosity.
- E. Substrate Patching Membrane: Low-viscosity, two-component, asphalt-modified coating.
- F. Mastic, Adhesives, and Tape: Liquid mastic and adhesives, and adhesive tapes recommended by waterproofing manufacturer.

2.03 DRAINAGE PANEL/PROTECTION COURSE

- A. Molded-Sheet Drainage Panel: "Hydroduct 220" as manufactured by Grace Construction Products, or approved equivalent. Prefabricated, composite drainage panels, manufactured with permeable, geotextile facing laminated to molded-plastic-sheet drainage core. Drainage composite shall be designed to promote positive drainage while serving as a protection course.
 1. Drainage Core: Three-dimensional, nonbiodegradable, molded-plastic-sheet material designed to effectively drain water under backfill pressure; complying with the following properties.

Compressive Strength: ASTM D1621 - 15,000 pounds per square foot minimum.

2. Accessories: Manufacturer's standard corner connectors and pipe inlet tee connectors.

2.04 ACCESSORIES

- A. Termination Bars: Type 304 stainless steel or aluminum; approximately 1-inch wide by 1/8-inch thick; with predrilled holes at 8 inches on center, or as recommended by waterproofing membrane manufacturer and approved by Engineer.
- B. Fasteners

1. For fastening into concrete substrates: Mushroom-head, type 304 stainless steel; 1/4-inch diameter with 1-1/4 inch minimum embedment, such as Zamac Nailin fasteners manufactured by Power Fastening, Inc. or Rawl Plug Company, Inc.
 2. For fastening into masonry substrates: Mushroom-head, type 304 stainless steel; 1/4-inch diameter with 1-1/4 inch minimum embedment, such as those manufactured by Olympic Manufacturing Group.
 3. For fastening into sheet metal substrates: No. 8-18 by 1-1/4 inch long, made of corrosion-resistant materials or coated for corrosion resistance, such as TEK screws manufactured by ITW Builders, Elco Industries, Inc. or Rawl Plug Company, Inc.
 4. For fastening into wood: Corrosion-resistant steel nails with 1-inch-minimum diameter, corrosion-resistant, washer heads of same material as nail. Nail length shall be sufficient to provide 1-1/2 inch minimum embedment into wood substrate.
- C. Draw bands: Stainless steel draw band as recommended by waterproofing manufacturer to terminate around round pipes.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions with Installer and waterproofing manufacturer's representative for compliance with requirements and other conditions affecting performance of waterproofing.
1. Ensure that Work done by other trades is complete and ready to receive waterproofing.
 2. Notify Engineer in writing of conditions which may adversely affect waterproofing system installation or performance. Do not proceed with waterproofing installation until these conditions have been corrected and reviewed by Engineer.

3.02 COORDINATION

- A. Coordinate Work to ensure that adjacent areas are not adversely affected. Coordinate:
1. With Owner's Representative.
 2. With other trades to avoid or minimize work on, or in immediate vicinity of, installation in progress.

3.03 SURFACE PREPARATION

- A. Clean and prepare cementitious parge coating substrate according to waterproofing manufacturer's written instructions and recommendations in ASTM D5295. Provide clean, dust-free, and dry substrate for waterproofing application.

1. Verify that parging has cured and aged for minimum time period recommended by waterproofing manufacturer.
 2. Verify that substrate is sound and is visibly dry and free of moisture. Test for moisture vapor emission by plastic sheet method according to ASTM D4263.
 3. Verify that concrete curbs, expansion joints, and transitions from one surface plane to another (inside and outside corners) are cleanly formed and free of broken edges and excess concrete.
 4. Remove fins and projections, splatter, and other surface irregularities which would prevent monolithic, continuous application of waterproofing.
 5. Properly patch substrate defects (such as voids, form tie holes, honeycombing, and cracks) with additional layer of cementitious parge coating or another material acceptable to waterproofing manufacturer and Engineer.
 6. Remove grease, oil, asphalt solids, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from parging.
 7. Clean surface by abrasive blasting or other approved means to achieve level of surface preparation recommended by waterproofing manufacturer.
- B. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.
- C. Installer and waterproofing manufacturer's representative shall examine substrate to ensure that it is properly prepared and ready to receive waterproofing. Waterproofing manufacturer's representative shall report in writing to Installer and Engineer conditions which will adversely affect waterproofing system installation or performance. Do not proceed with waterproofing installation until these conditions have been corrected and reviewed by Engineer.
- D. Proceed with installation only after unsatisfactory conditions have been corrected. Commencing installation constitutes acceptance of work surfaces and conditions.

3.04 FLASHING INSTALLATION

- A. At Non-Moving Cracks and Joints.
1. Prepare and seal joints and cracks in substrate according to Section 07 92 00. Remove dust and dirt from surface by air blast in general accordance with ASTM D4258.
 2. Cracks and Joints over 1/16 inch Wide: Install sheet strips, centered over sealed crack or joint.
 3. Deck-to-Wall Transitions: Prepare, prime, and treat inside and outside corners according to ASTM D6135.

At vertical inside corners, install membrane strips centered at intersection.

At horizontal inside corners, install 3/4-inch fillets of liquid membrane.

- 1) At footing-to-wall intersections, extend liquid membrane each direction from corner or install membrane strip centered over corner.
- 2) At plaza deck-to-wall intersections, extend liquid membrane or sheet strips onto deck waterproofing and to finished height of sheet flashing.

- B. At Walls: Terminate top of wall flashing with termination bar, sealed with mastic.
- C. At Expansion Joints, Isolation Joints, and Discontinuous Deck-to-Wall and Deck-to-Deck Joints (joint with possible movement): Bridge joint with overlapping sheet strips.
1. Invert and loosely lay first sheet strip over center of joint. Firmly adhere second sheet strip to first and overlap to substrate.
- D. At Drains, Terminations, Penetrations, and Protrusions: Prepare, treat, and seal vertical and horizontal surfaces according to ASTM D6135.

3.05 RUBBERIZED-ASPHALT SHEET INSTALLATION

- A. Install self-adhering sheets according to waterproofing manufacturer's written instructions and recommendations in ASTM D 6135.
- B. Apply primer to substrates at required rate and allow to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprime areas exposed for more than twenty-four (24) hours.
- C. Apply and firmly adhere sheets over area to receive waterproofing. Accurately align sheets and maintain uniform 2-1/2 inch minimum lap widths and end laps. Overlap and seal seams and stagger end laps to ensure watertight installation.
1. For horizontal applications, apply sheets from low point to high point of decks to ensure that side laps shed water.
 2. When ambient and substrate temperatures range between 25 and 40 degrees F, use self-adhering, rubberized-asphalt sheets produced for low-temperature application. Do not use low-temperature sheets if ambient or substrate temperature is higher than 60 degrees F.
- D. Apply continuous sheets over sheet strips bridging substrate cracks, construction, and contraction joints.
- E. Seal exposed edges of sheets at terminations not concealed by metal counterflashings or ending in reglets with mastic or sealant.
- F. Provide temporary water cut-offs to prevent water from getting under new membrane. Install water cut-offs at end of each workday and completely remove prior to installation of new membrane on following day. Use specific materials recommended by membrane manufacturer.
- G. Correct deficiencies in, or remove and replace, sheet waterproofing that does not comply with requirements.

1. Repair tears, voids, and lapped seams in waterproofing not complying with requirements.
2. Slit and flatten fishmouths and blisters.
3. Patch defects with sheets extending 6 inches beyond repaired areas in all directions.

H. Before installing protection course, flood test waterproofing and repair any leaks.

3.06 PROTECTION COURSE

- A. Install drainage panel protection course with end joints butted tightly together, before starting subsequent construction operations.
- B. Install filter fabric in accordance with waterproofing manufacturer's written instructions.
 1. Overlap edges at least 12 inches.

3.07 FIELD QUALITY CONTROL

- A. Site Visits by Waterproofing Manufacturer's Representative: Waterproofing manufacturer's representative shall visit site at following times.
 1. At beginning of waterproofing installation to establish standard of quality to be used for remainder of waterproofing Work.
 2. Periodically during Work at critical times and as required to meet provisions of waterproofing manufacturer's warranty.
 3. Submit written report with observations, field decisions, and request for design changes to Engineer for each site visit.
 4. Coordinate site visits with Engineer.

3.08 CLEANING AND PROTECTION

- A. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.
- B. Protect waterproofing from damage and wear during remainder of construction period.
 1. Do not permit foot or vehicular traffic on unprotected waterproofing.
 2. Do not allow waste products (petroleum, grease, oil, solvents, vegetable oil, mineral oil, animal fat, etc.) to come into contact with waterproofing. Exposure to foreign materials or chemical discharges must be presented to waterproofing manufacturer for evaluation to determine impact on waterproofing performance.
- C. Protect installed drainage panels from damage due to ultraviolet light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation

will be subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

- D. Over service life, do not expose waterproofing or accessories to constant temperature in excess of 180 degrees F (i.e., hot pipes and vents, direct steam venting, etc.).

END OF SECTION

SECTION 07 21 19 FOAMED-IN-PLACE INSULATION

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Closed-cell spray polyurethane foam insulation for installation on the underside of the crawlspace floor slab. Transition membranes, sealants, and low-expanding foam insulations are also included.

1.02 REFERENCES

- A. American Society for Testing and Materials International (ASTM)
 - 1. ASTM C 518-04 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter.
 - 2. ASTM D 1621-04a - Standard Test Method for Compressive Properties of Rigid Cellular Plastics.
 - 3. ASTM D 1622-03 - Standard Test Method for Apparent Density of Rigid Cellular Plastics.
 - 4. ASTM D 1623-03 - Standard Test Method for Tensile and Tensile Adhesion Properties for Rigid Cellular Plastics.
 - 5. ASTM D 6226-05 - Standard Test Method for Open Cell Content of Rigid Cellular Plastics.
 - 6. ASTM E 283-04 - Standard Test Method for Determining Rate of Air Leakage.
 - 7. ASTM E 2178-03 - Standard Test Method for Determining Air Permeance
 - 8. ASTM E 84-08 - Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 9. ASTM E 96-05 - Standard Test Method for Water Vapor Transmission of Materials.
 - 10. UL 1715 - 97 - Fire Test of Interior Finish Material. (revisions thru 2008).

1.03 SUBMITTALS

- A. Product Data: Insulation manufacturer's literature including written instructions for evaluating, preparing, and treating substrate; technical data including tested physical and performance properties; application instructions; and Material Safety Data Sheets.
- B. Product Test Reports: From qualified independent testing agency indicating and interpreting test results of insulation for compliance with requirements, based on comprehensive testing of current insulation formulations.

- C. Evaluation Reports: For spray-applied polyurethane foam-plastic insulation, from ICC-ES. Issued by an organization accredited by International Accreditation Services, Inc. (a subsidiary of ICC) indicating the products have a flame spread index < 25, smoke developed index < 450 and complies with all acceptance criteria of the UL 1715, 1040, FM 4880 or NFPA 286 large-scale fire test standards when tested without thermal barriers, ignition barriers or any other fire protective surface(s).
- D. Installer Qualifications:
 - 1. Certification signed by insulation manufacturer, certifying that Installer complies with manufacturer's requirements to install specified insulation system.
 - 2. Submit certificates of completion for all workers of the Center for Polyurethane Industry (CPI) Health and Safety Training Course.

1.04 QUALITY ASSURANCE

- A. Installer Qualifications: Qualified firm that is approved, authorized, or licensed by insulation manufacturer to install insulation. Must have installations of specified materials in local area in use for minimum of five years.
 - 1. Employ foreman trained by insulation manufacturer and with minimum of five years of experience as foreman on similar projects, who is fluent in English, to be on site at all times during Work.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Project site in original packages with seals unbroken, labeled with insulation manufacturer's name, product brand name and type, date of manufacture, lot number, and directions for storing and mixing with other components.
- B. Keep materials dry and do not allow materials to be exposed to moisture during transportation, storage, handling, and installation. Reject and remove from Site new materials which exhibit evidence of moisture during application, or have been exposed to moisture.
- C. Store materials in compliance with insulation manufacturer's recommendations and in original, undamaged containers in clean, dry, protected location on raised platforms with weather-protective coverings, within temperature range required by insulation manufacturer. Protect stored materials from direct sunlight. Insulation manufacturer's standard packaging and covering is **not** considered adequate weather protection.

1.06 PROJECT CONDITIONS

- A. Verify existing dimensions and details prior to installation of materials. Notify Engineer of conditions found to be different than those indicated in Contract Documents. Engineer will review situation and inform Contractor and Installer of changes.
- B. Comply with Owner's limitations and restrictions for site use and accessibility.

- C. Temperature and field conditions: Install products within range of ambient air and substrate temperatures recommended by manufacturer. Do not apply products when substrate has surface moisture or has been contaminated by condensation, rain, mist, fog or snow. It is recommended that spray foam application not be done within 5 degrees F of the dew point.
- D. Install materials in strict accordance with safety requirements required by insulation manufacturer, Material Safety Data Sheets, and local, state, and federal rules and regulations.
- E. Maintain adequate ventilation during preparation and application of insulation materials.

PART 2 - PRODUCTS

2.01 CLOSED CELL SPRAY POLYURETHANE FOAM

- A. Staycell 302 Spray Polyurethane Foam Insulation:
 - 1. Thermal Resistance/Insulation Value (ASTM C-518): R-7.0 per inch
 - 2. Compressive Strength (ASTM D-1621): 41 psi
 - 3. Density (ASTM D-1622): 2.0 pcf
 - 4. Tensile Strength (ASTM D-1623): 58 psi
 - 5. Closed Cell Content (ASTM D-6226): >96%
 - 6. Air Leakage (ASTM E-283): .0010 cfm/ft² @ 1 inch
 - 7. Water Vapor Permeance (ASTM E-96):
 - a. 1.49 perms @ 1 inch
 - b. 0.92 perms @ 1.5 inches
 - c. 0.77 perms @ 2 inches
 - 8. Fire Ratings: ASTM E-84 (tested at 4 inch thickness):
 - a. Flame spread index: <25
 - b. Smoke developed index: <450
 - 9. Manufacturer: Preferred Solutions, Inc.
- B. Staycell ONE STEP 255 Intumescent Spray Polyurethane Foam Insulation:
 - 1. Thermal Resistance/Insulation Value (ASTM C-518): R-4.6 per inch

2. Compressive Strength (ASTM D-1621): 22 psi
3. Density (ASTM D-1622): 2.0 pcf
4. Tensile Strength (ASTM D-1623): 28 psi
5. Closed Cell Content (ASTM D-6226): 90%
6. Air Leakage (ASTM E-283): .0014 cfm/ft² @ 1.25"
7. Water Vapor Permeance (ASTM E-96): .99 perms @ 2.4 inches
8. Fire Ratings: ASTM E-84 (tested at 4 inch thickness):
 - a. Flame spread index: 25
 - b. Smoke developed index: 400
 - c. Passes UL 1715 large-scale, enclosed-room fire test standard when tested exposed without thermal barriers, ignition barriers or any other fire protective surface(s)
9. Manufacturer: Preferred Solutions, Inc.

2.02 AUXILIARY MATERIALS

- A. Transition membranes for joints and transitions:
 1. AIR-SHIELD or AIR-SHIELD LT by W.R. Meadows, Inc.
 2. Blueskin SA or Blueskin SA LT by Henry Corporation.
 3. CCW 705 or CCW 705 LT by Carlisle Coatings and Waterproofing.
- B. Primers to prepare substrates for receipt of transition membranes:
 1. MEL-PRIME Adhesive or MEL-PRIME W/B by W.R. Meadows, Inc.
 2. Blueskin Adhesive or Blueskin LVC Adhesive by Henry Corporation.
 3. CCW-702 WD or CCW-702 LV by Carlisle Coatings and Waterproofing.
- C. Foam stop angle: Plastic angle used for foam stop at terminations and transitions:
 1. Jam-Ex extruded plastic angle or equal made by Exo-Tec Manufacturing, Inc.
- D. Single-component sealant to bond plastic angle to substrate:
 1. Dow 795 silicone building sealant, Dow Corning Corporation.

2. Sikaflex 1A polyurethane sealant, Sika Sarnafil Corporation.
3. Dymonic FC polyurethane sealant, Tremco Corporation.
- E. Portable SPF application units for sealing around penetrations:
 1. Versi-Foam by RHH, Inc.
 2. Froth-Pak, Dow Chemical Company.
 3. Filler Foam by Hilti, Inc.
 4. Touch n' Foam by Convenience Products, Inc.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions over which the spray polyurethane foam insulation will be installed for compliance with requirements.
- B. Verify that surfaces and conditions are suitable prior to commencing work of this section. Do not proceed with installation until unsatisfactory conditions have been corrected.
- C. Ensure items such as hangers for piping and ductwork are installed before work begins.

3.02 SURFACE PREPARATION

- A. Clean, prepare and treat substrate according to manufacturer's written instructions. Provide clean, dust-free and dry substrate for spray polyurethane foam application.
- B. Ensure installed transition membranes and foam stop angles are fully adhered to all applicable surfaces and are capable of receiving spray polyurethane foam.

3.03 PROTECTION

- A. Mask and cover adjacent areas to protect from over spray.
- B. Ensure any required foam stop or back up material are in place to prevent over-spray.
- C. Seal off existing ventilation equipment and ductwork.
- D. Erect barriers, isolate area and post warning signs to advise non-protected personnel to avoid the spray area.

3.04 APPLICATION OF SPRAYED POLYURETHANE FOAM

- A. Spray-application of spray polyurethane foam shall be installed in accordance with manufacturer's written instructions.

- B. Apply only when surfaces and environmental conditions are within limits prescribed by the material manufacturer.
- C. Apply in consecutive passes as recommended by manufacturer to thickness as indicated on drawings and to achieve the specified R-Value.
- D. Staycell® HYBRID System: The Staycell® HYBRID System (comprised of either the Staycell® 302 base layer sprayed at a nominal **1.5 inches thickness** covered by the Staycell ONE STEP® 255 top layer sprayed at a nominal **0.5 inch thickness**) shall be sprayed onto the specified substrates where shown on the applicable drawings.
- E. Do not install spray polyurethane foam within 3 inches of heat emitting devices such as light fixtures and chimneys.
- F. Remove masking materials and overspray from adjacent areas after the foam surface has hardened. Ensure cleaning methods do not damage work performed by other sections.
- G. Trim as required any excess thickness that would interfere with the installation of the interior finish (steel framing, gypsum board, etc.) by other trades.
- H. Clean and restore surfaces soiled or damaged by Work of the section.
- I. Do not permit adjacent Work to be damaged by Work of this section. Damage to work of this section caused by other trades shall be repaired at the expense of the subcontractor causing the damage.

3.05 FIELD QUALITY CONTROL

- A. Daily records: The applicator shall keep daily records as to the square feet of surface sprayed each day, quantities of all materials used and thickness tests performed. One thickness test shall be conducted on every 500 square feet of covered surface. Such records shall be provided upon request.
- B. Installed product evaluation: In addition to verifying the thickness of all installed products, the following characteristics shall also be provided:
 - 1. The cellular structure shall be uniform and not be soft or spongy.
 - 2. The foam shall not have areas with hard or brittle sections or improperly proportioned materials.

3.06 SAFETY REQUIREMENTS

- A. Applicator shall comply with all provisions of MSDS sheets for the product.
- B. Ventilation shall be provided to assure fresh air is brought into the area being sprayed. Air shall be exhausted to the outside of the building by utilizing existing fans or by supplemental ventilation.

- C. Disposal of waste materials and containers shall be comply with federal, state and local regulations.

3.07 CLEAN-UP

- A. At the completion of the project, applicator shall clean up and remove from the site all material containers, waste materials and debris.

END OF SECTION

SECTION 07 62 00 SHEET METAL WORK

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes

1. Water Conveyance Sheet Metal

1.02 REFERENCES

A. American Standard for Testing and Materials (ASTM)

1. ASTM A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
2. ASTM A792 - Standard Test method for Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants
3. ASTM B32 - Standard Specification for Solder Metal
4. ASTM D2244 - Standard practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
5. ASTM D4214 - Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films

B. ANSI/SPRI ES-1 - Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems

1.03 QUALITY ASSURANCE

- A. Skilled Workmen - All sheet metal Work shall be fabricated and installed by fully trained, qualified sheet metal mechanics properly skilled to perform the Work in accordance with the standards set forth in these Specifications. Substandard Work will be rejected.
- B. Accepted Flashing Details - In the event field conditions make installation of a flashing detail in accordance with SMACNA or NRCA Details impractical, the Contractor shall submit to the Architect/Engineer for review and approval, a Shop Drawing design for the particular conditions.
- C. For Soldering - reference Revere Copper "Copper and Common Sense" manual.
- D. All sheet metal copings, fasciae, gravel guards, and other metal edges shall be tested in accordance with ANSI/SPRI ES-1 to confirm and demonstrate performance under wind pressures generated by the design wind speeds.

1.04 SUBMITTALS

- A. Product Data Sheets - For each type of product indicated. Include material descriptions, ASTM standards, and dimensions of individual components and profiles.
- B. Shop Drawings - If Contractor proposes changes to flashing assemblies detailed in the Drawings, submit detailed Shop Drawings as necessary to illustrate the changes, and obtain Architect/Engineer's written acceptance prior to fabrication.
- C. Submit Samples - Prior to mass fabrication, submit to the Architect/Engineer physical samples of each of the following:
 - 1. Fasteners to anchor metal Work
 - 2. Color sample for prefinished metal

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Storage Compliance - Deliver, store, and handle all sheet metal Work in a covered container.

1.06 WARRANTY

- A. Special Warranty on Metal Finish (Prefinished Sheet Metal): Warranty form shall be a Single Source Twenty-Year Metal Finish Warranty in which manufacturer agrees to repair finish or replace sheet metal that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Exposed Finish: Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Hunter units when tested according to ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested according to ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - 2. Finish Warranty Period: Twenty years from date of Substantial Completion.

1.07 PROJECT/SITE CONDITIONS

- A. Dimensions Approximate - Dimensions as contained in these Specifications or as scaled from Detail Drawings shall be presumed to be approximate. In the event that site conditions uncovered during the Work require modification to, or alteration of those Specifications, the Contractor shall make adjustments as required to comply with that intent.
- B. Coordination with Other Trades - The Work of this Section shall be coordinated with and properly integrated into related Work covered by other Sections.

PART 2 - PRODUCTS

2.01 SHEET METAL

- A. Unless otherwise indicated on the Drawings, the following sheet metal materials and gauges shall apply:
1. Galvalume Sheet Metal - Galvalume coated (aluminum-zinc alloy coated) steel sheet coated on both sides with a layer of aluminum-zinc alloy by continuous hot dip method (approximately 55 percent aluminum, 45 percent zinc). Triple spot minimum 0.55 ounce per square foot as determined by ASTM A792.
 - a. 24-gauge shall be used for copings, sheet metal counterflashing, gravel stop, edge metal, and fascia.
 - b. Prefinished material shall have Kynar 500 finish. Unless otherwise specified, the color selected will be a premium manufacturer's color.
 2. Galvanized Sheet Metal - G-90 coating
 - a. All materials to be soldered shall be G-90 galvanized metal
 - b. 20-gauge shall be used for all wind clips and continuous cleats.
 - c. 24-Gauge shall be used for all metal flashings and for equipment curb flashing.
 3. Stainless Steel Sheet Metal - ASTM A240, Type 304; No. 2B finish; 24 gauge, unless otherwise indicated on the Drawings.

2.02 RELATED MATERIALS – SOLDERING

- A. Solder for Galvanized Metal - 50 percent tin, 50 percent lead - (ASTM B32), for galvanized sheet metal, and ASTM B32, composition 50 percent tin and 50 percent lead for copper sheet metal.
- B. Flux - Rosin, muriatic acid filled with zinc or non-acid type paste.
- C. Solder for Stainless Steel - comply with ASTM B22.

2.03 RELATED MATERIALS - FASTENERS

- A. Roofing Nails - Minimum 1-1/2 inches, hot-dipped galvanized, ring shank, with minimum 3/8-inch head - for nailing concealed cleats to wood substrates, and sheet metal flanges built into membrane.
- B. Flashing Nails - Flashing nails shall be of sufficient length to penetrate a minimum of 1 inch into receiving member. Use *hot dipped galvanized*, ring shank, with minimum 15/16-inch head, as manufactured by Simplex Nail Company, Americus, GA, or approved equal, for top-nailing plies, base flashings, and membrane flashing at "L" nailers and curbs.

- C. Hex-Head Wood Screws - 1-1/2 inches, stainless steel, prefinished, using coating to match the color and finish of the sheet metal to which it is attached, with neoprene washers, to fasten square-to-round counter flashings at curbed penetrations, new expansion joint covers, and copings.
- D. Pop Rivets - Pop rivets shall be No. 44 stainless steel with stainless steel shafts. Pop rivets shall be prefinished using coating to match the color and finish of the sheet metal to which it is attached.
- E. Sheet Metal Screws - All exposed screws used in sheet metal applications shall be stainless steel and be prefinished using coating to match the color and finish of the sheet metal to which it is attached.

2.04 RELATED MATERIALS - BITUMINOUS

- A. Asphalt Primer - (ASTM D41) - for priming metal flanges
- B. Secondary Waterproofing Membrane - Self-Adhering, High-Temperature Sheet, 30 to 40 mils thick minimum, consisting of slip-resisting, polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.
 - 1. Thermal Stability - Stable after testing at 240 degrees F; ASTM D1970.
 - 2. Low-Temperature Flexibility - Passes after testing at minus 20 deg F; ASTM D1970.
 - 3. Products - Subject to compliance with requirements, provide one of the following:
 - a. CCW WIP 300HT: Carlisle Coatings & Waterproofing Inc., Div. of Carlisle Companies Inc.
 - b. GAF Premium Stormguard Film Surfaced Leak Barrier: GAF Materials Corporation.
 - c. Grace Ultra: Grace Construction Products; a unit of Grace, W. R. & Co.
 - d. Titanium PSU 30: InterWrap Inc.
 - e. MetShield: Metal-Fab Manufacturing, LLC.
 - f. WeatherLock Metal High Temperature Underlayment: Owens Corning.
- C. Liquid Membrane - use liquid membrane products that are compatible with the selected secondary waterproofing membrane, as recommended by the material manufacturer.
- D. Flashing Cement - A heavy bodied SBS modified trowel grade asphaltic roof flashing cement to embed flanges of metal flashings; to embed backer plate/cover plate assemblies in gravel guard; and to provide seal as shown in Detail Drawings. Materials shall comply with ASTM D4586 Asphalt Roof Cement, Asbestos Free, Type I.

1. Johns Manville - MBR Utility Cement
2. GAF Matrix SBS - Flashing Cement
3. U.S. Ply, Inc. - DuraFlex™ #954 Premium SBS Flashing Cement
4. Firestone - MB All Purpose Flashing Cement
5. Siplast - PA-828 Flashing Cement

2.05 RELATED MATERIALS - NON BITUMINOUS

- A. Manufactured Expansion Joint Covers - Factory-manufactured expansion joint covers shall not be used in lieu of shop fabricated 24 gauge sheet metal covers unless specifically shown on the Drawings.
- B. Sealants - Refer to Section 07 90 00 Roof-related Joint Sealants
- C. Elastomeric Sealant - one part polyurethane Sonolastic NP-1, as manufactured by BASF, pipe collars, surface-mounted counterflashing, and lap joints in all metal flashings installed above roof-level.
- D. Elastomeric Sealant Primer - Prime all surfaces to receive elastomeric sealant using compatible material approved by the manufacturer of the sealant such as BASF Primer No. 733, or approved equal.
- E. Sealant Tape - polyisobutylene butyl elastic tape, such as Tremco 440 tape, minimum thickness of 1/8-inch with a 3/4-inch minimum width, unless otherwise instructed for use between metal connections, behind flashing termination bars, lap joints in metal flashings, and at coping seams.
- F. Paint Primer - Pittsburgh Paint Galvanized Primer No. 6-209 or approved equal for priming all metal surfaces to be field painted. Color to be chosen by the Owner.
- G. Paint - Pittsburgh Paint Industrial Metal Enamel No. 54-352 or approved equal for field painting of exposed visible face of all metal flashings constructed of paint grip metal. Color to be selected by Owner.
- H. Instant Cold Galvanizing Compound - Aerosol spray instant cold galvanizing compound as manufactured by LPS Inc., or approved equal.
- I. [Copper Through-Wall Flashing - 5 ounces per square foot, Asphalt Coated Copper Flashing - "Multi-flash" by York Manufacturing; "Coated Copper Flashing" by Sandell Manufacturing or "Cop-A-Cote" by AFCO Products. Provide all primers and mastics by same manufacturer.]
- J. [Membrane Flashing - to be used at through-wall flashings in masonry cavity walls.
 1. Self-Adhering, 30 to 60 mils thick, consisting of high density polyethylene file laminated to a layer of rubberized asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by product manufacturer.

2. Thermal Stability - Stable after testing at 240 degrees F; ASTM D1970.
3. Low-Temperature Flexibility - Passes after testing at minus 20 deg F; ASTM D1970.
4. Products - Subject to compliance with requirements, provide one of the following:
 - a. CCW 705 TWF Self Adhered Thru-wall Flashing, as manufactured by Carlisle
 - b. Perm-A-Barrier Wall Flashing, manufactured by Grace Construction Products

PART 3 - EXECUTION

3.01 GENERAL

- A. Precision Fabrication - Fabricate all flashings to exact, uniform, and consistent dimensions and ensure that same are properly fitted and well seated, particularly backer plates and cover plates.
- B. Minimize Joints - Install all continuous flashings of the longest practical length.
- C. Terminations and Intersections - Where flashings terminate or intersect, utilize and comply with methods and procedures as outlined in the latest edition of the "Architectural Sheet Metal Manual" as distributed by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA), the NRCA Roofing and Waterproofing Manual, latest edition, "Copper and Common Sense" manual published by Revere Copper Products, Inc., or "The Copper/Brass/Bronze Design Handbook" published by the Copper Development Association, Inc. Construct terminations and intersections as separate, fixed components independent from intersecting, continuous flashings in such a manner as to absorb thermal movement of adjacent components without stress on mitered joints of terminations and intersections. Each corner leg shall be approximately 18-inch long on each leg.
- D. Conflict Resolution and Authority - In the event any metal flashing component of any flashing is not specifically covered by the Specifications or Drawings, each shall comply with the theory and intent of construction details published by the National Roofing Contractors Association (NRCA) and those of the "Architectural Sheet Metal Manual," Seventh Edition, 2012, as published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
- E. No Dissimilar Metals - In no case, shall dissimilar metals come into contact with each other, nor shall a flashing be constructed in such a way as to permit water from running off one type metal onto another where chemical reaction or corrosion may occur.
- F. Lumber - Sheet metal components, other than nails or screws, shall not come into direct contact with lumber. Wherever lumber is used, a bituminous barrier such as self-adhering waterproofing membrane, or a #30 asphalt saturated roofing felt shall be used as a permanent separator.
- G. Use of Sealants - Sealants shall be used to provide secondary moisture protection, not primary. Wherever elastomeric sealant is used, it shall be applied beneath the component to

be sealed, and both surfaces shall be primed with the primer recommended by the manufacturer. If primer is required, failure to prime the surfaces of components to be sealed will be considered grounds for removal. Sealant shall match the color of the material to which it is being applied. Non-matching color sealant shall be completely removed, the substrate material cleaned, and new matching sealant applied. Where the sealant cannot be removed or the surface cleaned, the substrate material, or sheet metal shall be removed and replaced with clean material.

3.02 WOOD BLOCKING AND NAILERS

- A. Materials and installation of wood blocking and nailers are specified elsewhere. Contractor providing Work under this Section shall, however, comply with the following procedures.
- B. Edge Securement - The Contractor shall notify the Architect/Engineer of any securement deficiency prior to installation of any sheet metal components. Sheet metal attached to improperly secured wood blocking or nailers shall be removed at the Contractor's expense and reinstalled after the securement has been corrected. Anchor wood blocking and nailers to structure at:
 - 1. 4 feet on center with 1/2-inch anchor bolts at CMU and concrete walls, except two feet on center for 8'-0" from outside building corners.
 - 2. 4 feet on center with 1/2-inch through-bolts or 1/2-inch welded, threaded studs at steel angles or channels, except two feet on center for 8'-0" from outside building corners.
 - 3. 2 feet on center, staggered, with #10 screws to metal roof deck. Provide a 5/8" galvanized steel washer under screw heads where wood blocking is parallel to deck flutes.
- C. Level and Continuous Nailers - The Contractor is cautioned to ensure that during the installation of all wood blocking a continuously level and smooth elevation is provided to ensure a simplicity of installation.
- D. Copings and Parapet Caps - All copings and metal parapet wall caps shall be installed over tapered or beveled wood blocking securely anchored to the structure. The slope or bevel shall be installed in a manner to drain the water to the roof side of the building, not the outside face.
- E. Flange Supports - All metal flanges in imbedded metal details shall bear over wood nailers, not roof insulation, and shall be fully supported by such wood nailers with no gaps.
- F. Expansion Joint Curbs - Expansion joint curbs shall be sloped to drain.

3.03 SOLDERING

- A. Solder Using Irons - All soldering is to be done using soldering irons heated conventionally in a pot. The use of propane or other types of torches will not be permitted.
- B. Corners and Intersections - Solder only those fixed components such as corners, intersections, terminations, skirts, collars, and covers. Do not solder joints between adjacent 10-foot lengths of flashings.

- C. Cleaning Joints - When forming soldered joints, apply flux to surface and lift overlapping sheet to apply between sheets to minimum 1/2-inch depth. Thoroughly sweat joint drawing solder between sheets to minimum 1/2-inch depth and apply uniform surface without excess build-up.
- D. No Exposed Nails - Do not nail metal components in place and solder over nail heads. If necessary to join components prior to soldering, use only stainless steel pop rivets. Cut, notch, miter, and provide tabs as necessary to properly join and interlock individual components for soldering.
- E. Surface Treatment - Immediately neutralize all flux from surfaces after soldering, using cloth saturated with 10 percent solution of washing soda and water, and wipe again using separate cloth and water. Upon completion of pop riveting and soldering spray soldered joint and pop rivet heads with "Instant Cold Galvanizing Compound" to prevent rusting.

3.04 WATER CONVEYANCE SHEET METAL

A. Gutters and Downspouts

- 1. Gutters shall be fabricated from prefinished 24 gauge galvanized metal, and shall be of a standard color of the Owner's choosing. Downspouts shall be made of the same material, except interior downspouts, which shall be PVC, or cast iron as may be required by local codes or specified differently elsewhere.
- 2. All detailing shall be in accordance with SMACNA unless otherwise indicated in the Contract Documents to the contrary.
- 3. Gutters shall be formed in such a manner as to provide positive slope to downspouts. Standing water in gutters is not acceptable.
- 4. Support spacers shall be 1/8 inch thick galvanized metal and attached with stainless steel screws, not pop rivets.
- 5. Gutter support brackets consisting of 1/8 inch galvanized metal shall be installed every 36- inches and 6 inches from each end. Support brackets shall be covered with prefinished metal of a matching color to the gutter to provide continuity of appearance. Field painting is not acceptable.
- 6. Downspouts shall be supported with a minimum of two straps per downspout regardless of length and shall have additional straps as required by SMACNA for greater lengths. Straps shall be in the same finish as the downspout and shall be fastened behind the downspout to conceal the flanges.
- 7. Gutters shall have expansion joints at a maximum spacing of 30-foot on-center or as specified by SMACNA, whichever is the more stringent.
- 8. Unless otherwise detailed on the Drawings, the maximum downspout spacing permitted is 30' on-center

9. Gutters shall be formed and joined in such a manner as not to leak at the joints. Leaking gutter joints are a defect and will not be accepted.
 10. Downspouts shall not be located at or near corners which require water to turn a corner to drain.
- B. Splash Pans - Splash pans shall be used at all locations where downspouts discharge onto a roof. Set splash pan in compatible adhesive on additional ply of modified bitumen cap sheet or traffic pad. Set additional ply of cap sheet or traffic pad in compatible adhesive on roof surface.

3.05 WATER SHEDDING SHEET METAL

A. Copings and Cap Flashings

1. Secondary waterproofing consisting of a self-adhering modified bitumen membrane shall be installed over the wood blocking and extending down to 1 inch below the bottom of the nailer and over the top of the base flashing material or other wall moisture protection a minimum of 1 inch.
2. A continuous metal clip shall be attached to the outside of the nailer made one full gauge heavier than the metal coping itself. The clip shall extend 1 1/2 inches below the wood blocking and shall be nailed at 6 inches on-center
3. The metal cap shall be fabricated and installed precisely and large enough not to cause a curving, bowing and "bellying" on the top. Coping that is not flat on top when a straight edge is laid across the top may be considered grounds for rejection.
4. Joints shall be secured by means of a single lock, button punched standing seam. Cover plates are not acceptable.
5. Coping terminating into a higher wall shall be turned up the wall 6 inches, have a complete through-wall flashing above with a two-piece receiver/counterflashing imbedded in the wall.
6. The coping shall be secured on the outside by means of crimping the outside flange tightly over the continuous clip and on the reverse side with screws through a slotted hole with neoprene washers at 24 inches on-center

B. Expansion Joints

1. Factory-Made Components - All terminations, tees, crossovers, and other necessary assemblies shall be as manufactured for that purpose, and installed in accordance with the manufacturer's printed instruction, SMACNA or NRCA, whichever is the more stringent.
2. Shop Fabricated Sheet Metal Type - Where shown in the Drawings, expansion joint covers shall be constructed of 24 gauge galvanized metal, with a G-90 coating. Expansion joint covers shall have vertical standing seam ribs at all end laps or joints.

3. Roof-to-Wall Expansion Joints - Where shown on the Drawings, roof-to-wall expansion joints shall have secondary waterproofing beneath the metal cover.

C. Counterflashings

1. Walls and Elevation Changes - Fabricate counterflashings, using sheet metal of the approximate dimensions and configurations shown on the Drawings, or as necessary to overlap base flashings a minimum of 4 inches. Materials shall be compatible and shall match the material already present on the building in similar details.
2. Equipment Cannot Be Its Own Counterflashing - Equipment flanges cannot be a substitute for separate two-piece counterflashing. All equipment must have a separate receiver and counterflashing beneath the equipment flange.
3. Vents and Plumbing and Mechanical Equipment - At power exhaust units, fabricate counterflashing of 24 gauge galvalume as shown on the Drawings with reverse open hem (approximately 1 inch) on the vertical face extending under unit housing. Fasten at 16 inches on-center with approved fasteners with a minimum of two fasteners per side. All vent and plumbing and mechanical unit flashings shall have soldered and pop riveted seams. Seams and joints are not to be sealed with sealant as primary waterproofing.
4. Expansion Provisions - Fabricate all counterflashings in such a manner that each may be removed and reinstalled if necessary. Provide for differential movement between base flashing and counterflashing assemblies at all locations.
5. Wind Clips - All counterflashings at walls shall have 2-inch wide wind clips at 24 inches on-center in accordance with SMACNA.

END OF SECTION

3.06

SECTION 20 01 00 – BASIC PLUMBING AND HVAC REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Basic and supplemental requirements common, Plumbing and HVAC Work.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the Contract Documents.

1.04 DEFINITIONS

- A. These definitions are included to clarify the direction and intention of these Specifications. For further clarification, contact the Architect/Engineer.
 - 1. Concealed / Exposed: "Concealed" areas are those areas that cannot be seen by the building occupants. "Exposed" areas are all areas, which are exposed to view by the building occupants, including under counters, inside cabinets and closets, plus all mechanical rooms. "Exterior" areas are those that are outside the building exterior envelope and exposed to the outdoors.
 - 2. Furnish: The term "furnish" is used to mean "supply and deliver to the Project Site, ready for unloading, unpacking, assembly, installation, and similar operations.
 - 3. Install: The term "install" is used to describe operations at Project Site including the actual "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.
 - 4. Provide: The term "provide" means "to furnish and install, complete and ready for the intended use.

1.05 QUALITY ASSURANCE

- A. Plumbing and HVAC systems shall be coordinated with other systems and trades to include but not be limited to: Electrical systems, fire alarm, security systems, transport systems, telephone and data systems.
- B. Verification of Dimensions: The Contractor shall be responsible for the coordination and proper relation of Contractor's Work to the building structure and to the Work of all trades. The Contractor shall visit the premises and become thoroughly familiar with all details of the Work and working conditions, to verify all dimensions in the field, and to advise the Architect/Engineer of any discrepancy before performing any Work. Adjustments to the Work required in order to facilitate a coordinated installation shall be made at no additional cost to the Owner or the Architect/Engineer.
- C. All dimensional information related to new structures shall be taken from the appropriate Drawings. All dimensional information related to existing facilities shall be taken from actual measurements made by the Contractor on the Site.
- D. The Drawings are subject to the requirements of Reference Standards, structural and architectural conditions. The Contractor shall carefully investigate structural and finish conditions and shall coordinate the separate trades in order to avoid interference between the various phases of Work. Work shall be organized and laid out so that it will be concealed in furred chases and suspended ceilings, etc., in finished portions of the building, unless specifically noted to be exposed. All exposed Work shall be installed parallel or perpendicular to the lines of the building unless otherwise noted.
- E. When the Drawings do not give exact details as to the elevation of pipe and ducts, the Contractor shall physically arrange the systems to fit in the space available at the elevations intended with proper grades for the functioning of the system involved. Piping and duct systems are generally intended to be installed true and square to the building construction, and located as high as possible against the structure in a neat and workmanlike manner. The Drawings do not show all required offsets, control lines, pilot lines and other location details. Work shall be concealed in all finished areas.
- F. Where core drilling of floor or wall penetrations is required, Work shall be performed in accordance with Division 03 Specifications. Where applicable Division 03 Specifications are not included in the Project, core drilling shall be in accordance with generally accepted standards, and be performed by licensed personnel where applicable.
- G. Certify in writing that neither the Contractor nor any of Contractor's subcontractors or suppliers will supply any materials that contain any asbestos in any form for this Project.

1.06 DELIVERY, STORAGE AND HANDLING

- A. All equipment, ductwork, and materials shall be delivered to the Project Site clean and sealed for protection.
- B. Take particular care not to damage the existing construction in performing Work. All finished floors, step treads and finished surfaces shall be covered to prevent any damage by workers or their tools and equipment during the construction of the Project.

- C. Equipment and materials shall be protected from rust and dust/debris both before and after installation. Any equipment or materials found in a rusty condition at the time of final inspection must be cleaned of rust and repainted as specified elsewhere in these Specifications.
- D. All material affected by weather shall be covered and protected to keep the material free from damage while material is being transported to the Site and while stored at the Project Site.
- E. During the execution of the Work, open ends of all piping and conduit, and all openings in equipment shall be closed when Work is not in progress, and shall be capped and sealed prior to completion of final connections, so as to prevent the entrance of foreign matter.
- F. All equipment shall be protected during the execution of the Work. All ductwork and equipment shall be sealed with heavy plastic and tape to prevent build-up of dust and debris.
- G. All ductwork and air handling equipment shall be wiped down with a damp cloth immediately before installation to ensure complete removal of accumulated dusts and foreign matter.
- H. All plumbing fixtures shall be protected and covered to prohibit usage. All drains shall be covered until placed in service to prevent the entrance of foreign matter.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. All equipment installed shall have local representation, local factory authorized service, and a local stock of repair parts.
- C. Responsibility for furnishing proper equipment and/or material and ensuring that equipment and/or material is installed as intended by the manufacturer, rests entirely upon the Contractor. Contractor shall request advice and supervisory assistance from the representative of specific manufacturers during the installation.
- D. All materials, unless otherwise specified, shall be new, free from all defects, suitable for the intended use and of the best quality of their respective kinds. Materials and equipment shall be installed in accordance with the manufacturer's recommendations and the best standard practice for the type of Work involved. All Work shall be executed by mechanics skilled in their respective trades, and the installations shall provide a neat, precise appearance. Materials and/or equipment damaged in shipment or otherwise damaged prior to installation shall not be repaired at the job Site but shall be replaced with new materials and/or equipment.
- E. Materials and equipment manufactured domestically are preferred when possible. Materials and equipment that are not available from a domestic manufacturer may be by a non-domestic manufacturer provided they fully comply with Contract Documents.

- F. Prevention of Rust: Standard factory finish will be acceptable on equipment specified by model number; otherwise, surfaces of ferrous metal shall be given a rust inhibiting coating.

2.02 NAMEPLATES

- A. Each major component of equipment shall have the manufacturer's name, address, and catalog number on a plate securely attached to the item of equipment. All data on nameplates shall be legible at the time of Final Inspection.
- B. Nameplates shall be black laminated rigid phenolic with white core. Nameplate minimum size shall be 1 inch high by 3 inches long with 3/16-inch-high engraved white letters.
- C. Nameplate Fasteners: Fasten nameplates to the front of equipment only by means of stainless steel self-tapping screws. Stick-ons or adhesives will not be allowed unless the NEMA enclosure rating is compromised, then only epoxy adhesive shall be used to attach nameplates.
- D. Nameplate Information: In general, the following information is to be provided for the types of electrical components or enclosures supplied with equipment.
1. Individual Starters, Contactors, Disconnect Switches, and Similar Equipment: Identify the device, and voltage characteristics source and load served.

2.03 WALL, FLOOR AND CEILING PLATES (ESCUTCHEONS)

- A. Except as otherwise noted, provide stainless steel or chrome plated brass floor and ceiling plates around all pipes, ducts, conduits, etc., passing exposed through walls, floors or ceilings, in any spaces except underfloor and plenum spaces.
- B. Plates shall be sized to fit snugly against the outside of the pipe or against the insulation on lines that are insulated and positively secured to such pipe or insulation.
- C. NOT USED
- D. Plates will not be required for piping where pipe sleeves extend 3/4-inch or more above finished floor.
- E. NOT USED

2.04 NOT USED

PART 3 - EXECUTION

3.01 PREPARATION

- A. Cooperate with trades of adjacent, related or affected materials or operations, and with trades performing continuations of this Work in order to effect timely and accurate placing of Work and to coordinate, in proper and correct sequence, the Work of such trades.

- B. The size of equipment indicated on the Drawings is based on the dimensions of a particular manufacturer. While other manufacturers may be acceptable, it is the responsibility of the Contractor to determine that the equipment proposed will fit in the space. Fabrication Drawings shall be prepared when required by the Architect/Engineer or Owner to indicate a suitable arrangement.
- C. All equipment shall be installed in a manner to permit access to all surfaces. All valves, motors, drives, filters, and other accessory items shall be installed in a position to allow removal for service without disassembly of another part.
- D. Space Requirements:
 - 1. Consider space limitations imposed by contiguous Work in location of equipment and material. Do not provide equipment or material which is not suitable in this respect.
 - 2. Make changes in material and equipment locations of up to five (5) feet, to allow for field conditions prior to actual installation, and as directed by the Architect/Engineer at no additional cost to the Owner.
- E. Contractor shall note that the electrical design and Drawings are based on the equipment scheduled and indicated on the Drawings. Should any equipment be provided requiring changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.
- F. Connections for equipment other than Divisions 21, 22, 23:
 - 1. Rough-in and provide all, sewer, etc. connections to all fixtures, equipment, machinery, etc., furnished by the Owner and/or other trades in accordance with detailed rough-in Drawings provided by the equipment suppliers, by actual measurements of the equipment connections, or as detailed.
 - 2. After the equipment is set in place, make all final connections and provide all required pipe, fittings, valves, traps, etc.
 - 3. NOT USED
 - 4. Provide all ductwork, transition pieces, etc., required for a complete installation of ventilation systems

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Piping may be run exposed in rooms typically without ceilings such as mechanical rooms, janitor's closets, tight against pan soffits in exposed "tee" structures, or storage spaces, but only where necessary. Shutoff and isolation valves shall be easily accessible.

- D. All pipe, conduits, etc., shall be cut accurately to measurements established at the building and shall be worked into place without springing or forcing. All ducts, pipes and conduits run exposed in machinery and equipment rooms shall be installed parallel to the building lines, except that piping shall be sloped to obtain the proper pitch. Piping and ducts run in furred ceilings, etc., shall be similarly installed, except as otherwise shown. All pipe openings shall be kept closed until the systems are closed with final connections.
- E. Prior to the installation of any ceiling material, gypsum, plaster or acoustical board, the Contractor shall notify Owner's Project Manager so that arrangement can be made for an inspection of the above-ceiling area about to be "sealed" off. The Contractor shall provide written notification to the Owner at least five (5) calendar days prior to the inspection.
- F. Precedence of Materials:
1. The Specifications determine the nature and setting of materials and equipment. The Drawings establish quantities, dimensions and details.
 2. If interference is encountered, the following installation precedence of materials shall guide the Contractor to determine which trade shall be given the "Right of Way":
 - a. Building lines
 - b. Structural members
 - c. Structural support frames supporting ceiling equipment
 - d. Electric tracked vehicle system
 - e. Pneumatic trash and linen system
 - f. Pneumatic tube system
 - g. Soil and drain piping
 - h. Vent piping
 - i. Supply, return and outside air ductwork
 - j. Exhaust ductwork
 - k. HVAC water and steam piping
 - l. Condensate piping
 - m. Fire protection piping
 - n. Natural gas piping
 - o. Medical/Laboratory gases
 - p. Domestic water (cold and hot, softened, treated)
 - q. Refrigerant piping

r. Electrical conduit

3. Coordinate fire suppression, plumbing and HVAC systems with transport systems as required to maintain transport system right-of-way.

3.03 TESTING

- A. When any piece of mechanical equipment is operable and it is to the advantage of the Contractor to operate the equipment, Contractor may do so, provided that Contractor properly supervises the operation, and has the Owner's written permission to do so. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner, or date of Substantial Completion, whichever occurs first.
- B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, properly adjust, and complete all deficiency list items before final acceptance by the Owner. The date of acceptance and performance certification will be the same date.
- C. Before the Work is accepted, an authorized representative of the manufacturer of the installed materials and/or equipment shall personally inspect the installation and operation of manufacturer's materials and/or equipment to determine that materials and/or equipment are properly installed and in proper operating order. The qualifications of the manufacturer's representative shall be appropriate to the technical requirements of the installation. The qualifications of the manufacturer's representative shall be submitted to the Owner for approval. The decision of the Owner concerning the appropriateness of the manufacturer's representative shall be final. Testing and checking shall be accomplished during the course of the Work where required by Work being concealed, and at the completion of the Work. In addition, the Contractor shall submit to the Architect/Engineer a signed statement from each manufacturer's representative certifying as follows: **"I certify that the materials and/or equipment listed below have been personally inspected by the undersigned authorized manufacturer's representative and is properly installed and operating in accordance with the manufacturer's recommendations."**
- D. Check inspections shall include piping, equipment, heating, air conditioning, insulation, ventilating equipment, controls, mechanical equipment and such other items hereinafter specified or specifically designated by the Architect/Engineer.
- E. The Contractor shall execute, at no additional cost to the Owner, any tests required by the Owner or the National Fire Protection Association, ASTM, etc. Standards listed. The Contractor shall provide all equipment, materials and labor for making such tests. The Owner will pay reasonable amounts of fuel and electrical energy costs for system tests. Fuel and electrical energy costs for system adjustment and tests, which follow Substantial Completion by the Owner, will be borne by the Owner.
- F. Notify the Owner's Project Manager and the Architect/Engineer in writing at least seven (7) calendar days prior to each test and prior to other Specification requirements requiring Owner and Architect/Engineer to observe and/or approve tests.

- G. All tests shall have pertinent data logged by the Contractor at the time of testing. Data shall include date, time, personnel performing, observing and inspecting, description of the test and extent of system tested, test conditions, test results, specified results and other pertinent data. Data shall be delivered to the Architect/Engineer as specified under "Requirements for Final Acceptance." The Contractor or Contractor's authorized job superintendent shall legibly sign all Test Log entries.
- H. Refer to Commissioning Specification Sections for additional Start-up, prefunctional and operational checkout, and for functional performance test procedures.

3.04 TRAINING

- A. Operating and Maintenance Manuals and instruction shall be provided as specified under the Division 01 Section entitled "Project Closeout Procedures."
- B. Specific training and operating instructions for individual equipment components shall be as specified in the individual Specification Sections.

END OF SECTION 20 01 00

SECTION 20 05 13 – MOTORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install high efficiency single- and three-phase electric motors required for equipment supplied under this division of Work as indicated by the Contract Documents, with supplementary items necessary for proper installation. Refer to Electrical Drawings for motor starter sizes. Disconnect switches to be furnished in Division 26.
- B. The Plumbing and HVAC Subcontractor shall furnish starters for Plumbing and HVAC Work. Motor starters shall be provided in accordance with Division 26 Specifications. Some motors furnished in mechanical equipment rooms shall have starters furnished and installed as part of Division 26 (as per Specification Section 26 29 14, Motor Starters). Coordinate with Division 26.
- C. NOT USED
- D. NOT USED

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and Workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
 - 2. AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings.
 - 3. EISA - The Energy Independence & Securities Act 2007.
 - 4. ANSI/IEEE 112 – Test Procedure for Polyphase Induction Motors and Generators.

5. ANSI/NEMA/ MG 1 – Motors and Generators Part 31.
6. NFPA 70 – National Electrical Code.
7. ANSI C19 – Industrial Control Apparatus.
8. NEMA ICS – Industrial Control and Systems.
9. NEMA RV 3 - Application and Installation Guidelines for Flexible and Liquidtight Flexible Metal and Nonmetallic Conduits
10. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
11. NEMA FB 2.20 - Selection and Installation Guidelines For Fittings for Use With Flexible Electrical Conduit and Cable
12. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
13. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
14. NEMA OS 3 - Selection and Installation Guidelines for Electrical Outlet Boxes
15. UL 508 – Industrial Control Equipment.
16. ANSI/IEEE 117 – Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random Wound AC Electric Machinery.
17. ANSI/NEMA MG 2 – Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors.
18. ANSI/UL 674 – Electric Motors and Generators for Use in Hazardous (Classified) Locations.
19. ANSI/UL 1004 – Electric Motors.

1.04 QUALITY ASSURANCE

- A. Motors associated with variable frequency drives (VFD) shall be inverter-duty rated, and provided with grounded shaft or ceramic bearings to insulate shaft, and Class F 105 degrees C rise insulation. Ref. NEMA MG1 Part 31.
- B. Conform to NFPA 70.

1.05 SUBMITTALS

- A. All motors provided by the Contractor shall be of the same manufacturer unless they are an integral part of the piece of equipment to which they are attached.
- B. Product Data: Provide the following information for each motor:

1. Manufacturer.
 2. Rated full load horsepower.
 3. Rated volts.
 4. Number of Phases.
 5. Insulation Class.
 6. Frequency in Hertz.
 7. Full load amperes (FLA).
 8. Locked rotor amperes (LRA) at rated voltage or NEMA code letter.
 9. Nominal speed at full load (rpm).
 10. Service factor.
 11. NEMA design letter.
 12. NEMA machine type (ODP, WP-I, TEFC, etc.).
- C. For motors one horsepower and larger, include the following additional information:
1. NEMA frame size.
 2. NEMA insulation system classification. For motors required to be installed outdoors, include information showing compliance for outdoor application.
 3. Maximum ambient temperature for which motor is designed.
 4. Time rating.
 5. Bearing size and type data.
 6. Guaranteed efficiency and power factor at full load, 75% load, 50% load, 25% load and 0% load.
- D. NOT USED
- E. Operation and Maintenance Data:
1. Submit operation and maintenance data including assembly Drawings, bearing data including replacement sizes, and lubrication instructions.
- F. Alternate Motors:

1. If a motor horsepower rating larger than indicated is offered as a substitute and accepted, provide required changes in size of conductors, conduits, motor controllers, overload relays, fuses, circuit breakers, switches and other related items at no change in the Contract price.

1.06 WARRANTY

- A. Provide minimum one-year manufacturer's warranty including coverage for motors one horsepower and larger.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Electrical Service: Refer to Drawing schedules for required electrical characteristics.
- C. Design for continuous operation in 40 degrees C environment and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, Service Factor and motor enclosure type.
 1. Totally Enclosed Motors: Design for a service factor of 1.00 and an 80 degrees C maximum temperature rise in the same conditions.
 2. NOT USED
- D. Visible Stainless Steel Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency.
- E. Electrical Connection: Provide adequately sized metal electrical connection box for conduit connection. For fractional horsepower motors where connection is made directly, provide metal electrical box for conduit connection.
- F. Motors shall be built in accordance with the latest ANSI, IEEE and NEMA Standards and shall be fully coordinated with the equipment served, shall be of sizes and electrical characteristics scheduled and of approved manufacturer as listed below or of the same manufacturer as the equipment which they serve. Nameplate rating of motors shall match the characteristics scheduled.
- G. All motors shall be designed for normal starting torque unless the driven machine requires high starting torque and shall be selected for quiet operation, free from magnetic hum.

- H. All motors shall be provided with adequately sized electrical connection box for attachment of flexible conduit. Paragraph 1.03 of this specification refers to the NEMA standards and publications relevant to applications and use of both metal and liquid tight flexible conduit. When motors are connected to driven equipment by the use of a V-belt drive, they shall be furnished with adjustable rails.
- I. All exhaust fan motors shall be compatible with variable frequency drive controllers.
- J. Motors shall be open drip-proof type, except where specified or noted otherwise on the construction drawing.
- K. Motors $\frac{1}{4}$ to $\frac{3}{4}$ hp shall be Subtype II and meet the minimum requirements of EPCAct92 for minimum NEMA nominal efficiency motors.
- L. Motors 1 to 200 hp shall be Subtype I and meet the minimum requirements of NEMA Table 12-12 for NEMA premium efficiency motors.

2.02 MANUFACTURERS

- A. Manufacturer: Company specializing in the manufacture of electric motors for HVAC and plumbing equipment use, and their accessories, with minimum three (3) years documented product development, testing and manufacturing experience.
 - 1. Baldor - Super E – NEMA Premium Efficiency.
 - 2. Marathon - NEMA Premium Efficiency.
 - 3. Siemens – NEMA Premium Efficiency U.S. Electrical – NEMA Premium Efficiency.

2.03 NOT USED

2.04 NOT USED

2.05 NOT USED

2.06 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Enclosures shall be of the open drip proof type with a service factor as specified herein and Class B insulation rated at 90 degrees C temperature rise measured above 40 degrees C room ambient condition at full load, unless otherwise noted.
- B. All motors $\frac{3}{4}$ horsepower and larger, unless smaller motors are indicated to be supplied as 3-phase, shall be 3-phase and shall be squirrel cage high efficiency induction type with standard NEMA frame sizes.
- C. Three phase motors not connected to variable frequency drives are to be protected for phase loss and phase unbalance protection.
- D. Motors 1 HP and larger shall have integral frames.

- E. Starting Torque: Between one and one and one-half times full load torque.
- F. Starting Current: Six times full load current.
- G. Power Output, Locked Rotor Torque, Breakdown or Pullout Torque: NEMA Design B characteristics.
- H. Design, Construction, Testing and Performance: Conform to ANSI/NEMA MG 1 for Design B motors.
- I. Insulation System: NEMA Class B or better.
- J. Testing Procedure: In accordance with ANSI/IEEE 112, Test Method B. Load test motors to determine freedom from electrical or mechanical defects and compliance with performance data.
- K. Motor Frames: NEMA standard T-frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- L. Bearings:
 - 1. Ball or roller type, double shielded with continuous grease relief to accommodate excessive pressure caused by thermal expansion or over lubrication.
 - 2. All motor bearings shall be factory prepacked with a nondetergent lubricant and shall be provided with lubrication fitting arranged to provide easy access when installed on the driven apparatus except as noted hereinafter.
 - 3. Permanently lubricated factory-sealed motors may be provided in fractional horsepower sizes only where they are an integral part of a piece of approved apparatus.
 - 4. All bearings shall be designed for L-10, 40,000 hour minimum life hours of continuous service. Calculate bearing load with NEMA minimum V-belt pulley with belt centerline at end of NEMA standard shaft extension. Direct driven fans may require specific bearings other than ball type, verify equipment specification where motor may be used where bearing life requirement may exceed L-10 rating. Stamp bearing sizes on nameplate.
- M. Sound Power Levels: Refer to ANSI/NEMA MG 1.
- N. Part Winding Start (Where Indicated): Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel. Bearings shall be double shielded with waterproof non-washing grease.
- O. Nominal Efficiency and Power Factor: Meet or exceed values as scheduled at load and rated voltage when tested in accordance with ANSI/IEEE 112.
- P. Motors one horsepower and larger shall be provided with a copper frame grounding lug of hydraulic compression design, for installation by the electrical subcontractor.

2.07 STARTING EQUIPMENT

- A. Each motor shall be provided with proper starting equipment. Starting equipment shall be furnished by this Division.
- B. Relays and equipment supplied by this Contractor shall be integral with electrical equipment supplied.

2.08 RATING

- A. Speed and Size: Speed and approximate horsepower ratings are specified in equipment Specification Sections or are indicated on the Drawings. Furnish motors sufficiently sized for the particular application and with full-load rating not less than required by the driven equipment at specified capacity. Size motors so as not to overload at any point throughout the normal operating range.
- B. Voltage:
 - 1. Single phase: 115 volts for 120-volt nominal system voltage.
 - 2. Three phase: 200 volts for 208-volt nominal system voltage.
 - 3. Three phase: 230 volts for 240-volt nominal system voltage.
 - 4. Three phase: 230/460 volts for 240/480-volt nominal system voltage.
 - 5. Three phase: 460 volts for 480-volt nominal system voltage.
- C. Frequency: 60 Hertz.
- D. Efficiency: Provide energy-efficient motors meeting the requirements of NEMA MG1-12.55A, Table 12Y and MG 1.41.3. Efficiency to be determined by testing in accordance with NEMA MG 112.53 using IEEE 112A – Method B.
- E. Service Factor: According to NEMA MG 1-12.47 but not less than those indicated per the Table below.
- F. Table: NEMA Open Motor Service Factors:

<u>Horsepower</u>	<u>3600 RPM</u>	<u>1800 RPM</u>	<u>1200 RPM</u>	<u>900 RPM</u>
1/6 – 1/3	1.35	1.35	1.35	1.35
1/2	1.25	1.25	1.25	1.15
3/4	1.25	1.25	1.15	1.15
1	1.25	1.15	1.15	1.15
1.5-150 and above 150	1.15	1.15	1.15	1.15

PART 3 - EXECUTION

3.01 APPLICATION

- A. NOT USED
- B. NOT USED
- C. NOT USED
- D. Motors located in exterior locations shall be totally enclosed weatherproof epoxy-sealed type.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Properly install and align motors after installation on the driven equipment.
- D. Motor feeders shall be free of splices. In special cases when splice-free feeders are impractical, splices may be allowed given prior written approval from the Owner.
- E. Use crimp-on, solderless copper terminals on the branch circuit conductors. For motors 20 horsepower and larger, use 5300 Series 3M motor lead splicing kit or approved equal.
- F. When the motor and equipment are installed, the motor's nameplate must be in full view.

3.03 TESTING

- A. General: Provide all necessary instruments, labor and personnel required to perform motor inspection and testing.
- B. Inspection: Inspect all motors for damage, moisture absorption, alignment, freedom of rotation, proper lubrication, oil leaks, phase and rotation and cleanliness, and report any abnormalities to Owner before energizing.
- C. Tests: Motor full load current and full load voltage shall be measured. Motor phase loss and phase unbalance protection shall be tested. Motor Test Report forms included at the end of this Section shall be completed and submitted prior to Substantial Completion.
- D. Energizing: After installation has been thoroughly checked and found to be in proper condition, with thermal overloads in motor controllers properly sized and all controls in place, energize the equipment at system voltage for operational testing.
- E. Motor Test Report Form:

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October 12, 2018

DATE _____

SHEET ____ OF ____

PROJECT NAME _____

PROJECT NO. _____

MOTOR DESIGNATION _____, LOCATION _____

HP _____, FLA _____, LOCATION _____

PHASE LOSS AND PHASE UNBALANCE PROTECTION _____
INSULATION CLASS _____

SERVED FROM PANEL/MCC _____

MEASURED CONDITIONS

TEMPERATURE: _____ degrees F

RELATIVE HUMIDITY: _____ %

CURRENT (AMPS): ØA _____, ØB _____, ØC _____

VOLTAGE (VOLTS): ØB _____, ØBC _____, ØCA _____

ØAN _____, ØBN _____, ØCN _____

END OF SECTION 20 05 13

SECTION 20 05 53 – PIPING AND EQUIPMENT IDENTIFICATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install Owner's equipment tags, stencils, and pipe markers indicated by the Contract Documents with supplementary items necessary for proper installation.
- B. Contractor shall make it possible for Owner's operations and maintenance personnel to readily identify the various pieces of equipment, ductwork, etc., by marking them in accordance with this Specification.
- C. Clearly mark all items of equipment, including but not limited to, fans, using equipment tags as specified in this Section. The tagged item of equipment shall correspond to the same number as shown on the Drawings and as listed in the Equipment Matrix. Download an electronic version of the Equipment Matrix in Microsoft Excel format to use as a template for submittal purposes at the following website:
- D. Refer to Specification Section 01 91 00, General Commissioning Requirements, for a detailed description of Equipment Matrix information.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and Workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ASME A13.1 - Scheme for the Identification of Piping Systems.
 - 2. International Plumbing Code.

1.04 SUBMITTALS

- A. Product Data:

1. Provide manufacturer's catalog literature for each product.
- B. Record Documents:
 1. Submit Equipment Matrix schedules completed.xlsx
- C. Operation and Maintenance Data:
 1. Manufacturer's Installation Instructions: Indicate special procedures and installation.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. Equipment Tags and Markers:
 1. Marking Systems, Inc.
 2. Seton Name Plate Company.
 3. W.H. Brady Company.
 4. Graphic Products, Inc.

2.03 EQUIPMENT TAGS

- A. Description: 3" x 4" vinyl label, 3.0 Mil self-adhesive vinyl similar to DuraLabel Pro. Label color shall be black text on a white background. The label shall contain the following information per the template, described in Attachment "B":
 1. Asset Short Description As listed in Equipment Matrix.
 2. Asset Number: As listed in Equipment Matrix.
 3. Asset Location: As listed in Equipment Matrix.
 4. Asset Bar Code Number.
- B. All scheduled equipment shall be identified with an Equipment Tag.

2.04 NOT USED

2.05 PIPE AND DUCT MARKERS

- A. Round Pipe and Duct Markers shall conform to ANSI A13.1-2007 "Scheme for the Identification of Piping Systems", refer to Attachment "A" for abbreviation and label color designations. Arrow markers must have same ANSI background colors as their companion pipe markers, or be incorporated into the pipe identification marker.

- B. Rectangular Duct Stencils shall conform to ANSI A13.1-2007 "Scheme for the Identification of Piping Systems", refer to Attachment "B" for abbreviation and label color designations. Letter height shall be a minimum of 1-1/4". Stencil material shall be fiber board; Stencil paint shall be exterior, gloss, acrylic enamel. The following rectangular duct systems shall be stenciled:
 - 1. Underfloor crawlspace ventilation.
- C. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- D. Plastic Tape Pipe Markers: Heat sealed or heat shrink, spring fasteners, clips or snap-on are acceptable.
- E. NOT USED
- F. NOT USED
- G. Pipe markers and arrow markers also shall be provided for all piping systems.
- H. Use Seton Setmark Type SNA or Brady snap-on type identification for all piping systems, up through 6 inch. For piping systems larger than 6 inches, use Seton or Brady strap-on markers or similar by Marking Services, Inc.

2.06 NOT USED

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Install plastic tape, and pipe markers completely around pipe in accordance with manufacturer's instructions.
- D. Locate markers on the two (2) lower quarters of the pipe where view is unobstructed.

3.02 NOT USED

3.03 APPLICATION OF MARKERS AND STENCILS

- A. Piping runs throughout the Project including those above lift-out ceilings, under floor and those exposed to view when access doors or access panels are opened shall be identified by means of pipe markers and/or stencils. Concealed areas, for purposes of this identification section, are those areas that cannot be seen except by demolition of the building elements. In addition to pipe markers and/or stencils, arrow markers shall be used to indicate direction of flow.
- B. As a minimum, locate pipe markers and/or stencils as follows:

1. NOT USED
 2. Every 20 feet in exposed and concealed areas on all piping systems. Provide at least one (1) pipe marker in each room on all piping systems.
 3. At each branch or riser take off on piping systems, excluding short takeoffs for fixtures and terminal units.
 4. Provide a pipe marker or stencil and an arrow marker at every point of pipe entry or exit where the pipe penetrates a wall, floor, service column or enclosure.
 5. At access doors, manholes and similar access points that permit view of concealed piping.
 6. Near major equipment items and other points of origination and termination.
- C. Provide an arrow marker with each pipe marker pointing away from the pipe marker to indicate direction of flow.
- D. NOT USED
- E. NOT USED
- F. NOT USED
- G. Identify control panels and major control components outside panels with plastic nameplates.
- H. NOT USED
- I. Tag automatic controls, instruments and relays. Key to control schematic.
- J. NOT USED
- K. NOT USED
- L. NOT USED
- M. NOT USED

ATTACHMENTS:

“A” - Label Abbreviations, Background and Text colors

“B” – Label Examples with dimensions, font type and height

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END OF SECTION 20 05 53

ATTACHMENT “A”

Mechanical /Plumbing Piping System Abbreviations and Letter/Label Coloring

Pipe Contents	Label Abbreviation	Label Colors (Background/Text)
Acid Waste	ACID	Orange/Black
Argon	AR	Green/White
Biosafety Cabinet Exhaust	BCE	Purple/white
Brine Water	BR	Orange/Black
Carbon Dioxide	CO ₂	Gray/white
Chemical Fume Hood Exhaust	CFHE	Purple/white
Chilled Water Return	CHWR	Green/White
Chilled Water Supply	CHWS	Green/White
Condensate Drain	CD	Green/White
Condenser Water Return	CWR	Green/White
Condenser Water Supply	CWS	Green/White
Deionized Water Supply	DIS	Green/White
Deionized Water Return	DIR	Green/White
ETO Exhaust	ETOE	Purple/white
Fuel Oil Return	FOR	Yellow/Black
Fuel Oil Supply	FOS	Yellow/Black
Gray Water	Gray Water	Gray/White
Grease Waste (Kitchen)	GW	Black/White
Hazardous Waste	HAZ	Orange/Black
Helium	He	Brown/white
High Pressure Condensate	HPC	Blue/White
High Pressure Steam (above 125#)	HPS	Blue/White
Hot Water Heating Return	HWR	Green/White
Hot Water Heating Supply	HWS	Green/White
Instrument Air	IA	Red/white
Laboratory Compressed Air	Lab Air	Yellow and white checkerboard/black
Laboratory Vacuum	Lab Vac	White and black checkerboard/black boxed
Laboratory Waste	Lab Waste	Orange/Black
Laboratory Vent	Lab Vent	Orange/Black
Low Pressure Condensate	LPC	Blue/White
Low Pressure Steam (below 25#)	LPS	Blue/White
Medical Compressed Air	Med Air	Yellow/black
Medical–Surgical Vacuum	Med Vac	White/black
Medium Pressure Condensate	MPC	Blue/White
Medium Pressure Steam (above 25# - below 125#)	MPS	Blue/White
Natural Gas	NG	Yellow/Black
Nitrogen (gaseous)	N ₂	Black/white
Nitrogen (liquid)	LN2	Black/White
Nitrous Oxide	N ₂ O	Blue/white
Non-Potable Water	-	Green/White
Medical Oxygen	O ₂	Green/white

ATTACHMENT “A”

Pipe Contents	Label Abbreviation	Label Colors (Background/Text)
Potable Cold Water	DCW	Green/White
Potable Hot Water Return	DHWR	Green/White
Potable Hot Water Supply	DHW	Green/White
Pumped Condensate Return	PCR	Blue/White
Quench Vent	-	White/Fluorescent Orange
Radioisotope Exhaust	RE	Yellow/magenta
Refrigerant Liquid Line (Circuit #1, 2, 3, etc. as applicable)	Refrig Liq #	Green/White
Refrigerant Suction Line (Circuit #1, 2, 3, etc. as applicable)	Refrig Suct #	Green/White
Reverse Osmosis Water Supply	ROS	Green/White
Reverse Osmosis Water Return	ROR	Green/White
Sanitary Waste	SS	Green/White
Sanitary Vent	SV	Green/White
Storm Drain	SD	Green/White
Softened Water	SW	Green/White
Waste Anesthetic Gas Disposal	WAGD	Violet/white

ATTACHMENT “B”

Equipment Tag Layout

Standard Information	FACILITIES MANAGEMENT TAG	Arial	9
Asset Short Description (If required, text wrap)	Fan Coil Unit, FCU 13-4	Arial Bold (3 lines for text)	16
Asset Number	12260	Arial Bold	24
Asset Location	Asset Location: G15.3531	Arial	16
Asset Bar Code Number	 12260	BC C39 3 to 1Medium 3 lines for future text)	28
Standard Information	This is not an Institutional Tag	Arial	9

Tag Information

3”h X 4”w Tag

Font Description /Height

Example of Completed Equipment Tag

FACILITIES MANAGEMENT TAG Fan Coil Unit, FCU 13-4 12260 Asset Location: G15.3531  12260 This is not an Institutional Tag

ATTACHMENT “B”

Ceiling Grid Tag Layout for Equipment Located Above Finish Ceiling

Tag Information

Asset Bar Code #	Equipment Plan Designation

**$\frac{3}{4}$ " h x variable length
TAG**

 12260	Fan Coil Unit, FCU 13-4

Font & Height

BC C39 3 to 1 Medium	Arial 24

SECTION 20 08 00 –HVAC SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. The purpose of this Section is to define responsibilities in the Commissioning process. Additional system testing is required within individual Specification Sections.
- B. Ensure that all systems are operating in a manner consistent with the Contract Documents. General Commissioning requirements and coordination are detailed in Division 01. Execute all Commissioning responsibilities assigned and include the cost of Commissioning in the Contract price.
- C. HVAC systems to be commissioned include the following:
 - 1. Fans
 - 2. Ductwork Systems
 - 3. Building Automation System
- D. Not Used
- E. Not Used

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.04 DEFINITIONS

- A. Refer to Specification Section 01 91 00 – General Commissioning Requirements for definitions.

1.05 SUBMITTALS

- A. Contractor shall prepare Prefunctional Checklists and Functional Performance Test (FPT) procedures and execute and document results. All Prefunctional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Owner for review and approval.
- B. Contractor shall provide Owner with documentation required for Commissioning Work. At minimum, documentation shall include: Detailed Start-up procedures, full sequences of operation, Operating and Maintenance data, performance data, Functional Performance Test Procedures, control drawings, and details of Owner-contracted tests.
- C. Contractor shall submit to Owner installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.
- D. Contractor shall review and approve other relative documentation for impact on FPT's of the systems:
 - 1. Shop drawings and product submittal data related to systems or equipment to be commissioned. The Subcontractor responsible for the FPT shall review and incorporate comments from the Owner and A/E via the Contractor.
 - 2. Incorporate manufacturer's Start-up procedures with Prefunctional checklists.
 - 3. Draft Test, Adjust and Balance (TAB) Reports: Review and provide comments to Owner.
 - 4. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPT's.
 - 5. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's. Owner may require that system one-line diagrams and applicable Specification Section(s) be attached to the FPT documentation.
 - 6. Final TAB Reports: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's.
 - 7. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 TEST EQUIPMENT

- A. Provide all specialized tools, test equipment and instruments required to execute Start-up, checkout, and testing of equipment.
- B. Refer to Specification Section 01 91 00 – General Commissioning Requirements.

PART 3 - EXECUTION

3.01 PREPARATION

A. Construction Phase:

1. In each purchase order or subcontract that is written for changes in scope, include the following requirements for submittal data, Commissioning documentation, testing assistance, Operating and Maintenance (O&M) data, and training, as a minimum.
2. Attend Pre-Commissioning Meeting(s), Pre-Installation Meeting(s), and other Project meetings scheduled by the Contractor to facilitate the Commissioning process.
3. Provide manufacturer's data sheets and shop drawing submittals of equipment.
4. Provide additional requested documentation to the Contractor, prior to O&M manual submittals, for development of Prefunctional Checklist and Functional Performance Tests procedures.
 - a. Typically, this will include detailed manufacturer's installation and Start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified.
 - b. In addition, the installation, Start-up, and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Contractor.
 - c. This information and data request may be made prior to normal submittals.
5. With input from the BAS Provider and A/E, Clarify the operation and control of commissioned equipment in areas where the Specifications, BAS control drawings, or equipment documentation are not sufficient for writing detailed test procedures.
6. Prepare the specific Functional Performance Test procedures specified in Section 20 08 16. Ensure that Functional Performance Test procedures address feasibility, safety, and equipment protection and provide necessary written alarm limits to be used during the tests.

7. Develop the Commissioning Plan using manufacturer's Start-up procedures and the Prefunctional Checklists. Submit manufacturer's detailed Start-up procedures and the Commissioning Plan and procedures and other requested equipment documentation to Owner for review.
8. During the Start-up and initial checkout process, execute and document related portions of the Prefunctional Checklists for all commissioned equipment.
9. Perform and clearly document all completed Prefunctional Checklists and Start-up procedures. Provide a copy to the Owner prior to the Functional Performance Test.
10. Address current A/E and Owner punch list items before Functional Performance Tests. Air and water test, adjust and balance shall be completed with discrepancies and problems remedied before Functional Performance Tests of the respective air or water related systems are executed.
11. Provide skilled technicians to execute starting of equipment and to assist in execution of Functional Performance Tests. Ensure that they are available and present during the agreed-upon schedules and for a sufficient duration to complete the necessary tests, adjustments, and problem solving.
12. Correct deficiencies (differences between specified and observed performance) as interpreted by the Owner's Project Manager and A/E and retest the system and equipment.
13. Compile all Commissioning records and documentation to be included in a Commissioning and Closeout Manual.
14. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to actual conditions.
15. During construction, maintain Record Drawings and Specifications of all Contract Documents and Contractor-generated coordination Drawings. Update after completion of Commissioning activities (include deferred tests). The Record Drawings and Specifications shall be delivered to the Owner both in electronic format as required by the Owner.
16. Provide training of the Owner's operating personnel as specified.
17. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

B. Warranty Phase:

1. Execute seasonal or deferred tests, witnessed by the Owner, according to the Specifications.
 - a. Complete deferred tests as part of this Contract during the Warranty Period. Schedule this activity with Owner. Perform tests and document and correct deficiencies. Owner may observe the tests and review and approve test documentation and deficiency corrections.

- b. If any check or test cannot be completed prior to Substantial Completion due to the building structure, required occupancy condition, or other condition, execution of such test may be delayed to later in the Warranty Period, upon approval of the Owner. Contractor shall reschedule and conduct these unforeseen deferred tests in the same manner as deferred tests.
2. Correct deficiencies and make necessary adjustments to O&M manuals, Commissioning documentation, and Record Drawings for applicable issues identified in any seasonal testing.

3.02 TESTING

A. Prefunctional Checklists and Start-up:

1. Follow the Start-up and initial checkout procedures listed in this Section and in Division 01. Start-up and complete systems and sub-systems so they are fully functional, meeting the requirements of the Contract Documents.
2. Prefunctional Checklists shall be complete prior to commencement of a Functional Performance test.

B. Functional Performance Tests:

1. Functional Performance Tests are conducted after system Start-up and checkout is satisfactorily completed. Air balancing and water balancing shall be completed before Functional Performance Tests.

C. Coordination Between Testing Parties:

1. Factory Start-ups: Factory Start-ups are specified for certain equipment. Factory Start-ups generally are Start-up related activities that will be reviewed and checked prior to Functional Performance Tests. All costs associated with factory Start-ups shall be included with the contract price unless otherwise noted. Notify the Commissioning Team of the factory Start-up schedule and coordinate these factory Start-ups with witnessing parties. The Commissioning Team members may witness these Start-ups at their discretion.
2. Independent Testing Agencies: For systems that specify testing by an independent testing agency, the cost of the test shall be included in the Contract price unless otherwise noted. Testing performed by independent agencies may cover aspects required in the Prefunctional Checklists, Start-ups, and Functional Performance Tests. Coordinate with the independent testing agency so that Owner and/or A/E can witness the test to ensure that applicable aspects of the test meet requirements.

3.03 TRAINING

- A. Refer Specification Section 01 79 00 – Demonstration and Training.

END OF SECTION 20 08 00

SECTION 20 08 13 –HVAC SYSTEMS PREFUNCTIONAL CHECKLIST AND START-UPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. This Section expands on and defines responsibilities of the Contractor regarding Prefunctional Checklists and Start-up portions of the Commissioning process and addresses validation of proper and thorough installation of mechanical, plumbing and fire protection systems.
- B. Contractor shall oversee the Commissioning activities with the Contractor's Subcontractors and the Architect/Engineer (A/E).
- C. Contractor shall completely install, thoroughly inspect, Start-up, test, adjust and integrate air and water balance by Owner's TAB firm on systems and equipment. All activities shall be documented on specific, procedural forms developed for that purpose. Contractor shall notify A/E and Owner in writing that systems are complete and ready for verification and Functional Performance Tests.
- D. Completed Prefunctional Checklists for all pieces of equipment shall be submitted to the Owner prior to Functional Performance Tests.
- E. Responsibilities of the various parties involved in the Commissioning process are defined in Section 20 08 00.
- F. Refer to Attachments A, B, and C at the end of this Section for example forms that indicate level of documentation required for the Commissioning process.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.04 SUBMITTALS

- A. Prefunctional Checklists, Prefunctional Tests, and Start-up documents are the normal procedure of ensuring that the mechanical system components are properly installed.
- B. The Subcontractor in cooperation with the A/E and Contractor shall develop Prefunctional Checklists and Prefunctional Tests during the Construction Phase.
- C. Completeness of Prefunctional Checklists: This Section summarizes the minimum standard for systems and equipment checkout. A record of testing and acknowledgement that a procedure has been completed and that it checks out acceptably must be included in the Prefunctional Checklists. The Prefunctional Checklist shall identify in columnar format each device, location, test method, control sequence of operation reference, device code reported, and other data as appropriate.
- D. Equipment Data Documentation: Provide completed, as-installed, specific product nameplate data, product numbers, serial numbers, etc. to fully define the asset for Owner's use in maintenance management and asset tracking. This data may be incorporated within the Equipment Matrix as described in Division 01 as a spreadsheet format or electronic database. In addition to specific manufacturer's name and specific product identifiers such as model number, serial numbers, date of manufacture, etc, the following information shall be included with the equipment data documentation:
 - 1. Capacity data: Where applicable, use equipment schedules on the Drawings as a guideline for fields to be used.
 - 2. Location identifier field for each of the three dimensions (Floor Level, X axis, and Y axis) using the Drawing column grids as the basis for location.
- E. Submit the equipment data documentation with the draft Prefunctional Checklists to the Owner for approval. A/E and Owner will review the Prefunctional Checklists and request any additional information required to meet the Commissioning Plan criteria.
- F. Written Certification: The Contractor shall certify that the installation, Start-up, Prefunctional Checklist, and initial operation of the system or component is in accordance with the Contract Documents, Commissioning Plan, and manufacturer's requirements, and that the system is ready for Functional Performance Tests. Any outstanding items or non-conformance shall be clearly indicated and highlighted on the Prefunctional Checklist and an action item shall have been initiated. Refer to Division 01 for specific details on non-conformance issues relating to Prefunctional Checklists.
- G. Refer to Section 20 08 00 for additional documentation requirements.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

- B. The Prefunctional Checklist procedures described in this Section provide minimum guidelines for development of Prefunctional Checklists; Start-up procedures, and Prefunctional Tests. Contractor shall prepare the Prefunctional Checklists using these procedures and that of the manufacturers and/or applicable codes and standards.
- C. The Prefunctional Checklist form shall acknowledge that installation and Start-up procedures were successfully adhered to and completely performed and shall document relevant parameters (panel and equipment connections, measured values, ground faults, trip settings, etc.). When indicated as performing a checkout on multiple items or multiple procedure items, Prefunctional Checklist forms shall itemize each individual item.

PART 3 - EXECUTION

3.01 PREFUNCTIONAL CHECKLIST PROCEDURES

- A. Not Used
- B. Not Used
- C. Mechanical Identification:
 - 1. Verify that all duct, and equipment labeling corresponds with the Drawings and indexes and meets requirements specified. Correct any deficiencies for all piping and duct systems.
 - 2. Adjusting: Relocate any mechanical identification device which has become visually blocked by Work of this Division or other Divisions.
 - 3. Cleaning: Clean the face of identification devices.
- D. Not Used
- E. Not Used
- F. Not Used
- G. AC Motors:
 - 1. The following applies to all AC motors serving equipment.
 - a. Verify proper alignment, installation, and rotation.
 - b. Measure the insulation resistance, phase balance, and resistance to ground. These measurements will generally be the responsibility of the mechanical Subcontractor who is connecting the motor. The motor manufacturer will be responsible to correct any deficiencies. When electrical Subcontractor wires to a single point of a packaged device that is shipped with multiple motors, electrical Subcontractor shall check all motors in the package.
 - c. Verify that properly sized overloads are in place.

d. Measure voltage available to all phases at the time of initial connection and after the motor has been placed in operation under load measure amps and RPM.

e. Record all motor nameplate data.

H. Not Used

I. Not Used

J. Not Used

K. Not Used

L. Not Used

M. Not Used

N. Not Used

O. Not Used

P. Not Used

Q. Not Used

R. Not Used

S. Not Used

T. Not Used

U. Not Used

V. Not Used

W. Not Used

X. Fans – General Across Systems:

1. Manufacturer's Field Inspection: Arrange and pay for a factory-authorized service representative to inspect the field assembly of components and installation of fans including ductwork, and electrical connections.
2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Ensure that volatile irritants are contained and kept out of occupied spaces.
3. Vacuum clean the fan wheel and fan cabinet.
4. Adjust and lubricate dampers and linkages for proper damper operation.
5. Verify that the unit is secure on mountings and supporting devices and that connections for ductwork and electrical are complete. Verify that proper thermal overload protection is installed in motors, starters, and disconnects.

6. Ensure that vibration isolation integrity is maintained with the fan installation and connections to the fan.
7. Refer to AC Motors in this Section.
8. Properly align and tension all belts. Record tensioning parameters in the Prefunctional Checklists.
9. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align belts, and install belt guards.
10. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
11. Stroke all dampers to ensure free and full travel.
12. Refer to Division 25, BAS Commissioning, for procedures on starting controls related to fans.

Y. Not Used

Z. Not Used

AA. Metal Ductwork:

1. Inspect all ductwork for damage and dents and correct any deficiencies.
2. Check ductwork system to ensure that all required dampers, vanes, access doors, testing ports, and other appurtenances are required per the Contract Documents.
3. Not Used
4. Not Used
5. Clean ductwork internally of dust and debris, unit by unit as it is installed. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
6. Strip protective paper from stainless steel ductwork surfaces and repair finish wherever the finish has been damaged.
7. Temporary Closure: At ends of ductwork which are not connected to equipment or air distribution devices at the time of ductwork installation, provide temporary closure of polyethylene film or other covering that will prevent entrance of dust and debris until final ductwork connections are to be completed.
8. Check pressure class of ductwork against fan dead head to verify adequacy.

BB. Ductwork Accessories:

1. Inspect and operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leak proof performance.
2. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

CC. Building Automation System:

1. Start-Up: Refer to Division 25, BAS Commissioning. This Division requires the manufacturer's authorized representative to Start-up, test, adjust, and calibrate DDC control systems and to demonstrate compliance with Contract Document requirements. This will include verification of sequences, normal and emergency operations, calibration, interfaces, and interlocks, etc.
2. Inspect installation for conformance to manufacturer's requirements.
3. Not Used
4. Not Used

DD. Not Used**3.02 ACCEPTANCE CRITERIA**

- A. Acceptance criteria for tests are indicated in the Specification Sections applicable to the systems being tested. Unless indicated otherwise, acceptance criteria will be specified with the individual system, equipment, component, or device.

3.03 TRAINING

- A. Training requirements are specified in Specification Section 01 79 00 – Demonstration and Training.

END OF SECTION 20 08 13

EXAMPLE - PREFUNCTIONAL CHECKLIST
HVAC Pumps

Project: _____ Project #: _____

Identification of Equipment or System: _____

Location of Equipment or System: _____

Specification Section: _____ Detail/Drawing Number: _____

Manufacturer / Supplier: _____

This Date: _____ Inspection Requested for (Date): _____

PREFUNCTIONAL CHECKLIST NUMBER: _____

Components Included:

___ Valves, ___ Gauges, ___ Strainer, ___ Vibration isolators, ___ Base

Associated Prefunctional Checklists:

___ Piping, ___ Tubing, ___ Other _____

1. General:

- a. Submittal. The above systems and components integral to this equipment are complete and ready for Functional Performance Tests. The Prefunctional Checklist items are complete and have been checked off only by parties having direct knowledge of the event, as indicted below, respective to each responsible contractor. This Prefunctional Checklist is submitted for approval and is subject to the attached list of outstanding items not completed successfully. Submit a Deficiency Form upon completion of any outstanding or deficient items. None of the outstanding items preclude safe and reliable functional tests being performed.
- b. ___ Deficiency Form attached.
- c. This Prefunctional Checklist does not take the place of the manufacturer's recommended checkout and start-up procedures or report.
- d. Contractors assigned responsibility for sections of the Prefunctional Checklist shall be responsible to ensure that their subcontractors complete and check off their Checklist items.
- e. Prefunctional Checklist items shall be completed as part of start-up & initial checkout,

MD ANDERSON Project No. 15-0005

Tom Green & Company Engineers, Inc.
1311.00

GRIFFIN ANIMAL BUILDING CRAWLSPACE
IMPROVEMENTS

100% Construction Documents
October 12 2018

preparatory to functional testing.

Contractor/Entity	Company	Abbreviation
MD Anderson Staff		MD ANDERSON
Architect/Engineer		A/E
General Contractor / Construction Manager		GC
Mechanical Contractor		MC
Electrical Contractor		EC
Building Automation System Provider		BAS
Test, Adjust, and Balance Firm		TAB
Commissioning Consultant		CA

2. Requested Documentation Submitted:

Specified Requirement		Yes	No	Date to be Submitted
a)	Manufacturer's Product Data including Performance Data and Shop Drawings, as approved by Architect/Engineer			
b)	Required Test Reports and/or Certifications			
c)	Installation and Start-up Manual and Plan			
d)	Wiring Diagrams, Control Schematics and Sequences			
e)	Operating and Maintenance Manual Content for Applicable System			
f)	Equipment Matrix			

3. Equipment Verification:

Item	Specified	Submitted	Installed
Manufacturer			
Model Number			
Serial Number			
Service			
GPM			
Head (Ft)			
Motor Horsepower (hp)			
Voltage/Phase			

4. Installation Checks:

a) Unit and General Installation		Yes	No	Comments
1.	Permanent labels affixed			
2.	Housing condition good – no leaks			

a) Unit and General Installation		Yes	No	Comments
3.	Pumps mounted on base			
4.	Alignment appears correct			
5.	Vibration isolation equipment installed and active			
6.	Maintenance access acceptable			
7.	Coupling guard(s) installed			
8.	Pump lubricated			
9.	Instrumentation installed correctly per Contract Documents (thermowells, thermometers, pressure gages, flow meters, transmitters, sensors)			
10.	Equipment clean			

b) Valves and Piping (immediately around pump)		Yes	No	Comments
1.	Pipe fittings complete and pipes properly supported			
2.	Pipe pressure test complete and acceptable			
3.	Flexible pipe installed at pump connections			
4.	Pipes properly insulated			
5.	Pipes properly labeled			
6.	Piping system properly flushed			
7.	Piping system charged			
8.	No leaking evident around fittings or components			
9.	Strainer(s) installed			
10.	Strainer(s) clean			
11.	Valves properly labeled			
12.	Valves installed in proper direction			
13.	Isolation valves open and close			

c) Electrical and Controls		Yes	No	Comments
1.	HOA switch installed and functioning			
2.	Panel power source identified			
3.	Panel labeled with permanent label			
4.	Power disconnect in place and labeled			
5.	Low voltage wiring in separate conduit as 120 vac			
6.	120 vac lightning protection installed			
7.	Low voltage lightning protection installed (underground only)			
8.	Pneumatic devices separated from controller and electronics			
9.	End-of-line devices labeled and wiring tagged per Contract Documents			
10.	Panel devices labeled and wiring tagged per Contract Documents			
11.	I/O devices labeled and wiring tagged per Contract Documents			
12.	Digital inputs and outputs operational			
13.	Controller drawing and point summary log in panel			
14.	All electric connections tight			

c) Electrical and Controls		Yes	No	Comments
15.	Proper grounding installed for components and unit			
16.	Safeties in place and operable			
17.	Starter overload breakers installed and correct size			
18.	Sensors calibrated (see below)			
19.	Control system interlocks hooked up and functional			
20.	All control devices, pneumatic tubing and wiring complete			

d) Variable Frequency Drive		Yes	No	Comments
1.	VFD Prefunctional Checklist complete and approved			

e) Final		Yes	No	Comments
1.	Start-up report completed and attached with this Prefunctional Checklist			
2.	Safeties and safe operating ranges for this equipment have been reviewed and accepted			
3.	Sequence of operation adequately indicates all information			
4.	System is ready for Functional Performance Test			

5. Operational Checks:

- a. These checks supplement the manufacturer's list. This is not the Functional Performance Test.

Operational Checks		Yes	No	Comments
1.	Pump(s) rotation correct			
2.	Pump Phase Checks (%Imbalance = $100 \times (\text{avg.} - \text{lowest}) / \text{avg.}$). Imbalance less than 2%?			
3.	All pumps running less than maximum FL amps			
4.	Pump noise and vibration acceptable			
5.	Cavitation exists			
6.	Valves stroke fully and easily			
7.	Specified sequences of operation and operating schedules have been implemented with all variations documented			
8.	Specified point-to-point checks have been completed and documentation record submitted for this system			
9.	Record full load running amps for each pump. Pump No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) Pump No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) Pump No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) Pump No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) Pump No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) Pump No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps)			

6. Sensor and/or Actuator Calibration:

- a. All field-installed temperature sensors, pressure sensors, and gages, and all actuators and valves on this piece of equipment shall be calibrated. Sensors installed in the unit at the factory with calibration certification provided are not required to be field calibrated.

b. All test instruments have had a certified calibration within the last 12-months: Y / N

c. Sensor/Actuator Verification Table

Sensor or Actuator	Correct Location (Y/N) (1)	Thermometer or Gage Value	BAS Value (2)	Instrument Measured Value (3)	Pass (Y/N)
Discharge Pressure					
Suction Pressure					
Differential Pressure					

1. Thermometer/Gage reading is the reading of the permanently mounted instrument on the equipment.

2. BAS is the Building Automation System. Instrument = testing instrument.

3. All sensors are calibrated within required tolerances ____ YES ____ NO

FINAL SIGN-OFF

Contractors attest that the above items have been verified and meet the requirements of the Contract Documents except as noted on the attached Deficiency form.

General Contractor:	Print Name:	
	Signature:	
	Title:	
	Date:	
Mechanical Subcontractor	Print Name:	
	Signature:	
	Title:	
	Date:	
Other Subcontractor:	Print Name:	
	Signature:	
	Title:	
	Date:	

Prefunctional Checklist received and reviewed for completeness by MD ANDERSON representatives.
Functional Performance Test can proceed.

MD ANDERSON:	Print Name:	
	Signature:	
	Title:	
	Date:	
MD ANDERSON:	Print Name:	
	Signature:	

MD ANDERSON Project No. 15-0005

GRIFFIN ANIMAL BUILDING CRAWLSPACE
IMPROVEMENTS

Tom Green & Company Engineers, Inc.
1311.00

100% Construction Documents
October 12 2018

	Title:	
	Date:	

EXAMPLE - PREFUNCTIONAL CHECKLIST

Air Handling Units - Modular

Project: _____ Project #: _____

Identification of Equipment or System: _____

Location of Equipment or System: _____

Specification Section: _____ Detail/Drawing Number: _____

Manufacturer / Supplier: _____

This Date: _____ Inspection Requested for (Date): _____

PREFUNCTIONAL CHECKLIST NUMBER: _____

Components Included:

___ Supply Fan, ___ Return Fan, ___ Cooling Coil(s), ___ Valves, ___ Control Dampers

Associated Prefunctional Checklists:

___ Chilled Water Piping, ___ Hot Water Piping, ___ Exhaust Fans, ___ Terminal Units, ___ VFD,
___ Smoke Dampers, ___ Fire Dampers, ___ Other _____

1. General:

- a. Submittal. The above systems and components integral to this equipment are complete and ready for Functional Performance Tests. The Prefunctional Checklist items are complete and have been checked off only by parties having direct knowledge of the event, as indicated below, respective to each responsible contractor. This Prefunctional Checklist is submitted for approval and is subject to the attached list of outstanding items not completed successfully. Submit a Deficiency Form upon completion of any outstanding or deficient items. None of the outstanding items preclude safe and reliable functional tests being performed.
- b. ___ Deficiency Form attached.
- c. This Prefunctional Checklist does not take the place of the manufacturer's recommended checkout and start-up procedures or report.
- d. Contractors assigned responsibility for sections of the Prefunctional Checklist shall be responsible to ensure that their subcontractors complete and check off their Checklist items.

- e. Prefunctional Checklist items shall be completed as part of start-up & initial checkout, preparatory to functional testing.

Contractor/Entity	Company	Abbreviation
MD Anderson Staff		MD ANDERSON
Architect/Engineer		A/E
General Contractor / Construction Manager		GC
Mechanical Contractor		MC
Electrical Contractor		EC
Building Automation System Provider		BAS
Test, Adjust, and Balance Firm		TAB
Commissioning Consultant		CA

2. Requested Documentation Submitted:

Specified Requirement	Yes	No	Date to be Submitted
a) Manufacturer's Product Data including Performance Data and Shop Drawings, as approved by Architect/Engineer			
b) Required Test Reports and/or Certifications			
c) Installation and Start-up Manual and Plan			
d) Wiring Diagrams, Control Schematics and Sequences			
e) Operating and Maintenance Manual Content for Applicable System			
f) Equipment Matrix			

3. Equipment Verification:

Item	Specified	Submitted	Installed
Manufacturer			
Model Number			
Serial Number			
Service			
Sensible Capacity (BTU/hr)			
Total Capacity (BTU/hr)			
Fan CFM (Total)			
Fan Motor Horsepower (hp)			
Voltage/Phase			

4. Installation Checks:

a) Unit and General Installation		Yes	No	Comments
1.	Permanent labels affixed			
2.	Casing condition good – no dents, leaks; door gaskets installed			
3.	Access doors close tightly – no apparent leaks			
4.	Flexible duct between unit and rigid duct tight; in good condition			
5.	Vibration isolation equipment installed and active			
6.	Maintenance access acceptable			
7.	Thermal insulation installed properly			
8.	Instrumentation installed correctly per Contract Documents (thermowells, thermometers, pressure gages, flow meters, transmitters, sensors)			
9.	Equipment clean			
10.	Filters clean with correct efficiency or MERV installed			
11.	Filter frame housing installation allows for easy filter replacement			
12.	Filter pressure differential measuring device installed and functional (magnahelic, etc.)			
13.	Electronic filtration installed			
14.	Electronic filtration operational			

b) Valves, Piping, and Coils		Yes	No	Comments
1.	Pipe fittings complete and pipes properly supported			
2.	Pipes properly labeled			
3.	Pipes properly insulated			
4.	Piping system properly flushed			
5.	Piping system charged			
6.	No leaking evident around fittings or components			
7.	Coils are clean, fins are in good condition			
8.	Condensate drain pan(s) installed, clean, sloped properly			
9.	Condensate drain line(s) installed and supported correctly			
10.	Control valve and isolation valves installed			
11.	Valves properly labeled			
12.	Valves installed in proper direction			
13.	Isolation valves open and close			
14.	Outside air (OA) temperature, mixed air temperature, supply air temperature, return air temperature, chilled water supply/return sensors properly located and secure (related OA temperature sensor shielded)			
15.	Sensors calibrated (see calibration section below)			
16.	Pressure/temperature plugs and isolation valves installed per Contract Documents			

c) Fans and Dampers		Yes	No	Comments

c) Fans and Dampers		Yes	No	Comments
1.	Supply fan and motor alignment correct			
2.	Supply fan belt tension and condition good			
3.	Supply fan protective shrouds for belts in place and secure			
4.	Supply fan area clean			
5.	Supply fan and motor lube lines installed and lubed			
6.	Return fan and motor alignment correct			
7.	Return fan belt tension and condition good			
8.	Return fan protective shrouds for belts in place and secure			
9.	Return fan area clean			
10.	Return fan and motor lube lines installed and lubed			
11.	Exhaust fan Checklists for service area complete			
12.	Smoke and fire dampers installed properly per Contract Documents (proper location, access doors, appropriate ratings verified)			
13.	All isolation and smoke dampers close and seal properly			
14.	All dampers (outside air, return air, supply air) stroke fully without binding			
15.	All damper linkages have minimum play			

d) Duct		Yes	No	Comments
1.	Sound attenuators installed			
2.	Duct joint sealant properly installed			
3.	No apparent severe duct restrictions			
4.	Turning vanes in square elbows as per Contract Documents			
5.	Outside air intakes located away from pollutant sources and exhaust outlets			
6.	Pressure leakage tests completed			
7.	Branch duct control dampers operable			
8.	Ducts cleaned as per Contract documents			
9.	Terminal units installed, Checklist complete			
10.	Balancing dampers installed per Contract Documents and TAB Firm's direction			
11.	Supply and return air devices installed			

e) Electrical and Controls		Yes	No	Comments
1.	HOA switch installed and functioning			
2.	Panel power source identified			
3.	Panel labeled with permanent label			
4.	Power disconnect in place and labeled			
5.	Low voltage wiring in separate conduit as 120 vac			
6.	120 vac lightning protection installed			
7.	Low voltage lightning protection installed (underground only)			

e) Electrical and Controls		Yes	No	Comments
8.	Pneumatic devices separated from controller and electronics			
9.	End-of-line devices labeled and wiring tagged per Contract Documents			
10.	Panel devices labeled and wiring tagged per Contract Documents			
11.	I/O devices labeled and wiring tagged per Contract Documents			
12.	Digital inputs and outputs operational			
13.	Controller drawing and point summary log in panel			
14.	All electric connections tight			
15.	Proper grounding installed for components and unit			
16.	Safeties in place and operable			
17.	Starter overload breakers installed and correct size			
18.	Sensors calibrated (see below)			
19.	Control system interlocks hooked up and functional			
20.	Smoke detectors in place			
21.	All control devices, pneumatic tubing and wiring complete			
22.	All casing wall penetrations including control wiring are properly sealed			

f) Variable Frequency Drive		Yes	No	Comments
1.	VFD Prefunctional Checklist complete and approved			

h) Final		Yes	No	Comments
1.	Start-up report completed and attached with this Prefunctional Checklist			
2.	Safeties and safe operating ranges for this equipment have been reviewed and accepted			
3.	Sequence of operation adequately indicates all information			
4.	Fire/smoke dampers and terminal units are open			
5.	Construction filters installed on return air devices to minimize dirt in ductwork and coils and in any finished areas			
6.	Verification of potential moisture migration has been performed via inspection of wall/building construction and review of operating sequences for all make-up air, outside air, supply, return, and exhaust fans			
7.	System is ready for Functional Performance Test			

5. Operational Checks:

- a. These checks supplement the manufacturer's list. This is not the Functional Performance

Test.

Operational Checks		Yes	No	Comments
1.	Supply fan rotation correct			
2.	Fans > 5 Hp Phase Checks (%Imbalance = 100 x (avg. – lowest) / avg.). Imbalance less than 2%?			
3.	All fans running less than maximum FL amps			
4.	Return fan noise and vibration acceptable			
5.	Supply fan has no unusual noise or vibration			
6.	Valves stroke fully and easily			
7.	Valves verified not to leak through coils when closed at normal operating pressure			
8.	The HOA switch properly activates and deactivates the unit			
9.	Specified sequences of operation and operating schedules have been implemented with all variations documented			
10.	Specified point-to-point checks have been completed and documentation record submitted for this system			
11.	Record full load running amps for each pump. SF Fan No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) SF Fan No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) SF Fan No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) RF Fan No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) RF Fan No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps) RF Fan No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps)			

6. Sensor and/or Actuator Calibration:

- a. All field-installed temperature sensors, pressure sensors, and gages, and all actuators and valves on this piece of equipment shall be calibrated. Sensors installed in the unit at the factory with calibration certification provided are not required to be field calibrated.
- b. All test instruments have had a certified calibration within the last 12-months: Y / N
- c. Sensor/Actuator Verification Table (AHU in Operation)

Sensor or Actuator	Correct Location (Y/N) (1)	Thermometer or Gage Value	BAS Value (2)	Instrument Measured Value (3)	Pass (Y/N)
Supply air discharge					
Return air					
Outside air					
CHWR (at AHU)					
CHWS (at AHU)					
Duct SP (at SA discharge)					

CHW Control Valve Position					
HWR (at AHU)					
HWS (at AHU)					
HW Control Valve Position					

1. Thermometer/Gage reading is the reading of the permanently mounted instrument on the equipment.

2. BAS is the Building Automation System. Instrument = testing instrument.

3. All sensors are calibrated within required tolerances ____ YES ____ NO

FINAL SIGN-OFF

Contractors attest that the above items have been verified and meet the requirements of the Contract Documents except as noted on the attached Deficiency form.

General Contractor:	Print Name:	
	Signature:	
	Title:	
	Date:	
Mechanical Subcontractor	Print Name:	
	Signature:	
	Title:	
	Date:	
Other Subcontractor:	Print Name:	
	Signature:	
	Title:	
	Date:	

Prefunctional Checklist received and reviewed for completeness by MD ANDERSON representatives.
Functional Performance Test can proceed.

MD ANDERSON:	Print Name:	
	Signature:	
	Title:	
	Date:	
MD ANDERSON:	Print Name:	
	Signature:	

MD ANDERSON Project No. 15-0005

GRIFFIN ANIMAL BUILDING CRAWLSPACE
IMPROVEMENTS

Tom Green & Company Engineers, Inc.
1311.00

100% Construction Documents
October 12 2018

	Title:	
	Date:	

EXAMPLE - PREFUNCTIONAL CHECKLIST**Terminal Units**

Project: _____ Project #: _____

Identification of Equipment or System: _____

Location of Equipment or System: _____

Specification Section: _____ Detail/Drawing Number: _____

Manufacturer / Supplier: _____

This Date: _____ Inspection Requested for (Date): _____

PREFUNCTIONAL CHECKLIST NUMBER: _____

Components Included:

___ Damper, ___ Temperature Sensor, ___ Heating Coil, ___ Fan

Associated Prefunctional Checklists:

___ AHU- _____, ___ Other _____

1. General:

- a. Submittal. The above systems and components integral to this equipment are complete and ready for Functional Performance Tests. The Prefunctional Checklist items are complete and have been checked off only by parties having direct knowledge of the event, as indicated below, respective to each responsible contractor. This Prefunctional Checklist is submitted for approval and is subject to the attached list of outstanding items not completed successfully. Submit a Deficiency Form upon completion of any outstanding or deficient items. None of the outstanding items preclude safe and reliable functional tests being performed.
- b. ___ Deficiency Form attached.
- c. This Prefunctional Checklist does not take the place of the manufacturer's recommended checkout and start-up procedures or report.
- d. Contractors assigned responsibility for sections of the Prefunctional Checklist shall be responsible to ensure that their subcontractors complete and check off their Checklist items.
- e. Prefunctional Checklist items shall be completed as part of start-up & initial checkout, preparatory to functional testing.

Contractor/Entity	Company	Abbreviation
MD Anderson Staff		MD ANDERSON
Architect/Engineer		A/E
General Contractor / Construction Manager		GC
Mechanical Contractor		MC
Electrical Contractor		EC
Building Automation System Provider		BAS
Test, Adjust, and Balance Firm		TAB
Commissioning Consultant		CA

2. Requested Documentation Submitted:

Specified Requirement		Yes	No	Date to be Submitted
a)	Manufacturer's Product Data including Performance Data and Shop Drawings, as approved by Architect/Engineer			
b)	Required Test Reports and/or Certifications			
c)	Installation and Start-up Manual and Plan			
d)	Wiring Diagrams, Control Schematics and Sequences			
e)	Operating and Maintenance Manual Content for Applicable System			
f)	Equipment Matrix			

3. Equipment Verification:

Item	Specified	Submitted	Installed
Manufacturer			
Model Number			
Serial Number			
Service			
Capacity (CFM)			
Maximum CFM			
Minimum CFM			
Fan Motor Horsepower (hp)			
Fan Voltage/Phase			
Electric Heat (kW) if applicable			

4. Installation Checks:

a) Unit and General Installation		Yes	No	Comments
1.	Permanent labels affixed			
2.	Permanent label affixed within building space identifying			

a) Unit and General Installation		Yes	No	Comments
	location			
3.	Casing condition good – no dents, leaks; door gaskets installed			
4.	Access doors close tightly – no apparent leaks			
5.	Hard duct connecting high/medium pressure duct to unit			
6.	Vibration isolation equipment installed and active			
7.	Maintenance access acceptable			
8.	Sound attenuation installed properly			
9.	Instrumentation installed correctly per Contract Documents			
10.	Equipment clean			

b) Heating Coil		Yes	No	Comments
1.	Pipe fittings complete and pipes properly supported			
2.	Pipes properly labeled			
3.	Pipes properly insulated			
4.	No leaking evident around fittings or components			
5.	Coils are clean, fins are in good condition			
6.	Valves properly labeled			
7.	Control valve installed and wired properly			
8.	Valves installed in proper direction			

c) Fans and Dampers		Yes	No	Comments
1.	Fan and motor alignment correct			
2.	Fan area clean			
3.	Fan responds to temperature sensor settings			
4.	Damper installed properly			
5.	Damper closes and opens properly			
6.	Damper linkages have minimum play			

d) Electrical and Controls		Yes	No	Comments
1.	Temperature sensor location accessible for maintenance			
2.	Temperature sensor not damaged			
3.	Temperature sensor labeled with respect to terminal unit and air handler			
4.	Panel power source identified			
5.	Power disconnect for electric heating coil and/or fan in place and labeled			
6.	Panel devices labeled and wiring tagged per Contract Documents			
7.	I/O devices labeled and wiring tagged per Contract Documents			
8.	Digital inputs and outputs operational			
9.	Controller drawing and point summary log in panel			
10.	All electric connections tight			

d) Electrical and Controls		Yes	No	Comments
11.	Proper grounding installed for components and unit			
12.	Safeties in place and operable			
13.	Sensors calibrated (see below)			
14.	Control system interlocks hooked up and functional			
15.	All control devices and wiring complete			
16.	All control devices, pneumatic tubing and wiring complete			

f) Variable Frequency Drive		Yes	No	Comments
1.	VFD Prefunctional Checklist complete and approved			

h) Final		Yes	No	Comments
1.	Start-up report completed and attached with this Prefunctional Checklist			
2.	Safeties and safe operating ranges for this equipment have been reviewed and accepted			
3.	Sequence of operation adequately indicates all information			
4.	Terminal unit damper open			
5.	System is ready for Functional Performance Test			

5. Operational Checks:

- a. These checks supplement the manufacturer's list. This is not the Functional Performance Test.

Operational Checks		Yes	No	Comments
1.	Actuated damper(s) responds to sensor temperature settings			
	Fan rotation correct			
2.	Record full load running amps for fan:			
	Fan No. ____: ____ rated FL amps x ____ svc factor = ____ (Max amps)			
3.	Fan running less than maximum FL amps			
4.	Fan noise and vibration acceptable			
5.	Fan responds to temperature sensor settings			
6.	Heating coil responds to temperature sensor settings			
8.	Disconnect switch properly activates and deactivates the heating coil			
9.	Specified sequences of operation and operating schedules have been implemented with all variations documented			
10.	Specified point-to-point checks have been completed and documentation record submitted for this system			

6. Sensor and/or Actuator Calibration:

- a. All field-installed temperature sensors, pressure sensors, and gages, and all actuators and

valves on this piece of equipment shall be calibrated. Sensors installed in the unit at the factory with calibration certification provided are not required to be field calibrated.

b. All test instruments have had a certified calibration within the last 12-months: Y / N

c. Sensor/Actuator Verification Table

Sensor or Actuator	Correct Location (Y/N) (1)	Thermometer or Gage Value	BAS Value (2)	Instrument Measured Value (3)	Pass (Y/N)
Temperature Sensor					

1. Thermometer/Gage reading is the reading of the permanently mounted instrument on the equipment.

2. BAS is the Building Automation System. Instrument = testing instrument.

3. All sensors are calibrated within required tolerances ____ YES ____ NO

FINAL SIGN-OFF

Contractors attest that the above items have been verified and meet the requirements of the Contract Documents except as noted on the attached Deficiency form.

General Contractor:	Print Name:	
	Signature:	
	Title:	
	Date:	
Mechanical Subcontractor	Print Name:	
	Signature:	
	Title:	
	Date:	
Other Subcontractor:	Print Name:	
	Signature:	
	Title:	
	Date:	

Prefunctional Checklist received and reviewed for completeness by MD ANDERSON representatives.
Functional Performance Test can proceed.

MD ANDERSON:	Print Name:	
	Signature:	
	Title:	
	Date:	
MD ANDERSON:	Print Name:	
	Signature:	
	Title:	
	Date:	

MD ANDERSON Project No. 15-0005
Tom Green & Company Engineers, Inc.
1311.00

GRIFFIN ANIMAL BUILDING CRAWLSPACE
IMPROVEMENTS
100% Construction Documents
October 12 2018

SECTION 20 08 16 – HVAC SYSTEMS FUNCTIONAL PERFORMANCE TESTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. This Section expands on and defines responsibilities of the Contractor in regards to Functional Performance Tests (FPT's) of the Commissioning process.
- B. Contractor shall oversee the Commissioning activities with the Contractor's Subcontractors and the Architect/Engineer (A/E).
- C. Prefunctional Checklists, tests and Start-ups are to be completed and documented for the record prior to commencing with FPT's. Refer to Section 20 08 00 and 20 08 13 for additional requirements.
- D. Completed FPT Forms for all pieces of equipment and systems shall be submitted to the Owner prior to Substantial Completion.
- E. Refer to Attachments A and B at the end of this Section for example forms that indicate level of documentation required for the Commissioning process.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with all applicable requirements and standards.

1.04 SUBMITTALS

- A. Maintain and use an action item tracking system, "Action Item List," that indicates as a minimum, required information, identified deficiencies, work required, etc.). Each item shall be tracked with the initiator, the parties responsible, due date, the date of closure, and a description of the resolution. Each item shall be categorized for sorting and tracking and for documentation on applicable forms. Action Item List shall be distributed and documented using Microsoft Excel or a database format approved by Owner.

- B. Disseminate this list as appropriate to keep all parties involved with the FPT informed.
- C. Functional Performance Test procedure forms must include the following:
 - 1. System and equipment or component name(s).
 - 2. Equipment location and identification number as identified in the Equipment Matrix described in Division 01.
 - 3. Unique test identification number and reference to unique Prefunctional Checklist and Start-up Documentation Identification Numbers for the equipment.
 - 4. Date and time of test.
 - 5. Project name.
 - 6. Participating parties.
 - 7. Specific sequence of operation or other specified parameters, including performance data being verified.
 - 8. Instructions for setting up a Functional Performance Test.
 - 9. Specific script-type, step-by-step procedures to perform a Functional Performance Test, in a clear, sequential and repeatable format that is customized for the system being tested.
 - 10. A Yes/No checkbox (or data entry box as appropriate) for clearly indicating whether or not proper performance of each part of a Functional Performance Test was achieved with space for actual readings.
 - 11. Section for comments.
 - 12. Signatures and date block for participants and Owner approvals.
- D. Refer to Division 01 and 20 08 00 for additional documentation requirements.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 TEST EQUIPMENT

- A. Refer to Specification Section 01 91 00 – General Commissioning Requirements.

PART 3 - EXECUTION

3.01 PREPARATION

- A. The objective of FPT's is to demonstrate that each system operates according to the Contract Documents through all specified modes of operation.
- B. Contractor shall operate each system through all modes of operation where there is a specified system response. Verification of each sequence in the sequences of operation is required.
- C. All equipment, components and devices applicable to the FPT must be started and this Start-up must be documented. This documentation includes completion of the Prefunctional Checklists, pressure testing of equipment, duct, etc., flushing/cleaning of applicable systems, completed labeling and identification, completed insulation of applicable systems, etc. Refer to Section 20 08 13 for additional Prefunctional Checklist and Start-up requirements.
- D. Unless specifically agreed to by the Commissioning Team, all support systems shall be complete prior to FPT.
 - 1. The electrical system serving it is completed and tested.
 - 2. Not Used
 - 3. Balancing has been accomplished on the air side.
 - 4. The building automation system (BAS) has been started and calibrated.
- E. Commissioning Team members shall assist in development and review of the optimal sequence of testing.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.

3.03 FUNCTIONAL PERFORMANCE TEST PROCEDURES

- A. The purpose of a Functional Performance Test is to verify and document compliance with the stated criteria of acceptance. Contractor shall develop specific script-type test procedures and associated test forms to verify and document proper operation of each piece of equipment and system.
- B. Contractor shall operate, or cause to be operated, each system, device, or equipment item, both intermittently and continuously, for a duration period as indicated in the Specification Section(s) for such item and/or in accordance with the manufacturer's written recommendations, the Contract Documents, and the Commissioning Plan.
- C. Contractor shall operate each component device and each building system to the full extent of its capability, from minimum to maximum, and under automatic control and manual control.

- D. Contractor and manufacturer's representatives shall supervise and coordinate adjustments and balancing of all devices and systems for proper operation prior to requesting the Functional Performance Test(s).
- E. Where final balancing of a system is to be performed by Owner or Owner's consultants, such as final air balancing, Contractor shall provide all services indicated in the applicable Technical Sections and under this Section, including the following prior to Owner's final balancing:
 - 1. Operational verification of all component devices and the total system, including automatic controls when applicable. Operational verification includes verification that all motors, fans, dampers, and other operable devices are performing in compliance with Specifications throughout their operable range and that all devices are controlled as described in the specified sequence of operation.
 - 2. All tabulated data, motor amperage readings, valve tag verifications, and other data required by Technical Specifications.
- F. Where final balancing of a system or particular components of a system are not specifically indicated to be performed by Owner or Owner's consultants, Contractor shall provide final balancing and adjustments for operation within specified tolerances prior to Functional Performance Test of such system.
- G. Sampling: Some types of identical equipment (such as terminal devices) will be tested using a sampling strategy. The sample percentage is indicated below. [Insert equipment list and sampling percentage.]
- H. Failure Limit on Sample Tests: With the sampling percentages is listed a failure limit. This limit indicates the maximum percentage of the tested devices that may have any test that fails before an entirely new sample must be tested. When the maximum number of failures is reached, testing on that sample will be terminated and re-testing will be scheduled.
 - 1. Where sample tests involve multiple systems the maximum failure limit will apply per system.
- I. Not Used
- J. Provide and deliver the required submitted documentation convenient to testing area. Validate that all required documentation has been submitted to the Owner and is per the Contract Document requirements.
- K. Review the Start-up documentation at the start of FPT's. Ensure that any items indicated as outstanding in the Prefunctional Checklist is entered as an Action Item and enter one if it is not. The Prefunctional Checklists and Start-up tests/measurements shall be spot checked at the beginning of FPT's to ensure accuracy. Complete a test that indicates Contractor has reviewed the Prefunctional Checklists and finds the Prefunctional Checklists acceptable and notes any outstanding items.
- L. Check for and as applicable direct the Subcontractor to demonstrate that access is sufficient to perform required maintenance.

- M. Validate that all prerequisite work is complete and confirm this validation via a test record for documentation.
- N. Specifically check labeling and ensure conformance to the Contract Documents.
- O. Analyze trends of the system operating parameters to evaluate normal system functionality. The trending requirements are specified in the BAS Commissioning Specification, however all systems must be trended and reviewed prior to and as part of functional performance trending. Subcontractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the Contractor. Analyzed trends shall be organized and/or grouped in a manner that clearly demonstrates the individual components of a piece of equipment is under total control and display this information together. The trend group data shall be labeled with the system name or the purpose of the trend group or data and submitted in a Microsoft Excel spreadsheet.
- P. Check proof indication, alarming on failure and restart/acknowledgement as applicable.
- Q. Observe operating conditions encountered at the start of the FPT. Contractor shall examine for normal functionality and record parameters as a test.
- R. All dynamic systems powered by electricity shall be tested to simulate a power outage to ensure proper sequencing. Those on emergency power or uninterruptible power shall be tested on all sources. This test shall generally be coordinated with electrical power systems testing addressed in the Contract Documents.
- S. Inspect the installation and compare it to the Contract Documents. Record the inspection as a test.
- T. Capacities and adjusted and balanced conditions as applicable will generally be checked.
- U. Verify all sequence modes and sequences of operation. Contractor must initiate all modes and may not refer to or rely on a Prefunctional Test done by the building automation system. Some examples of generic modes that apply to most systems include:
 - 1. Off mode.
 - 2. Failed mode: Proof, safeties, power outage etc. See below for crash testing.
 - 3. Start sequence in various modes.
 - 4. Stop sequences in various modes.
- V. All adjusted, balanced, controlled systems shall be assessed to determine the optimal setting for the system as applicable. The optimal settings should be determined to establish reliable, efficient, safe and stable operation. The Contractor is responsible for placing systems in optimal condition for occupancy and not simply relying on initial design estimated settings.
- W. Dynamic Graphics: The graphic for all components, systems, and areas sampled and required to be represented by a graphic shall be checked for adequacy and accuracy. Furthermore, when setpoints are required to be adjustable, verify that they can be adjusted directly from the graphic screen.

- X. All interfaces between two systems or equipment of different manufacturers must be checked for accuracy and functionality.
- Y. Contractor shall to the extent possible, load the heating and cooling systems during initial FPT's to check the capacity of the building central systems and initially optimize system settings. This will typically be done using the preheat system to false load the cooling system. This test will incorporate varying the load to check central systems response.
- Z. "Crash Testing": Contractor shall analyze systems to identify possible conditions where functionality may be compromised. Contractor shall design non-destructive tests that will demonstrate either the automated response to the conditions or so that team can identify the best method for responding or fixing the condition. All tests and their findings shall be documented in a Microsoft Excel spreadsheet.

3.04 PARTICIPATION

- A. Required participating parties are indicated with the individual tests. Typically, multiple parties are required for any given test, yet participation for any given party is only required for the respective portion of the test for which the party is responsible. In many cases, the maximum required time in hours is indicated in parenthesis for any given test. The time is typically per unit system unless indicated otherwise. If no time is indicated, participation is required throughout the entire test.
- B. Frequently, on multiple samples where a given party does not directly conduct the test, the participation of that party will only be required for an initial quantity of systems/equipment. It is required that the parties be available on-site throughout the testing of any given system for which they are required participants. Therefore time for which they are not directly involved can be spent performing other work (typically addressing identified punch list items or failed test).
- C. No party involved with the Project is prohibited from participation in or witnessing of any tests. Any Subcontractor may elect to witness all tests on their systems even if their involvement is not directly required.
- D. Coordinate effectively with the individual Subcontractors throughout the development and execution of FPT's and maximize Subcontractors' involvement.

3.05 ACCEPTANCE CRITERIA

- A. Acceptance criteria for tests are indicated in the Specification Sections applicable to the systems being tested. Unless indicated otherwise, acceptance criteria will be specified with the individual system, equipment, component, or device.

END OF SECTION 20 08 16

EXAMPLE – FUNCTIONAL PERFORMANCE TEST

HVAC Pumps

Project: _____ Project #: _____

Identification of Equipment or System: _____

Location of Equipment or System: _____

Specification Section: _____ Detail/Drawing Number: _____

Manufacturer / Supplier: _____

This Date: _____ **Time of Test:** _____

FUNCTIONAL PERFORMANCE TEST PROCEDURE NUMBER: _____

PREFUNCTIONAL CHECKLIST NUMBER: _____

Components Included:

___ VFD for pump, ___ Heat Exchanger, ___ Other _____

Other Related Functional Performance Tests: _____

1. General:

a. This Functional Performance Test is submitted for approval and is subject to the attached list of outstanding items not completed successfully. Submit a Commissioning Deficiency Report upon completion of any outstanding or deficient items. None of the outstanding items preclude safe and reliable functional tests being performed.

b. ___ Commissioning Deficiency Report attached.

2. Participants:

Name	Company	Role/Participation

3. Functional Performance Test Prerequisites:

Specified Requirement		Yes	No	Date to be Submitted
a)	The Prefunctional Checklist for this system is complete and approved			
b)	The Prefunctional Checklist for the pump variable frequency drive system is complete and approved			
c)	The Prefunctional Checklist for the air handling unit related to this pump variable frequency drive system is complete and approved			
d)	All Architect/Engineer punchlist items for this system and related equipment have been addressed and corrected			
e)	Sequence of operation is attached			
f)	Test, adjust, and balance (TAB) completed and approved for the associated systems			
g)	TAB report provided			
h)	Design setpoint information included on forms			
	Controls:			
	i) DDC loops operational, temperature/pressure setpoints met without hunting			
	ii) Master transmission diagram is updated on device graph			
	iii) Graphic programming is complete and operational			
	iv) System communicates with main controller			
	v) Pump is set to design/final setpoints			
	vi) Local reading of setpoints agree with remote readings			
i)	These Functional Performance Test procedures have been reviewed and approved by installing contractor and applicable subcontractors			

4. Functional Performance Test Procedure:

Step	Mode	Test Procedure	Expected Response	Pass	
				Yes	No
1	Pump Off	Standby check. HOA in Auto position. Unit commanded Off by BAS.	Verify by visual inspection that: a) Discharge gauge pressure equals suction gauge pressure. b) No rotation of pump shaft. c) Pump light indication shows pump is off. Pump indication shows pump as being Off at the BAS.		
2	Pump Start-up	HOA in Auto position. Unit commanded On by BAS.	Verify by visual inspection that: a) Discharge gauge pressure greater than suction gauge pressure. b) Rotation of pump shaft. c) Pump light indication shows pump is On. Pump indication shows pump as being On at the BAS.		

3	Pump Operation	HOA in Auto position. Test results are recorded in table.	Verify by local and remote reading that test results correspond with TAB report and sequence of operation as described in the Contract Documents.		
4	Simulate Pump Overload Trip	HOA in Auto position. Test results are recorded in table.	BAS indicates an alarm for Pump Trip condition.		
5	Simulate Loss of Pump Flow	HOA in Auto position. Test results are recorded in table. Isolate DP switch across suction and discharge of pump and open sensing line vent valves to relieve pressure across DP switch.	BAS indicates an alarm condition for Loss of Pump condition.		

5. Comments:

FINAL SIGN-OFF

Contractors attest that the above items have been verified and meet the requirements of the Contract Documents except as noted on the attached Commissioning Deficiency Report.

General Contractor: Print Name:

 Signature:

 Title:

 Date:

Mechanical Subcontractor Print Name:

 Signature:

 Title:

 Date:

Other Subcontractor: Print Name:

 Signature:

 Title:

 Date:

Functional Performance Test procedure received and reviewed for completeness by MD ANDERSON representatives. Integrated System Test can proceed.

MD ANDERSON: Print Name:

 Signature:

 Title:

 Date:

MD ANDERSON: Print Name:

 Signature:

 Title:

 Date:

EXAMPLE – FUNCTIONAL PERFORMANCE TEST

Air Handling Units - Modular

Project: _____ Project #: _____

Identification of Equipment or System: _____

Location of Equipment or System: _____

Specification Section: _____ Detail/Drawing Number: _____

Manufacturer / Supplier: _____

This Date: _____ **Time of Test:** _____

FUNCTIONAL PERFORMANCE TEST PROCEDURE NUMBER: _____

PREFUNCTIONAL CHECKLIST NUMBER: _____

Components Included:

___ VFD for AHU, ___ Return Fans (RF), ___ Outside Air Handling Unit, AHU _____,
Other _____

Other Related Functional Performance Tests: _____

1. General:

- a. This Functional Performance Test is submitted for approval and is subject to the attached list of outstanding items not completed successfully. Submit a Commissioning Deficiency Report upon completion of any outstanding or deficient items. None of the outstanding items preclude safe and reliable functional tests being performed.
- b. ___ Commissioning Deficiency Report attached.

2. Participants:

Name	Company	Role/Participation

3. Functional Performance Test Prerequisites:

The University of Texas
MD Anderson Cancer Center

MS052616

ATTACHMENT "B" TO HVAC SYSTEMS FUNCTIONAL
PERFORMANCE TESTS

20 08 16 B

1 OF 9

Specified Requirement		Yes	No	Date to be Submitted
a)	The Prefunctional Checklist for this system is complete and approved			
b)	The Prefunctional Checklist for the following systems and components are complete and approved:			
	i) Chilled water system			
	ii) Chilled water piping and valves			
	iii) Condenser water pumps			
	iv) Cooling towers			
	iii) Associated terminal units			
	iv) Variable frequency drives for associated pumps			
c)	All control system functions for this and all interlocking systems are programmed and operable per the Contract Documents including final setpoints and schedules with debugging, loop tuning, and sensor calibrations completed.			
d)	Piping system flushing complete and required test reports approved			
e)	Water treatment system complete and operational			
f)	Vibration control report approved			
g)	Test, adjust, and balance (TAB) completed and approved for the hydronic systems and associated terminal units.			
h)	TAB report provided			
i)	All Architect/Engineer punchlist items for this system and related equipment have been addressed and corrected			
j)	Safeties and operating ranges reviewed			
k)	Sequences of operation is attached			
l)	Schedules and setpoints attached			
m)	False loading equipment, system, and procedures ready (boilers, preheat or reheat coils, control loops, override on outside air (OSA) dampers, etc.)			
n)	Have all energy savings control strategies, setpoints, and schedules been incorporated that this equipment and control system are capable of? If not, list recommendations below:			
o)	Control Program Review: Review the software control program(s) for this equipment. Parameters, setpoints, and logic sequences appear to follow the specified written sequences.			
p)	These Functional Performance Test procedures have been reviewed and approved by installing contractor and applicable subcontractors			

4. Current Setpoints for Functional Performance Test Procedure:

- c. Record all values for current setpoints (SP), control parameters, limits, delays, lockouts, schedules, etc., changed to accommodate testing.

Parameter	Pre-Test Values	Returned to Pre-Test Values ☒
Discharge air static pressure (SP)		
Discharge air temp.		
Static P. reset schedule		
Discharge air reset schedule		

Parameter	Pre-Test Values	Returned to Pre-Test Values ☒
Building static pressure		
Dirty filter D.P.		
OSA CFM		

5. Sensor Calibration Checks:

- d. Check the sensors listed below for calibration and adequate location. This is a sampling check of calibrations done during Prefunctional Checklist.
- e. "In calibration" means making a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage, or building automation system (BAS)) compared to the test instrument-measured value is within the tolerances specified in the Prefunctional Checklist requirements (_____). If not, install offset in BAS, calibrate or replace sensor. Use the same test instruments as used for the original calibration, if possible.

Sensor & Location	Location OK ¹	1st Gage or BAS Value	Instr. Meas'd Value	Final Gage or BAS Value	Pass Y/N?
DAT					
RAT					
OSAT					

Sensor & Location	Location OK ¹	1st Gage or BAS Value	Instr. Meas'd Value	Final Gage or BAS Value	Pass Y/N?
Dis-charge SP					

¹Sensor location is appropriate and away from causes of erratic operation.

6. Device Calibration Checks:

- f. The actuators or devices listed below checked for calibration. This is a spot check on a sample of calibrations done during Prefunctional Checklist and start-up.
- g. "In calibration" means observing a readout in the BAS and going to the actuator or

controlled device and verifying that the BAS reading is correct. Fix items out of calibration or adjustment, via an offset in the BAS, or a mechanical fix.

Device or Actuator & Location	Procedure / State	1st BAS Value	Site Observation	Final BAS Reading	Pass Y/N
Cooling coil valve (CCV) position or command and stroke*	1. Intermediate positions				
	2. Full open				
	3. Increase pressure (open)				
	4. Closed				
	5. Remove power or air (closed)				
Relief damper position **	1. Closed				
	2. Full open				
Mixed air damper position **	1. Closed				
	2. Full open				
Main OSA damper position**	1. Closed				
	2. Full open				
Min. OSA damper position**	1. Closed				
	2. Full open				
Variable frequency drive speed (VFD)***	1. Min.: _____ %				
	2. Max.: _____ %				

* Set pumps to normal mode. Procedure 1. Command valve to a few intermediate positions. Verify that readings in BAS reasonably correspond to the actual positions. For cooling coil valves (NO): Procedure 2. Lower space setpoint to 20 deg. F. below space temperature. Verify BAS reading says CCV is 100% open. Visually verify valve is 100% open. Procedure 3. For pneumatic actuators, by override in the BAS, increase pressure to valve by ____ psi (do not exceed actuator rating). Verify valve stem and actuator position does not change. Restore to normal. Procedure 4. Set space setpoint to 20F above space temperature. Verify BAS reading says CCV is closed. Visually verify valve is closed. Procedure 5. Remove control air or electricity from the valve and verify that the valve stem and actuator position do not change.

** 1. Command damper closed and verify that damper is shut and BAS reads shut.
2. Do the same, commanding damper fully open.

*** VFD: Procedure 1. Lower the controlling static pressure setpoint (duct or discharge) to be 1/4 of its current value. Verify that the vanes are shut, or fan speed is at minimum for VFD and packaged controller reads the same. Return the static pressure setpoint to normal. Procedure 2. Lower the space temperature setpoint to be 20F below space temperature and cause TU dampers to go to full cooling. Raise the static pressure setpoint as necessary to cause the setpoint to not be met. Verify that the inlet vanes are fully open or the fan speed is at its maximum and verify that the packaged controller reads the same. Return all to normal.

Notes:

7. Functional Performance Test Procedure:

Step ¹	Mode ²	Test Procedure ³	Expected Response ⁴	Pass	
				Yes	No
1	Fan Off	Standby check with units commanded Off by BAS.	Verify by visual inspection that: 1. Return Air Dampers to AHU- are Open. 2. Outside Air Dampers in AHU- are Closed. 3. Isolation Dampers on AHU- are Closed. 4. Relief Dampers in RF- are Closed. 5. Cooling Coil Valve on Cooling Coil of AHU- is Closed.		
2	Unit Start-up	With units commanded on by BAS.	1. Supply Fan Isolation Dampers Open in AHU- 2. Supply Fan start through VFDs 3. Supply Fan Isolation Dampers in AHU- Open 4. AHU- Fans Start 5. RF- Isolation Dampers Open 6. RF- Fans start through VFDs 7. Exhaust Fans EF- start.		
3	RF Volume Control	1. Verify RF Volume, utilizing airflow meters in Return Fans RF____, Supply Fans in AHU-____ and Garage Exhaust Fan EF-1, and TAB established CFMs for Exhaust Fans EF-____, and ____ , TAB established Fixed Differential, make the following calculation: (Return Air Flow=Supply Air Flow, - EF-	Verify that RF airflow meter readings correspond to calculation.		

Step ¹	Mode ²	Test Procedure ³	Expected Response ⁴	Pass	
				Yes	No
		1and2 Flow, -SF1 Flow-Fixed Differential} 2. Trend Log RF ____, AHU ____, and SF-1 airflow rates at 5 min. intervals. Command off EF-1 and 2 sequentially at 5 min. Intervals.	Verify that RF airflow meter readings continue to correspond to calculation		
4	Duct Static Pressure Control	Disable Duct Static Pressure Reset utilizing BAS Software. Adjust space temperature setpoint on significant quantity of zones to be well below observed reading.	Verify that VFD's modulate as required to maintain SP setpoint without hunting or overshooting setpoint.		
5	High Static Pressure Alarm and Shutdown	With units running at low flow condition, utilizing a squeeze bulb, simulate an increase in discharge air static pressure.	Verify that BAS indicates an alarm condition at ____" WG and shuts fans down at ____"WG		
6	Static Pressure Reset	1. For Perimeter Terminal Units on floors 9-16, Reset space temperature setpoints to be below space temperatures. Utilizing BAS trend logging capabilities, Record at 5 min. intervals, Discharge Air SP Spt, Perimeter TU Units in saturation. 2. Reset space temperature setpoints to be above space temperatures. Utilizing the same Trending as above, Record the same data points.	Verify that DA SP Spts increase by ____" WG at __ min intervals until only one Perimeter TU remains in saturation. Verify that setpoints are met and maintained without excessive hunting. Verify that DA SP Spt decreases by ____"WG at __ min intervals until one Perimeter TU reaches saturation.		
7	Discharge Temp. Reset	1. For Perimeter Terminal Units Floors 1-2, Reset space sensor setpoints to be above space temperatures. Utilizing BAS Trend Logging, at 6 min intervals, record DAT setpoint, DAT, and perimeter TU cooling Flow rates. 2. For Perimeter Terminal Units Floors 1-2, Reset space sensor setpoints to be below space temperatures. Utilizing BAS Trend Logging, at 6 min intervals, record DAT setpoint, DAT, and perimeter TU cooling Flow rates.	Verify that Discharge Air Temperature Setpoint is reset upwards at 2 deg increments every 6 min to maintain design cooling CFM at 5 perimeter TU's to maintain design cooling CFM Verify that Discharge Air Temperature Setpoint is reset downwards at 2 deg increments every 6 min to reach design cooling CFM at only 5 perimeter TU's. Both should happen without excessive hunting.		
8	Smoke Conditions	Interfacing with EC, simulate a fire mode with the Fire Alarm System.	Verify that AHU System returns to FAN OFF Status, with OSA and Relief Dampers in a Closed		

Step ¹	Mode ²	Test Procedure ³	Expected Response ⁴	Pass	
				Yes	No
			Position.		
9	Warm-up Control	Place Unit's BAS Control Mode into Warmup. Overwrite RAT Sensor Reading to be 65 Deg. F.	Verify that dampers assume a 100% Return Air Mode.		
10	Warm-up Control	Place Unit's BAS Control Mode in Warmup. Overwrite RAT Sensor Reading to be ____ Deg. F.	Verify that unit returns to Normal Operation Mode.		
11	Freeze Condition	Overwrite Low Limit Detection Thermostat reading to be ____ Deg. F.	Verify that system alarms, fans stop, OSA Dampers close, Relief Dampers Close, and RA dampers open.		
12	Return Fan Static Pressure	With AHU Unit ____ running at low air flow condition, Overwrite RF ____ return air fan inlet SP to a reading below - ____ W.G.	Verify that system alarms and that all Fans are shut down.		
13	Manual Smoke Pressuriz. System	With Fire Alarm System in alarm, utilizing control panel in Fireman Control Center, select a floor and place floor into purge mode.	Verify that Single Fan operates, Isolation dampers open only on selected Fans, Return Fans are off, Outside Air Handling Units are off, OSA dampers open, and return air dampers close.		
14	Minimum OSA Unit Fan Off	Command AHU-1&2 System off.	Verify that AHU ____ isolation dampers are closed, and if OSA temperature is above ____ Deg. F, heating coil control valve is closed.		
15	Minimum OSA Unit Fan Off	Simulate a OSA temperature below 35 Deg. F.	Verify that heating coil control valve opens.		
16	Minimum OSA Unit Temp. Control	Utilizing BAS software, reset discharge air setpoint to 80 Deg. F.	Verify that Face and Bypass Dampers and Heating Coil Control Valves modulate in sequence to maintain ____ Deg. F. Setpoint.		
17	Minimum OSA Unit Freeze Condition	Simulate a condition at low limit detection thermostat of below 40 Deg. F.	Verify that BAS system goes into alarm, AHU- ____ Fans Shut Down, AHU-____ Isolation Dampers Close, and Heating Valve Opens.		
18	On-Floor Return Fan Operation	Place AHU-____ in normal operating mode.	Verify that RAF ____ - ____ Start and Run.		
19	Building Static Pressure	Trend log the supply fan speed, the relief fan speed, relief damper position and the building static pressure for 12 hrs at 20 min. intervals. During the trend, force, if necessary,	Observe in the trends that the building static pressure is maintained within +/- 0.05" of setpoint without excessive hunting. Carefully examine during the extreme economizer		

Step ¹	Mode ²	Test Procedure ³	Expected Response ⁴	Pass	
				Yes	No
		the economizer damper to be full open and at minimum. Document these times.	damper positions. Observe that any relief dampers modulate as expected relative to relief fan operation and static pressure.		
20	AHU Filter Drop	Reset the Filter Differential Pressure to exceed the setting recommended by the filter manufacturer.	Verify that the BAS reports an alarm.		
21	Chilled Water Valve Closing Efficiency	- Utilizing BAS, place AHU Units in WARMUP Mode. - Manually close isolation Valve in Chilled Water Supply to AHU Coil. - Place thermometer in Chilled Water Return Piping adjacent to AHU. Record temp. at 1 min. intervals for 15 min. - Manually open isolation Valve in Chilled Water Supply to AHU Coil. - Repeat Step 3. - Graph Results on Temperature-Time Basis.	Chilled Water Return Temperature should approach RAT. If significant divergence is noted, review specified performance requirements of Chilled Water Control Valves.		
22	Supply Fan Isolation Damper	Utilizing BAS, Command AHU-1, SF-1 into the off position.	Verify that AHU-1, SF-1 Isolation Dampers Close.		
23	Review	Review schedules, current setpoints and sequences with Specification Section 15____ and Control Drawings prepared by BAS Provider.	Submit approved differences to be incorporated into the Record Drawings.		

Record Footnotes:

¹Sequences of operation specified in Contract Documents (attached).

²Mode or function ID being tested from testing requirements of the Contract Documents.

³Step-by-step procedures for manual testing, trend logging, or data-logger monitoring.

⁴Include tolerances for a passing condition.

⁵Record any permanently changed parameter values and submit to Owner.

8. Comments:

FINAL SIGN-OFF

Contractors attest that the above items have been verified and meet the requirements of the Contract Documents except as noted on the attached Commissioning Deficiency Report.

General Contractor:	Print Name:	
	Signature:	
	Title:	
	Date:	
Mechanical Subcontractor	Print Name:	
	Signature:	
	Title:	
	Date:	
Other Subcontractor:	Print Name:	
	Signature:	
	Title:	
	Date:	

Functional Performance Test procedure received and reviewed for completeness by MD ANDERSON representatives. Integrated System Test can proceed.

MD ANDERSON:	Print Name:	
	Signature:	
	Title:	
	Date:	
MD ANDERSON:	Print Name:	
	Signature:	
	Title:	
	Date:	

SECTION 22 10 00 – PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Provide materials and installation for complete first class plumbing systems, within and to five feet beyond building perimeter unless noted otherwise on Contract Drawings; Sanitary Waste and Vent Piping, Storm Drain Piping, Testing and other normal parts that make the systems operable, code compliant and acceptable to the authorities having jurisdiction.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. 2015 Edition of the International Plumbing Code.
 - 2. NOTE: MD Anderson takes various exceptions to the International Plumbing Code and has adopted the more stringent requirements within the Uniform Plumbing Code. These exceptions are included within Project Specifications and/or Project Design Drawings.
 - 3. NOT USED
 - 4. NOT USED

1.04 QUALITY ASSURANCE

- A. NOT USED
- B. NOT USED
- C. Manufacturer Qualifications: Company shall have minimum three years documented experience specializing in manufacturing the products specified in this section.
- D. NOT USED

E. Installer Qualifications:

1. Company shall have minimum three years documented experience specializing in performing the work of this section.
2. Installation of plumbing systems shall be performed by individuals licensed by the Texas State Board of Plumbing Examiners as a Journeyman or Master Plumber. Installation may be performed by Apprentice Plumbers provided they are registered with the Texas State Board of Plumbing examiners and under direct supervision of a licensed plumber. All installation shall be supervised by a licensed Master Plumber.
3. NOT USED
4. NOT USED

1.05 SUBMITTALS

A. Product Data:

1. Code and Standards compliance, manufacturer's data for pipe, fittings, valves and all other products included within this specification section.
2. NOT USED
3. Manufacturer's installation instructions.

B. Record Documents:

1. NOT USED
2. Test reports and inspection certification for all systems listed herein.
3. NOT USED
4. Submit proposed location of access panels which vary from quantities or locations indicated on Contract Drawings.
5. Provide full written description of manufacturer's warranty.

C. Operation and Maintenance Data:

1. Include components of system, servicing requirements, Record Drawings, inspection data, installation instructions, exploded assembly views, replacement part numbers and availability, location and contact numbers of service depot.

1.06 DELIVERY, STORAGE AND HANDLING

- A. All materials shall be new, undamaged, and free of rust.
- B. NOT USED
- C. NOT USED

- D. Provide temporary end caps and closures on pipe and fittings. Maintain in place until installation.
- E. Protect installed piping, and associated materials during progression of the construction period to avoid clogging with dirt, and debris and to prevent damage, rust, etc. Remove dirt and debris and repair materials as work progresses and isolate parts of completed system from uncompleted parts.
- F. Protect all materials that are to be installed within this project from exposure to rain, freezing temperatures and direct sunlight. EXCEPTION: Materials manufactured for exterior locations.

1.07 NOT USED

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Provide materials as specified herein and indicated on Contract Drawings. All materials and work shall meet or exceed all applicable Federal and State requirements and conform to adopted codes and ordinances of authorities having jurisdiction.
- C. Pressure ratings of pipe, fittings, couplings, valves, and all other appurtenances shall be suitable for the anticipated system pressures in which they are installed.

2.02 SANITARY WASTE AND VENT PIPING

- A. Cast iron soil pipe and fittings with hubless connections using clamp type gasketed mechanical fasteners above ground and hub and spigot DWV pipe and fittings with neoprene compression gasket joints for all buried pipe. Cast iron soil pipe, fittings and hub gaskets shall be manufactured by Tyler Pipe or Charlotte Pipe and Foundry. All cast iron pipe and fittings shall be of the same manufacturer.
- B. NOT USED
- C. NOT USED
- D. NOT USED
- E. Cast iron soil pipe compression gaskets shall be monolithically molded from an elastomer meeting ASTM C 564 and shall be of same manufacturer as pipe and fittings.
- F. Clamps for joining hubless cast iron pipe and fittings sizes 1-1/2" through 15" shall meet the performance criteria of FM 1680, have type 304 stainless steel jacket, ASTM C 564 neoprene gasket and type 305 stainless steel band screws designed to be installed with a pre-set torque wrench. Couplings shall be manufactured by Clamp-All, Inc. HI-TORQ 125 or Husky, Inc., Orangeshield SD 4000.

G. Hubless piping systems shall not be used in a directly buried, underground application. EXCEPTION: No-hub type fittings with clamp type coupling joints may be used below ground for pipe sizes up to 10" at connections to existing cast iron sewers provided couplings are cast iron with stainless steel bolts as manufactured by MG Piping Products.

H. NOT USED

I. Lubricant for drainage cleanout plugs shall be Loctite Marine Grade Anti-Seize or approved equal by Bostik Chemical Group, or Dow Corning Corporation.

J. Double sanitary tee fittings shall be not be used as a drainage fitting.

K. Provide IAPMO figure one, IAPMO figure five or double wye and eighth bend fittings on vertical lines serving back-to-back fixture drains.

L. Double wye and eighth bend fittings shall not be installed in horizontal drain lines.

M. All P-traps for floor drains, floor sinks and hub drains shall be deep-seal type.

N. NOT USED

2.03 NOT USED

2.04 NOT USED

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that excavations are to required grade, dry and not over-excavated. Do not install underground piping when bedding is wet or frozen.

B. Before commencing work, check final grade and pipe invert elevations required for drain terminations and connections to ensure proper slope.

3.02 PREPARATION

A. Ream pipes and tubes. Remove burrs, scale and dirt, inside and outside, before assembly. Remove foreign material from piping.

B. Prepare piping connections to equipment with flanges or unions.

3.03 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer's published recommendations.

C. General

1. Care shall be exercised to avoid all cross connections and to construct the plumbing systems in a manner which eliminates the possibility of water contamination.
2. Install all materials and products in accordance with manufacturer's published recommendations. Use tools manufactured for the installation of the specific material or product.
3. NOT USED
4. NOT USED
5. Pipe joints, no-hub clamps, flanges, unions, etc., shall not directly contact or be encased in concrete.
6. Route piping in direct orderly manner and maintain proper grades. Installation shall conserve crawlspace accessibility and interfere as little as possible with reaching all areas within crawlspace. Group piping whenever practical at common elevations.
7. Install piping to allow for expansion and Contraction without stressing pipe, joints or connected equipment.
8. Furnish all supports required by the piping included in this specification section.
9. Penetrations through fire rated walls, floors and partitions shall be sealed to provide a U.L. rating equal to or greater than the wall, floor or partition.
10. Seal all penetrations through floors, exterior building walls and grade beams air and water tight.
11. NOT USED
12. Furnish and install all necessary traps, tailpieces, etc. for each piece of equipment (including Owner furnished equipment) having plumbing connections, to facilitate proper functioning, servicing and compliance with code.
13. Provide code-approved transition adaptors when joining dissimilar piping materials. Adaptors installed shall be manufactured specifically for the particular transition.
14. All piping shall have reducing fittings used for reducing or increasing where any change in the pipe sizes occurs. No bushing of any nature shall be allowed in piping.
15. Close nipples shall not be installed in plumbing piping systems.
16. Bury outside drainage pipe minimum one foot below recorded frost depth.
17. Buried piping shall be supported throughout its entire length.
18. All excavation required for plumbing work is the responsibility of the plumbing Contractor and shall be done in accordance with Contract Documents.
19. NOT USED

20. NOT USED

21. Provide dielectric isolation device where non-ferrous components connect to ferrous components. Devices shall be dielectric union, coupling or dielectric flange fitting.

22. All piping shall be isolated from building structures, including partition studs, to prevent transmission of vibration and noise.

23. Isolate all bare copper pipe from ferrous building materials. "Tape is not an acceptable isolator.

D. Drainage and Vent Systems

1. Slope drainage lines uniformly at 1/4" per foot, for lines 3" and less, and 1/8" per foot for larger lines, unless noted otherwise on Contract Drawings. Maintain gradients through each joint of pipe and throughout system.

2. Buried pipe shall be laid on a smoothly graded, prepared subgrade soil foundation true to alignment and uniformly graded. Bell holes shall be hand-excavated so that the bottom of the pipe is in continuous contact with the surface of the prepared subgrade material. Piping invert shall form a true and straight line.

3. The size of drainage piping shall not be reduced in size in the direction of flow. Drainage and vent piping shall conform to the sizes indicated on the Contract Drawings. Waste lines from water closets shall not be smaller than four inches. Under no circumstances shall any drain or vent line below slab be smaller than two inches.

4. Unburied horizontal cast iron soil piping shall be supported at least at every other joint except that when the developed length between supports exceeds four feet, they shall be provided at each joint. Supports shall also be provided at each horizontal branch connection and at the base of each vertical rise. Supports shall be placed immediately adjacent to the joint. Suspended lines shall be braced to prevent horizontal movement. Unburied vertical cast iron soil piping rising through more than one floor level shall be supported with riser clamps at each floor level.

5. Install couplings for hubless pipe and fittings in accordance with manufacturer's published recommendations. Use pre-set torque wrench and tighten band screws as required by manufacturer's published instructions.

6. NOT USED

7. Provide cleanouts within sanitary waste systems at locations and with clearances as required by the code, at the base of each waste stack and at intervals not exceeding 75 feet in horizontal runs.

8. NOT USED

9. NOT USED

10. NOT USED

11. NOT USED

12. NOT USED

13. Lubricate cleanout plugs with anti-seize lubricant before installation. Prior to final completion, remove cleanout plugs, re-lubricate and reinstall using only enough force to provide a water and gas tight seal.

14. NOT USED

15. NOT USED

16. NOT USED

17. NOT USED.

18. Wastewater when discharged into the building drainage system shall be at a temperature not higher than 140°F. When higher temperatures exist, approved cooling methods shall be provided.

3.04 TESTING AND CLEANING

A. General

1. Equipment, material, power, and labor necessary for the cleaning, flushing, sterilization, inspection and testing of systems covered within this Specification Section shall be furnished by the Plumbing Contractor. All testing and inspection procedures shall be in accordance with Division 01 and Special Condition requirements of this Contract.
2. For any requested inspection, the Contractor shall complete prior inspections and tests to ensure that items are ready for inspection and acceptance by the Owner and/or Architect/Engineer. The Contractor shall be responsible for any and all costs incurred by Owner and/or Owner representatives, including consultants, resulting from a review or inspection that was scheduled prematurely.
3. The Contractor shall conduct the tests and the Owner's Construction Inspector will witness and approve the results.
4. Verify systems are complete, flushed and clean prior to testing. Isolate all equipment subject to damage from test pressure. Test and inspect for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. Piping being tested shall not leak nor show any loss in test pressure for duration specified.
5. Leave piping uncovered and unconcealed until it has been tested and approved. Where any portion of piping system must be concealed before completion of entire system, the portion shall be tested separately as specified for the entire system prior to concealment. Contractor shall expose all untested covered or concealed piping.
6. In cases of minor installation and repairs where specified water and/or air test procedures are deemed impractical, Contractor shall obtain written approval from Owner's Representative to perform alternate testing and inspection procedures. Alternate testing and inspection procedures for minor installation and repairs shall include visual evaluation of installed components by Owner's Representative during a simulation of use.

7. Prepare testing reports. If testing is performed in segments, submit separate report for each segment, complete with diagram or clear description of applicable portion of piping. After inspection has been approved or portions thereof, certify in writing the time, date, name and title of the persons reviewing the test. This shall also include the description of what portion of the system has been approved. Obtain approval signature by Owner's Representative. A complete record shall be maintained of all testing that has been approved, and shall be made available at the job Site. Upon completion of the work, all records and certifications approving testing requirements shall be submitted to the Owner's Representative before final payment is made.
8. Gauges used for testing shall have increments as follows:
 - a. Tests requiring a pressure of 10 psi or less shall utilize a testing gauge having increments of 0.10 psi or less.
 - b. Tests requiring a pressure of greater than 10 psi but less than or equal to 100 psi shall utilize a testing gauge having increments of 1 psi or less.
 - c. Tests requiring a pressure of greater than 100 psi shall utilize a testing gauge having increments of 2 psi or less.
9. Separately test above and below ground piping.
10. Do not introduce test water into piping systems when exposure to freezing temperatures is possible.
11. Do not introduce test water into sections of piping located above existing sensitive areas and/or equipment that may be damaged or contaminated by water leakage. Coordinate with Owner's Representative to determine areas and/or equipment considered as being sensitive.
12. Defective work or material shall be reworked and replaced, and inspection and test repeated. Repairs shall be made with new materials. Pipe dope, caulking, tape, dresser couplings, etc., shall not be used to correct deficiencies.
13. The Contractor shall be responsible for cleaning up any leakage during flushing, testing, repairing and disinfecting to the original condition any building parts subjected to spills or leakage.

B. Drainage and Vent System

1. Testing:
 - a. Subject gravity drainage and vent piping and joints to a vertical water column pressure of at least ten feet. If after 12 hours the level of the water has been lowered by leakage, the leaks must be found and stopped and the water level shall again be raised to the level described and the test repeated until, after a 12 hour retention period, there shall be no perceptible lowering of the water level in the system being tested. This pressure shall be held for a test period of at least 15 minutes while being witnessed by the Owner's Representative.

- 1) Portions of drainage and vent piping located on uppermost level of building shall be subjected to a water column pressure created by filling the system to point of overflow at roof vent terminals and roof drains. The pipes for the level being tested shall be filled with water to a verifiable and visible level as described above and be allowed to remain so for 12 hours. This pressure shall be held for a test period of at least 15 minutes while being witnessed by the Owner's Representative.
- b. Piping located above sensitive areas and/or equipment that may be damaged or become contaminated due to test water leakage shall be tested with air. Isolate the test section from all other sections and slowly fill pipe with oil-free air until there is a uniform gauge pressure of 5 pounds per square inch (34.5 kPa) or sufficient pressure to balance a 10-inch (254 mm) column of mercury. The air pressure shall be regulated to prevent the pressure inside the pipe from exceeding 5.0 PSIG. This pressure shall be held for a test period of at least 15 minutes. Any adjustments to the test pressure required because of changes in ambient temperature or the seating of gaskets shall be made prior to the beginning of the test period. This pressure shall be held for a test period of at least 15 minutes while being witnessed by the Owner's Representative.
2. Test forced (pumped) drainage piping by plugging the end of the piping at the point of connection with the gravity drainage system and applying a pressure of 5psi (34.5 kPa) greater than the pump rating, and maintaining such pressure for 15 minutes while being witnessed by the Owner's Representative.
3. Should the completion of these tests leave any reasonable question of a doubt relative to the integrity of the installation, additional tests or measures shall be performed to demonstrate the reliability of these systems to the complete satisfaction of the Owner's Representative.
4. Test plugs must extend outside the end of pipe to provide a visible indication for removal after the test has been completed.
5. Cleaning and Flushing:
 - a. During the Plumbing Systems Functional Performance Tests, each floor drain p-trap that has successfully passed pressure testing shall be proven clean and free of debris as follows:
 - 1) An inspection request shall be submitted to the Owner, identifying the quantity and location of drain(s) to be inspected.
 - 2) Vacuum out each floor drain p-trap in the presence of the Owner's Representative. A visual inspection of the trap shall be performed to verify that the trap is debris free.
 - 3) Perform a free flowing test by pouring two five gallon buckets of water down the floor drain.
 - 4) After the Owner's Representative has confirmed that the floor drain trap is clean and free of debris, insure that the trap is filled with water.

5) Install Trap Guard if required.

6) At the discretion of the Owner's Representative, a visual inspection of the trap utilizing a sewer scope may be required in addition to, or in lieu of, a vacuum procedure.

b. During the Plumbing Systems Functional Performance Tests, the Owner's Representative may require that any portion of the drainage, waste and vent systems installed under this Project Contract be proven undamaged, clean and free of debris. Verification of the interior condition of piping shall be accomplished utilizing a sewer scope or other method as determined by the Owner's Representative.

C. NOT USED

3.05 NOT USED

END OF SECTION 22 10 00

SECTION 22 10 30 – PLUMBING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Provide all materials and installation for plumbing specialties within sanitary waste and storm drainage systems; area drains, cleanouts, and other normal parts that make the systems complete, operable, code compliant and acceptable to the authorities having jurisdiction.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. 2015 Edition of the International Plumbing Code.
 - 2. NOTE: MD Anderson takes various exceptions to the International Plumbing Code and has adopted the more stringent requirements within the Uniform Plumbing Code. These exceptions are included within Project Specifications and/or Project Design Drawings.
 - 3. ANSI/NSF Standard 61 - Drinking Water System Components - Health Effects.

1.04 QUALITY ASSURANCE

- 1. Manufacturer's name and pressure rating shall be permanently marked on valve body.
- 2. All materials shall be new, undamaged, and free of rust. Protect installed products and associated materials during progression of the construction period to avoid clogging with dirt, and debris and to prevent damage, rust, etc. Remove dirt and debris as work progresses.
- 3. Manufacturer Qualifications: Company shall have minimum three years documented experience specializing in manufacturing the products specified in this section.

4. Installer Qualifications: Company shall have minimum three years documented experience specializing in performing the work of this section. Installation of plumbing systems shall be performed by individuals licensed by the Texas State Board of Plumbing Examiners as a Journeyman or Master Plumber. Installation may be performed by Apprentice Plumbers provided they are registered with the Texas State Board of Plumbing examiners and under direct supervision of a licensed plumber. All installation shall be supervised by a licensed Master Plumber.

1.05 SUBMITTALS

A. Product Data:

1. Provide Code and Standards compliance, component dimensions, service sizes and finishes.

B. Record Documents:

1. NOT USED
2. NOT USED
3. Provide full written description of manufacturer's warranty.
4. Record actual locations of plumbing specialties installed.

C. NOT USED

1.06 DELIVERY, STORAGE AND HANDLING

- A. Accept specialties on site in shipping containers and maintain in place until installation.
- B. Provide temporary protective coating and end plugs on valves not packaged within containers. Maintain in place until installation.
- C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work and isolating parts of completed system.
- D. Protect all materials before and after installation from exposure to rain, freezing temperatures and direct sunlight. EXCEPTION: Materials manufactured for installation within exterior environments.

1.07 NOT USED

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

- B. Provide plumbing specialties as indicated and scheduled on the Contract Drawings and as specified herein. All materials and work shall meet or exceed all applicable Federal and State requirements and conform to adopted codes and ordinances of authorities having jurisdiction.
- C. Pressure and temperature ratings of plumbing specialties shall be suitable for the anticipated system pressures and temperatures in which they are installed.
- D. NOT USED
- E. NOT USED
- F. Specialties of same type shall be product of one manufacturer.

2.02 ACCEPTABLE MANUFACTURERS

- A. Area Drains and Cleanouts: Wade, Zurn, Smith, Josam..

2.03 AREA DRAINS (FD)

- A. Provide area drains as scheduled on Drawings

2.04 NOT USED

2.05 NOT USED

2.06 NOT USED

2.07 CLEANOUTS:

- A. Cleanouts shall be the same nominal size as the pipe they serve up to four inches.
- B. Cleanouts shall have cast iron body with tapered cast brass or bronze plug providing gas and watertight seal.

- 2.08 NOT USED
- 2.09 NOT USED
- 2.10 NOT USED
- 2.11 NOT USED
- 2.12 NOT USED
- 2.13 NOT USED
- 2.14 NOT USED
- 2.15 NOT USED
- 2.16 NOT USED
- 2.17 NOT USED

PART 3 - EXECUTION

3.01 PREPARATION

- A. Coordinate cutting and forming of areaway construction to receive drains with General Contractor.
- B. NOT USED

3.02 INSTALLATION

- A. General
 - 1. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
 - 2. Install plumbing specialties in accordance with manufacturer's published instructions.
- B. Drains and Cleanouts
 - 1. Extreme care shall be used to set the top elevation of area drains to meet the low point elevation of the areaway.
 - 2. NOT USED
 - 3. NOT USED
 - 4. NOT USED
 - 5. Locate cleanouts with required clearance for rodding of drainage system.
- C. NOT USED

D. NOT USED

E. NOT USED

END OF SECTION 22 10 30

**SECTION 23 05 90 – CONTRACTOR COORDINATION WITH TESTING, ADJUSTING, AND
BALANCING**

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to prepare the building HVAC systems for testing, adjusting, and balancing (TAB) Work indicated by the Contract Documents, including the following:
 - 1. Preparation of air systems for testing, adjusting and balancing.
 - 2. NOT USED
 - 3. Providing materials and labor to assist TAB Firm in meeting testing, adjusting and balancing requirements.
- B. Testing, adjusting and balancing of the air conditioning systems and related ancillary equipment will be performed by a technically qualified TAB Firm. The preparation for and corrections necessary for the testing, adjusting and balancing of these systems, as described herein, are the responsibility of this Contractor.
- C. Make any changes or replacements to the sheaves, belts, dampers and valves required for correct balance as advised by the TAB Firm, at no additional cost to the Owner.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AABC: National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems.
 - 2. AABC: Testing and Balancing Procedures.
 - 3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.

4. ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

1.04 QUALITY ASSURANCE

- A. Provide and coordinate the services of qualified, responsible Subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including during the testing, adjusting and balancing period.
- B. In order that systems may be properly tested, adjusted, and balanced, the Contractor shall operate systems at Contractor's expense for the length of time necessary to properly verify the systems' completion and readiness for TAB.
- C. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. Allow adequate time for the testing and balancing activities during the construction period and prior to Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL

- A. None used.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Contractor shall be responsible to prepare the building heating, ventilating, and air conditioning systems ready for TAB when scheduled.
- B. Operational readiness requires that construction status of the building will permit the closing of doors, windows, ceilings installed, etc., to obtain simulated or projected operating conditions.
- C. Notification of System Readiness:
 1. Upon completion of the system installation Work, the Contractor shall notify the Owner and TAB Firm in writing, certifying that the Work has been accomplished and that the air conditioning systems are in operational readiness for testing, adjusting, and balancing.
 2. TAB Firm shall notify the Contractor of TAB Firm's readiness for balancing.

3. Should the TAB Firm be notified as described above, and the TAB Work commenced and the systems are found NOT to be in readiness or a dispute occurs as to the readiness of the systems, the Contractor shall request an inspection be made by a duly appointed representative of the Owner, Architect, TAB Firm and the Contractor. This inspection will establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for TAB services. Should the inspection reveal the TAB services notification to have been premature, all cost of the inspection and wasted Work accomplished by the TAB Firm shall be the responsibility of the Contractor.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Allow sufficient time for the TAB Firm to perform TAB Firm's Work within the Project schedule. Complete installation Work by system or floor, whichever is the most efficient for scheduling. Develop the Project schedule in close coordination with the TAB Firm.
- D. The Drawings and Specifications indicate dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions. Install these devices in a manner that will leave the devices accessible and readily able to be adjusted. Immediately correct any malfunction encountered that the TAB Firm reports so that the balancing Work can proceed with minimal delay.
- E. Contractor shall promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB Work.

3.03 SYSTEMS VERIFICATION

- A. Air Distribution Systems:
 1. Verify installation for conformity to the Contract Documents. All supply ducts shall be terminated and pressure tested for leakage as required by the Contract Documents.
 2. All volume dampers are properly located and functional.
 3. All supply diffusers are installed and airflow at each device shall be verified.
 4. NOT USED
 5. All fans operating and verified for freedom from vibration, with proper fan rotation and belt tension. Heater elements in motor starters are of proper size and rating. Record motor amperage and voltage on each phase at Start-up and running, and verify they do not exceed nameplate ratings.
 6. NOT USED
 7. Duct systems are clean and free of debris.
 8. NOT USED

B. NOT USED

C. Building Automation System (BAS):

1. Verify that all control components are installed in accordance with the Contract Documents and that all control components are functional.
2. Verify that all controlling instruments are calibrated and set for design operating conditions with the exception of room thermostats or sensors, which shall be calibrated at the completion of TAB services with cooperation between the TAB Firm and BAS Provider.
3. BAS Provider shall thoroughly check all controls, sensors, operators, sequences, etc. before notifying the TAB Firm that the building automation system is operational. The BAS Provider shall provide technical support, including technicians and necessary computers, to the TAB Firm for a complete check of these systems.
4. BAS Provider shall assist the Contractor with functional performance testing and point-to-point testing back to the main graphics.
5. NOT USED

END OF SECTION 23 05 90

SECTION 23 05 93 – SYSTEM TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Testing, adjusting, and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by a technically qualified TAB Firm.
- B. TAB Firm shall be capable of performing the TAB services as specified in accordance with the Contract Documents, including the preparation and submittal of a detailed report of the actual TAB Work performed.
- C. TAB Firm shall check, adjust, and balance components of the air conditioning system which will result in optimal noise, temperature, and airflow conditions in the conditioned spaces of the building while the system equipment is operating economically and efficiently. This is intended to be accomplished after the system components are installed and operating as specified in the Contract Documents. It is the responsibility of the Contractor to place the equipment into service. Systems shall be balanced in accordance with AABC Standard, Latest Edition or NEBB Standards for Testing, Adjusting, Balancing of Environmental Systems (Latest Edition).
- D. NOT USED
- E. Liaison and Early Field Inspection:
 - 1. TAB Firm shall act as a liaison between the Owner, Architect and Contractor. TAB Firm shall perform the following reviews (observations) and tests:
 - a. During construction, review all HVAC submittals that pertain to the ability to satisfactorily balance systems.
 - b. NOT USED
 - c. NOT USED
 - 2. During the balancing process, as the TAB Firm discovers abnormalities and malfunctions of equipment or components, the TAB Firm shall advise the Contractor in writing so that the condition can be corrected by the Contractor prior to finishing the TAB scope of Work. Data from malfunctioning equipment shall not be recorded in the final TAB report.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AABC - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.
 - 2. NEBB - National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
 - 3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.
 - 4. ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.
 - 5. CTI - Cooling Technology Institute CODE ATC-105.

1.04 QUALITY ASSURANCE

- A. TAB Firm shall have operated a minimum of five (5) years under TAB Firm's current name and shall be in good standing with the State of Texas, Franchise Tax Board. TAB Firm shall submit full incorporated name, Charter Number, and Taxpayer's I.D. Number for proper verification of TAB Firm's status.
- B. TAB Firm's personnel performing Work at the Project Site shall be either professional engineers or certified air and water balance technicians, who shall have been permanent, full time employees of the TAB Firm for a minimum of six (6) months prior to the start of Work for this Project.
- C. TAB firm shall have a background record of at least five (5) years of specialized experience in the field of air and hydronic system balancing and shall possess properly calibrated instrumentation.

1.05 SUBMITTALS

- A. The activities described in this Section shall culminate in a report to be provided in quadruplicate (4), individually bound and also provided electronically to the Contractor to be presented to the Owner. Neatly type and arrange data. Include with the data, the dates tested, personnel present, weather conditions, nameplate record of test instrument and list all measurements taken after all corrections are made to the system. Record all failures and corrective action taken to remedy incorrect situation. The intent of the report is to provide a reference of actual operating conditions for the Owner's operations personnel.

- B. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the report must have been made at the Project Site by the permanently employed technicians or engineers of the TAB Firm.
- C. At the Owner's option, all data sheets tabulated each day by TAB Firm personnel shall be submitted for review and sign-off by the Owner's Construction Inspector. Those data sheets, as initialed by Owner's Construction Inspector, shall be presented as a supplement to the final TAB report.
- D. Submit reports on electronic forms approved by the Owner and Architect/Engineer which will include the following information as a minimum:
 - 1. Title Page:
 - a. Company name.
 - b. Company address.
 - c. Company telephone number.
 - d. Project name.
 - e. Project location.
 - f. Project Manager.
 - g. Project Engineer.
 - h. Project Contractor.
 - i. Project identification number.
 - 2. Instrument List:
 - a. Instrument.
 - b. Manufacturer.
 - c. Model.
 - d. Serial number.
 - e. Range.
 - f. Calibration date.
 - g. What test instrument was used for.
 - 3. Fan Data (Supply and Exhaust):
 - a. Identification and location.
 - b. Manufacturer.

- c. Model.
- d. Air flow, specified and actual.
- e. Total static pressure (total external), specified and actual.
- f. Inlet pressure.
- g. Discharge pressure.
- h. Fan RPM.
- 4. NOT USED
- 5. Electric Motors:
 - a. Manufacturer.
 - b. Horsepower/brake horsepower.
 - c. Phase, voltage, amperage, nameplate, actual.
 - d. RPM.
 - e. Service factor.
 - f. Starter size, heater elements, rating.
- 6. V-Belt Drive:
 - a. Identification and location.
 - b. Required driven RPM.
 - c. Driven sheave, diameter and RPM.
 - d. Belt, size and quantity.
 - e. Motor sheave, diameter and RPM.
 - f. Center-to-center distance, maximum, minimum and actual.
- 7. Duct Traverse:
 - a. System zone/branch.
 - b. Duct size.
 - c. Area.
 - d. Design velocity.
 - e. Design air flow.

- f. Test velocity.
 - g. Test air flow.
 - h. Duct static pressure.
 - i. Air temperature.
 - j. Air correction factor.
- 8. NOT USED
- 9. NOT USED
- 10. NOT USED
- 11. NOT USED
- 12. NOT USED
- 13. NOT USED
- 14. NOT USED
- 15. NOT USED
- 16. NOT USED
- 17. Sound Level Report:
 - a. Location (Location established by the Engineer).
 - b. Baseline background NC curve for eight (8) bands – with equipment off.
 - c. Operating NC curve for eight (8) bands – with equipment on.
- 18. NOT USED
- 19. Control verification indicating date performed and any abnormalities identified:
 - a. Point Location/Description.
 - b. EMS Readout (Setpoint and Actual).
 - c. Actual Readout.
 - d. Alarms.
 - e. Sequences of Operation.
- 20. NOT USED

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 AIR BALANCE

- A. When systems are installed and ready for operation, the TAB Firm shall perform an air balance for all air systems and record the results. The air volume for each, supply fan and exhaust fan and the supply, air volume for each distribution device shall be adjusted to within +/- 5 percent of the value shown on the Drawings. Fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the fan. Air distribution device volume shall be adjusted using the device opposed blade damper (OBD) for duct connected devices. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown.
- B. The general scope of balancing by the TAB Firm shall include, but is not limited to, the following:
 1. Filters: Check air filters and filter media and balance only systems with essentially clean filters and filter media. The Contractor shall install new filters and filter media prior to the final air balance.
 2. Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Contractor shall make any required changes.
 3. Ampere Readings: Measure and record full load amperes for motors.
 4. Static Pressure: Static pressure gains or losses shall be measured across each supply fan, cooling coil, heating coil, return air fan, air handling unit filter and exhaust fan. These readings shall be measured and recorded for this report at the furthest air device or terminal unit from the air handler supplying that device. Static pressure readings shall also be provided for systems, which do not perform as designed.
 5. Equipment Air Flow: Adjust and record exhaust, return, outside and supply air CFM(s) and temperatures, as applicable, at each fan, blower and coil.
 6. NOT USED
 7. NOT USED
 8. Outlet Air Flow: Adjust each supply diffuser, to within + 5 percent of design air CFM. Include all terminal points of air supply and all points of exhaust.
 9. Pitot Tube Traverses: For use in future troubleshooting by Owner, all, main ducts shall have air velocity and volume measured and recorded by the traverse method. Locations of these traverse test stations shall be described on the sheet containing the data.
 10. NOT USED

3.02 NOT USED

3.03 SOUND

- A. Sound: Read and record sound levels at up to fifteen (15) locations per floor in the building as designated by the Architect/Engineer. All measurements shall be made using an Octave Band Analyzer. All tests shall be conducted when the building is quiet and in the presence of the Architect/Engineer, at the Architect/Engineer's option.

3.04 BUILDING AUTOMATION SYSTEMS

- A. In the process of performing the TAB Work, the Contractor shall:

1. Work with the Building Automation System (BAS) Provider and Owner to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
2. Verify that all control devices are properly connected.
3. Verify that the intended controllers operate all dampers and other controlled devices.
4. Verify that all dampers are in the position indicated by the controller; open, closed, or modulating.
5. NOT USED
6. NOT USED
7. Observe the calibration and operation of all controllers.
8. NOT USED
9. NOT USED
10. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. BAS Provider will relocate sensors as deemed necessary by the TAB Firm or Contractor.
11. Verify that the sequence of operation for any control mode is in accordance with approved Shop Drawings and Specifications.
12. Verify that all controller setpoints meet the Contract Documents.
13. Check all dampers for free travel.
14. Verify the operation of all interlock systems.
15. NOT USED

3.05 NOT USED

END OF SECTION 23 05 93

SECTION 23 31 00 – DUCTWORK

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Provide materials and installation for complete first class HVAC systems; install ductwork, hangers, supports, sleeves, and all necessary accessories as indicated in the Contract Documents. Provide any supplementary items necessary for proper installation that make the systems operable, code compliant and acceptable to the authorities having jurisdiction.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ASHRAE - Handbook of Fundamentals; Duct Design.
 - 2. ASHRAE - Handbook of HVAC Systems and Equipment; Duct Construction.
 - 3. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
 - 4. ASTM E 96 - Standard Test Methods for Water Vapor Transmission of Materials.
 - 5. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - 6. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
 - 7. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.
 - 8. ASTM B209 - Aluminum and Aluminum Alloy Sheet and Plate.
 - 9. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
 - 10. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.

11. NOT USED

12. NOT USED

13. SMACNA – HVAC Duct Construction Standards.

14. SMACNA – Rectangular Industrial Duct Construction Standards.

15. SMACNA – Round Industrial Duct Construction Standards.

16. SMACNA – HVAC Air Duct Leakage Test Manual.

17. UL 181 - Factory-Made Air Ducts and Connectors.

18. Engineering Design Manual for Air Handling Systems, United McGill Corporation (UMC).

19. Assembly and Installation of Spiral Ducts and Fittings, UMC.

20. Engineering Report No. 132 (Spacing of Duct Hangers), UMC.

21. AWS D1.1 American Welding Society Structural Welding Code.

1.04 INSTALLER QUALIFICATIONS:

- A. Company shall have minimum three years documented experience specializing in performing the work of this section.
- B. Installation of HVAC systems shall be performed by qualified Journeyman.

1.05 DEFINITIONS

A. Low Pressure

- 1. 2 inch W.G. Pressure Class: Ductwork systems up to 2 inch w.g. positive or negative static pressure with velocities less than or equal to 1500 fpm.

B. Medium Pressure

- 1. 3 inch W.G. Pressure Class: Ductwork systems over 2 inch w.g. and up to 3 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
- 2. 4 inch W.G. Pressure Class: Ductwork systems over 3 inch w.g. and up to 4 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
- 3. 6 inch W.G. Pressure Class: Ductwork systems over 4 inch w.g. and up to 6 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.

C. High Pressure

- 1. 10 inch W.G. Pressure Class: Ductwork systems over 6 inch w.g. and up to 10 inch w.g. positive or negative static pressure with velocities greater than 2500 fpm.

1.06 SUBMITTALS

A. Product Data:

1. Provide the following information for each sheet metal system furnished on the Project:
 - a. System name and type.
 - b. Duct system design pressure.
 - c. Duct material.
 - d. Duct gage.
 - e. Transverse joint methods.
 - f. Longitudinal seam type.
 - g. Sealant type.
 - h. SMACNA rectangular reinforcement type.
 - i. SMACNA intermediate reinforcement type.
 - j. SMACNA transverse reinforcement type.

B. Record Documents:

1. Submit Shop Drawings on all items of ductwork, plenums, and casings including construction details and accessories specified herein in accordance with Division 01. Ductwork construction details and materials used for duct sealant, flexible connections, etc. shall be submitted and approved prior to the fabrication of any ductwork.
2. NOT USED
3. Draw ductwork Shop Drawings on minimum 1/4 inch equal to one foot scale building floor plans and shall indicate duct sizes, material, locations of transverse joints, fittings, ductwork bottom elevation, offsets, ductwork specialties, and other information required for coordination with other trades. Clearly designate the following on the Shop Drawings:
 - a. Clearance dimensions between ducts and or location dimensions from walls, floors, columns, beams and large bore piping.
 - b. Duct materials i.e., stainless steel, galvanized steel, prefabricated fire rated ductwork pressure class ratings of ducts as defined within this specification.
 - c. NOT USED
 - d. Fire and fire/smoke partitions.
4. NOT USED
5. Coordinate with all other trades and building construction prior to submitting Shop Drawings for review.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to the Project Site and store and protect products under provisions of Division 01 and Division 20.
- B. Protect materials from rust both before and after installation.

1.08 WARRANTY

- A. All ductwork shown on the Drawings, specified or required for the air conditioning and ventilating systems shall be constructed and erected in a first class workmanlike manner.
- B. The Work shall be guaranteed for a period of one (1) year from the Project Substantial Completion date against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall be corrected as directed by the Owner at Contractor's expense.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 APPLICATION

- A. Ductwork systems shall be constructed in accordance with the following Materials as a minimum standard. Refer to Drawings for any deviation from this Table.

AIR SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION ⁽¹⁾
Supply and Return Systems:		
Crawl space Ventilation Air	Galvanized Steel	Low Pressure

- B. Notes to Table:

- 1. Positive pressure unless noted otherwise in Table.
- 2. NOT USED
- 3. NOT USED
- 4. NOT USED
- 5. NOT USED

2.03 DUCTWORK MATERIAL AND CONSTRUCTION

- A. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise on Drawings. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein.
- B. Ductwork shall be constructed of G90 coated steel meeting ASTM A653 and A924 standards.
- C. Minimum gage of round, oval or rectangular ductwork shall be 26 gage per SMACNA Standards.
- D. All duct sizes shown on the Drawings are clear inside dimensions.
- E. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with plastic covers
- F. Except for specific duct applications specified herein, all ductwork sheet metal shall be constructed from prime galvanized sheets and/or coils up to 60 inches in width. Each sheet shall be stenciled with manufacturer's name and gage.
- G. Conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."
- H. NOT USED
- I. NOT USED
- J. Duct Sealing: All ductwork, regardless of system pressure classification, shall be sealed in accordance with Seal Class A, as referenced in SMACNA Standards. All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.
 - 1. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3 inches wide open weave fiberglass scrim tape. Sufficient additional sealant shall then be applied to completely embed the cloth.
 - 2. NOT USED
 - 3. Scrim tape shall be fiberglass open weave tape, 3 inches wide, with maximum 20/10 thread count, similar to Hardcast FS-150.
 - 4. Sealer shall be rated by the manufacturer and shall be suitable for use at the system pressure classification of applicable ductwork.
 - 5. NOT USED
 - 6. For crawlspace/exterior applications, "Uni-Weather" (United McGill Corporation), solvent-based sealant, or Foster 32-19 shall be used.

2.04 RECTANGULAR AND ROUND DUCTWORK

- A. Metal gages listed in SMACNA HVAC Duct Construction Standards, Metal and Flexible Duct, are the minimum gages which shall be used. Select metal gage heavy enough to withstand the physical abuse of the installation. In no case shall ductwork be less than 26 gage per SMACNA Standards.
- B. All longitudinal seams for rectangular duct shall be selected for the specified material and pressure classification. Seams shall be as referenced in SMACNA Standards.
- C. NOT USED
- D. All transverse joints and intermediate reinforcement on rectangular duct shall be as shown in SMACNA Standards. Transverse joints shall be selected consistent with the specified pressure classification, material, and other provisions for proper assembly of ductwork.
- E. Spiral round duct and fittings shall be as manufactured by United McGill Sheet Metal Company or approved equivalent. All fittings shall be factory fabricated, machine formed and welded from galvanized sheet metal.
- F. Joints in spiral duct and fittings shall be assembled, suspended, sealed, and taped per manufacturer's published assembly and installation instructions.
- G. Contractor may use DUCTMATE or Ward Industries coupling system, as an option, on rectangular ductwork. The DUCTMATE or Ward Industries system shall be installed in strict accordance with manufacturer's recommendations.
- H. Rectangular ductwork field fabricated offsets shall not exceed 30 degrees.

2.05 NOT USED

2.06 NOT USED

2.07 NOT USED

2.08 NOT USED

2.09 ELBOWS RECTANGULAR DUCTS

- A. Construct elbows as follows in order of preference:
 - 1. Long radius, unvaned elbows.
 - 2. Short radius, single thickness vaned elbows.
 - 3. Rectangular, double thickness vaned elbows.
- B. Long radius elbows shall have a centerline radius of not less than one and one-half (1-1/2) times the duct width. Short radius elbows shall have a centerline radius of not less than one times the duct width.
- C. Contractor shall have the option to substitute short radius vaned elbows, but shall request the substitution at the time of submittal of Product Data.

- D. Provide turning vanes in all rectangular elbows and offsets.
- E. Job fabricated turning vanes, if used, shall be fabricated of the same gage and type of material as the duct in which they are installed. Vanes must be fabricated for same angle as duct offset. Submit Shop Drawings on factory fabricated and job fabricated turning vanes.
- F. All turning vanes shall be anchored to the cheeks of the elbow in such a way that the cheeks will not breathe at the surfaces where the vanes touch the cheeks. In most cases, this will necessitate the installation of an angle iron support on the outside of the cheek parallel to the line of the turning vanes.
- G. In 90-degree turns that are over 12 inches wide in the plane of the turn, provide and install double thickness vanes on integral side rails. For ducts under 12 inches in width, use single thickness vanes. The installation of the turning vanes shall be as described for single thickness vanes. On other types of turns or elbows, single thickness trailing edge vanes shall be used.

2.10 NOT USED

2.11 NOT USED

2.12 NOT USED

2.13 NOT USED

2.14 NOT USED

2.15 NOT USED

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Cleanliness:
 - 1. Before installing ductwork, wipe ductwork to a visibly clean condition.
 - 2. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.
 - 3. NOT USED

4. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.
- D. Provide openings in ductwork where required to accommodate thermometers, controllers and other devices. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Sleeve of pitot tube opening shall be no more than one inch long. Opening shall be one inch wide to accept pitot tube.
- E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- F. NOT USED
- G. NOT USED
- H. NOT USED
- I. NOT USED
- J. A NOT USED
- K. NOT USED
- L. Project inspector shall be notified to inspect all field fabricated offsets.
- M. NOT USED
- N. NOT USED
- O. Hangers and Supports:
 1. All ductwork supports shall be in accordance with Table 4-1(rectangular duct) and Table 4-2 (round duct) of the SMACNA standards.
 2. Rectangular duct shall have at least one pair of supports on minimum 8'-0" (eight feet) centers. All horizontal round and flat oval ducts shall have ducts hangers spaced 10'-0" (ten feet) maximum.
 3. NOT USED
 4. NOT USED
 5. NOT USED
 6. NOT USED

3.02 DUCTWORK SYSTEM CLEANING

- A. If the system has been operated without scheduled filters or if the integrity of temporary closures has been compromised, Contractor shall have ductwork cleaned according to National Air Duct Cleaners Association (NADCA) Standards by a Certified Regular Member of the NADCA.

1. NOT USED

- B. Before turning the installation over to the Owner, Contractor shall certify that the air handling systems have only been operated with scheduled filters in place. Otherwise, Contractor shall present evidence that the ductwork was cleaned as required above.

3.03 TESTING

A. NOT USED

- B. All low-pressure duct systems (positive or negative) shall be inspected for visible and audible signs of leakage.

1. Leaks identified by inspection shall be repaired by:

- a. Complete removal of the sealing materials.
- b. Thorough cleaning of the joint surfaces.
- c. Installation of multiple layers of sealing materials.

2. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.

C. NOT USED

D. NOT USED

END OF SECTION 23 31 00

SECTION 23 33 00 – DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install the following ductwork accessories indicated by the Contract Documents with supplementary items necessary for proper installation.
 - 1. Airflow control dampers.
 - 2. NOT USED
 - 3. Flexible duct connections.
 - 4. NOT USED
 - 5. Screens
 - 6. Duct test holes.
 - 7. NOT USED

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AMCA 500D – Laboratory Method of Testing Dampers for Rating.
 - 2. AMCA 500L – Laboratory Method of Testing Louvers for Rating.
 - 3. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
 - 4. NFPA 101 - Life Safety Code.
 - 5. SMACNA - HVAC Duct Construction Standards.

- 6. NOT USED
 - 7. NOT USED
 - 8. NOT USED
 - 9. NOT USED
- 1.04 SUBMITTALS
- A. Product Data:
 - 1. Provide product data for shop fabricated assemblies including, but not limited to, volume control dampers, and duct test holes. Provide product data for hardware used.
 - B. NOT USED

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. Dampers:
 - 1. Greenheck.
 - 2. Louvers and Dampers, Inc.
 - 3. Nailor Industries.
 - 4. Prefco.
 - 5. Ruskin.
 - 6. Portorff
- B. Regulators, Locking Quadrants:
 - 1. Ventfabrics
 - 2. Mercer Rubber

2.03 AIR FLOW CONTROL DAMPERS

- A. Furnish and install dampers where shown on the Drawings and wherever necessary for complete control of airflow, including all supply branches, "division" in main supply, and each individual air supply outlet.

- B. Dampers larger than three (3) square feet in area shall be controlled by a self-locking splitter damper assembly.
 - C. Volume damper blades shall not exceed 48 inches (48") in length or twelve inches (12") in width and shall be of the opposed interlocking type. The blades shall be of not less than No. 16 gage galvanized steel supported on one-half inch (1/2") diameter rust-proofed axles. Axle bearings shall be the self-lubricating ferrule type.
 - D. Volume dampers and other manual dampers shall be carefully fitted, and shall be manually controlled by damper regulators as follows:
 - 1. On exposed uninsulated ductwork the locking quadrant shall be made with a base plate of 16-gage cold-rolled steel and a heavy die cast handle designed with a 3/8 inch bearing surface. A 1/4 inch-20 zinc plated wing nut shall firmly lock the handle in place.
 - 2. NOT USED
 - 3. NOT USED
 - 4. Furnish and install end bearings for the damper rods on the end opposite the quadrant.
 - E. NOT USED
- 2.04 NOT USED
- 2.05 NOT USED
- 2.06 NOT USED
- 2.07 FLEXIBLE CONNECTIONS
- A. Where ducts connect to, flexible connections shall be made using "Flexmaster TL-M" or "Ventglas" fabric that is temperature-resistant, fire-resistant, waterproof, mildew-resistant and practically airtight, weighing approximately thirty ounces (30 oz.) per square yard. Ventglas is good for connections for inside building environments where ultra-violet light is not present.
 - B. There shall be a minimum of three inch (3-inch) slack in the connections, and a minimum of six inches (6-inch) distance between the edges of the duct.
 - C. NOT USED
- 2.08 NOT USED
- 2.09 SCREENS
- A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor which lead to, or are located outdoors.
 - B. Screens shall be No. 16 gage, one-quarter inch (1/4") mesh in removable galvanized steel frame.
 - C. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

2.10 NOT USED

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Provide balancing dampers at points on low pressure supply systems where branches are taken from larger ducts as required for air balancing.
- D. NOT USED
- E. NOT USED
- F. Provide backdraft dampers on exhaust fans or exhausts ducts where indicated. Install dampers so that they will open freely.
- G. NOT USED
- H. NOT USED
- I. Provide duct test holes where indicated and where required for testing and balancing purposes.
 - 1. Furnish and install Ventlok No. 699 instrument test holes in the return air duct and in the discharge duct of each fan unit.
 - 2. Install test holes in locations as required to measure pressure drops across each item in the system, e.g., outside air louvers, filters, fans, coils, intermediate points in duct runs, etc.
- J. NOT USED
- K. NOT USED

3.02 NOT USED

END OF SECTION 23 33 00

SECTION 23 34 23 – POWER VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install the following fans indicated by the Contract Documents with supplementary items necessary for proper installation.
 - 1. Centrifugal , up-blast, exhausters.
 - 2. Centrifugal supply fan.
 - 3. NOT USED
 - 4. NOT USED
 - 5. NOT USED
 - 6. Motors and drives.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
 - 3. AMCA 99 - Standards Handbook.
 - 4. ACMA 203 - Fan Application Manual - Field Performance Measurements.
 - 5. AMCA 204 - Balance Quality and Vibration Levels For Fans
 - 6. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

7. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
8. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
9. NEMA MG1 - Motors and Generators.
10. NFPA 70 - National Electrical Code.
11. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
12. UL 705 – Power Ventilators.

1.04 QUALITY ASSURANCE

- A. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.
- B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal. The sound power levels must not exceed those indicated on Drawings.
- C. Fabrication: Conform to AMCA 99.
- D. Performance Base: 50 feet above sea level.
- E. Fans shall be capable of operating stably at reduced loads imposed by means of variable speed drives, inlet guide vanes or controlling pitch of fan blades.

1.05 SUBMITTALS

- A. Product Data:
 1. Submittal data for approval for all fans of every description furnished under this section of these Specifications.
 2. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gages and finishes of materials, special coatings and construction, electrical characteristics and connection requirements.
 3. Fan curves with specified operating point clearly plotted. The recommended range of operation shall be stable.
 4. Data on sound power levels for both fan inlet and outlet at rated capacity.
 5. All data on fan accessories.
- B. Operation and Maintenance Data:
 1. Manufacturer's installation instructions and operating and maintenance data.
 - a. Submit under provisions of Division 01.
 - b. Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01 and Division 20.
- B. Accept products on Site in factory-fabricated protective containers or coverings, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- D. Check and maintain equipment on a monthly basis to ensure equipment is being stored in accordance with manufacturer's recommended practices. Additionally, during each check, fans and motors shall be rotated and greased and shafts shall be left approximately 180 degrees from that of previous month. Maintain storage records that indicate these maintenance requirements have been met.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Fans shall be either belt or direct drive as scheduled on Drawings.
- C. Select fans such that they do not increase motor size, increase noise level, or increase tip speed by more than 10 percent, or increase inlet air velocity by more than 20 percent, from specified criteria. Provide fans capable of accommodating static pressure variations of plus or minus 10 percent.
- D. Statically and dynamically balance fans to eliminate vibration or noise transmission to occupied areas.

2.02 MANUFACTURERS

- A. Carnes.
- B. Greenheck.
- C. Loren-Cook.
- D. Penn Ventilation.

2.03 CENTRIFUGAL UPBLAST EXHAUSTER

- A. Backward inclined fan wheel with spun aluminum housing; resilient mounted motor and drive assembly; 16 gage aluminum birdscreen; square base to suit curb with continuous curb gaskets; secured to curb with cadmium plated or stainless steel bolts and screws.
- B. Curb: Curb shall be coordinated with Owner and Contractor.

- C. Backdraft Damper: Gravity activated or motorized as indicated. Where type is not indicated on Drawings or Specifications, provide gravity-activated damper. Aluminum construction, felt edged with nylon bearings.
- D. Upblast exhausters shall have integral drain trough.
- E. NOT USED

2.04 CENTRIFUGAL SUPPLY FAN

- A. Forward curved, double width double inlet, with heavy gage galvanized steel housing; resiliently mounted motor and drive assembly.
- B. Backdraft Damper: Gravity activated or motorized as indicated. Where type is not indicated on Drawings or Specifications, provide gravity-activated damper. Aluminum construction, felt edged with nylon bearings.
- C. Curb: Curb shall be coordinated with Owner and Contractor.
- D. Filters: 1-inch washable, aluminum, permanent type as furnished with unit.
- E. Hood shall be easily removable for service.

2.05 NOT USED

2.06 NOT USED

2.07 NOT USED

2.08 NOT USED

2.09 MOTORS AND DRIVES (ALL UNITS UNLESS OTHERWISE SPECIFIED)

- A. Motors: In total compliance with motors and controllers Specification sections.
- B. Disconnect Switches: Provide for each fan under Division 26. No switches shall be provided in fan housing. All disconnects shall be external to fan housing.
- C. Bearings: L-10 life at 200,000 hours self-aligning, ball or roller bearings.
- D. Shafts: Hot rolled steel, ground and polished, with key-way, protectively coated with lubricating oil. Provide 316 stainless steel shafts for corrosive applications.
- E. Belt Drive: All belt drives shall be designed for a minimum of 50 percent overload. Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 15 horsepower and under, selected so required rpm is obtained with sheaves set at mid-position. Fixed sheave for 20 horsepower and over. Where more than one belt is required, matched sets shall be used. Include an additional set of drives for each fan to be used for final adjustments. After correct speed has been determined with variable sheave, provide fixed sheaves.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Curbs: Curb installation shall be coordinated with Owner and Contractor.
- D. Disconnect Switches/ Starters: Disconnect switches and starters shall be installed on exterior wall near fan per Division 26. Coordinate installation with Owner.

3.02 PAINTING

- A. Provide equipment with factory finish in accordance with the manufacturer's standards. Touch up scratches and marks from handling and installation with masking enamel to match manufacturer's color.
- B. NOT USED
- C. NOT USED

END OF SECTION 23 34 23

SECTION 25 00 10 – BUILDING AUTOMATION SYSTEMS (BAS) GENERAL - RETROFIT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section includes:
 - 1. Description of Work.
 - 2. Quality Assurance.
 - 3. System Architecture.
 - 4. Distributed Processing Units/Quantity and Location.
 - 5. Demolition and Reuse of Existing Materials and Equipment.
 - 6. Sequence of Work.
- B. Furnish and install a direct digital control and building automation system (BAS). The new BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves (except where noted otherwise) to perform control sequences and functions specified. The BAS for this Project will generally consist of monitoring and control of systems described herein. Reference shall also be made to control Drawings, Sequence of Operation, and points lists.
- C. The HVAC systems being controlled are crawlspace ventilation systems. This Section defines the manner and method by which these controls function.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

2. ASHRAE 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. and all current addenda and annexes.
3. Electronics Industries Alliance:
 - a. EIA-709.1-A-99: Control Network Protocol Specification.
 - b. EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification.
 - c. EIA-232: Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
 - d. EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes.
 - e. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
 - f. EIA-472: General and Sectional Specifications for Fiber Optic Cable.
 - g. EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
 - h. EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.
 - i. EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.
4. NEMA Compliance:
 - a. NEMA 250: Enclosure for Electrical Equipment.
 - b. NEMA ICS 1: General Standards for Industrial Controls.
5. NFPA Compliance:
 - a. NFPA 90A: "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
 - b. NFPA 70: National Electrical Code (NEC).
6. Institute of Electrical and Electronics Engineers (IEEE):
 - a. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
 - b. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN.
 - c. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN.
 - d. IEEE 519: Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.

1.04 QUALITY ASSURANCE

- A. [Reserved].
- B. JCI Metasys Product Line Demonstrated History: The product line being proposed for the Project must have an installed history of demonstrated satisfactory operation for a length of one (1) year since date of final completion in at least ten (10) installations of comparative size and complexity. Documents with references shall be submitted verifying this requirement has been met at Owner's request.
- C. JCI Installers Field Coordinator and Sequence Programmer Qualifications: Individual(s) shall specialize in and be experienced with control system installation for not less than five (5) years. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than two (2) projects of similar size and complexity. Installer shall submit the names of the proposed individual and at least one alternate for each duty at Owner's request. Proposed individuals must show proof of the following training:
 - 1. Product Line Training: Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the manufacturer on that product line for installation and configuration.
 - 2. Programming Training: Individuals involved with programming the Site-specific sequences shall provide evidence of the most advanced programming training offered by the vendor of the programming application offered by the manufacturer.
- D. The BAS and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.
- E. Not Used

1.05 SUBMITTALS

- A. General: Submit documents under provisions of Division 01. Two (2) copies of the materials shall be delivered directly to MD ANDERSON Monitoring Services staff, in addition to the copies required by other Sections. In addition, an electronic version of the completed materials shall be provided on CD or DVD. Refer to Section 25 08 10 for additional Commissioning submittal requirements.
- B. Electronic Submittals: While all requirements for hard copy submittal apply, control submittals and operation and maintenance (O&M) information shall also be provided in electronic format as follows:
 - 1. Drawings and Diagrams: Shop Drawings shall be provided on electronic media as an AutoCAD drawing per Owner's CAD standards. All 'x reference' and font files must be provided with AutoCAD files.
 - 2. Other Submittals: All other submittals shall be provided in Adobe Portable Document Format.
- C. Product Data: Submit manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Include installation and start-up instructions.

D. Record Documents:

1. JCI shall submit separately and directly to Owner a pricing breakdown of all cost associated to Project for review. This is to include but not be limited to material quantity, description, unit list price, multiplier, cost, extended cost, material costs adjustment less Owner's discount price, outside material price totaled and itemized, itemized subcontract price associated to Project, and total Project support price.
 - a. JCI labor hours quantities shall be itemized by mechanical labor, electrical labor, and design and management labor. Hour quantities shall be itemized by journeyman rate, technician rate and design/management rate with quantity of hours listed separately.
 - b. All estimated overtime shall be disclosed. Profit for Project shall be disclosed. Total Project price shall not exceed the sum of the listed itemized costs.
 - c. Provide an accurate spreadsheet breakdown of physical point counts of all analog inputs, analog outputs, digital inputs, digital outputs, building controllers and application specific controllers. The total point count for the project shall be itemized in a logical manner to allow the owner to confirm point count accuracy. Below is an example.

Project Physical Point Count	Drawing M-006	Drawing M-007	Drawing M-008	Drawing M-010	Drawing M-014	Drawing M-015
Physical Digital Input(s)						
Physical Digital Output(s)						
Physical Analog Input(s)						
Physical Analog Output(s)						
Building Controller(s)						
Application Specific Controller(s)						
TOTALS						

- d. All subcontracts greater than \$10K shall be competitively priced by a minimum of two owner approved subcontractors. Both subcontract proposals shall be fully disclosed.
 - e. This pricing summary, including any attachments, is intended only for the Owner and contains confidential and/or privileged information. Any unauthorized review; use, disclosure or distribution is prohibited.
2. Qualifications: Manufacturer, installer, and key personnel qualifications as indicated for the appropriate item above.

3. Shop Drawings: Submit Shop Drawings electronically on AutoCAD software for each control system with all point descriptors, addresses and point names indicated. Shop Drawings shall contain the following information:
 - a. System Architecture and System Layout:
 - 1) One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, gateways, etc. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the diagram.
 - 2) Provide floor plans locating all control units, workstations, servers, LAN interface devices, gateways, etc. Include all WAN and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans. Wiring routing conditions shall be maintained accurately throughout the construction period and the Record Drawings shall be updated to accurately reflect accurate, actual installed conditions.
 - b. Schematic flow diagram of each air system showing fans, dampers and control devices. Include written description of sequence of operation.
 - c. All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
 - d. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number). If this information is not available at the time of Shop Drawings submittals, furnish with O&M manual documentation for Owner review and approval. See Section 25 15 10 for additional requirements.
 - e. Label each control device with setting or adjustable range of control.
 - f. Label each input and output with the appropriate range.
 - g. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.
 - h. Not Used

- i. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination Drawings on separate Drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that is existing, factory-installed and portions to be field-installed.
- j. Details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.
- k. Sheets shall be consecutively numbered.
- l. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.
- m. Table of Contents listing sheet titles and sheet numbers.
- n. Legend and list of abbreviations.
- o. Record copies of product data, as built control Shop Drawings and final sequence of operation updated to reflect the final installed condition.
- p. Provide network architecture Record Drawings showing all nodes including a description field with specific controller identification, description and location information.
- q. Provide record riser diagram showing the location of all controllers. Indicate device instance, MAC address and drawing reference number.

E. Operation and Maintenance Data:

- 1. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.
- 2. Submit BAS User's Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.
- 3. Submit BAS advanced Programming Manuals for each controller type and for all workstation software.
- 4. Manufacturer's Certificates: For all listed and/or labeled products, provide certificate of conformance.
- 5. Product Warranty Certificates: Submit manufacturer's product warranty certificates covering the hardware provided.

1.06 SYSTEM ARCHITECTURE

- A. The communication speed between the controllers, LAN interface devices, CSS, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with Shop Drawings including calculations to support the guarantee. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall modify their BAS control design as necessary to accomplish these performance requirements. Generally requirements do not apply when a remote connection must be established via modem:
1. 5 seconds between a Level 1 (critical) alarm occurrence and enunciation at operator workstation.
 2. 10 seconds between a Level 2 alarm occurrence and enunciation at operator workstation.
 3. 20 seconds between a Level 3-5 alarm occurrence and enunciation at operator workstation.
 4. 10 seconds between an operator command via the operator interface to change a set point and the subsequent change in the controller.
 5. 5 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controller.
 6. 10 seconds between a change of value or state of an input and it being updated on the operator interface.
 7. 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least ten (10) points.
- B. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other BAS nodes on the network. If a LAN is severed, two (2) separate networks shall be formed and communications within each network shall continue uninterrupted.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

1.08 WARRANTY

- A. Contractor shall warranty all products and labor for a period of [insert Warranty Period] after Substantial Completion.

- B. The Owner reserves the right to make changes to the BAS during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and installation work regardless of any such changes made by Owner, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS. Any disagreement between Owner and Contractor on such matters shall be subject to resolution through the Contract 'Disputes' clause.
1. At any time during the Warranty Period that Contractor is on the Project Site for maintenance, emergency, or normal service, Contractor shall notify Owner via MD ANDERSON Monitoring Services and the local building operating personnel.
 2. Contractor shall notify said personnel of all work anticipated being involved for the service work. In addition, no work affecting system operation shall commence until express permission is granted.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. The BAS and digital control and communications components installed as Work of this Contract shall be an integrated distributed processing system of the following manufacturer or communication protocol. No other products will be considered as substitutions.
1. JCI Metasys: Provide control products and systems that completely integrate and operate from the existing Metasys system currently in operation at the institution. All access, programming, alarming, and system configuration shall be utilized from the existing system software and database without any third party programs or gateways.
 2. Substitutions: None

2.03 MATERIALS AND EQUIPMENT

- A. Materials shall be new, the best of their respective kinds without imperfections or blemishes, and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where Drawings or Specifications specifically allow existing materials to remain in place.

2.04 UNIFORMITY

- A. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Fasteners requiring explosive powder (shooting) or pneumatic-driven actuation will not be acceptable under any circumstances.
- D. Refer to additional requirements in other Sections of this Specification.

3.02 SURGE PROTECTION

- A. Contractor shall furnish and install any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BCs, AAC/ASCS operator interfaces, printers, routers, gateways and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10 percent above or below measured nominal value, with no affect on hardware, software, communications, and data storage.

3.03 CONTROL POWER SOURCE AND SUPPLY

- A. BAS Provider shall extend all power source wiring required for operation of all equipment and devices provided under Division 25 and the Drawings if not specified under Division 26.
- B. General requirements for obtaining power include the following:
 - 1. All control power for a given stand alone controller and all associated controls for this stand alone controller shall originate from the same circuit.
 - 2. Not Used
 - 3. Not Used

END OF SECTION 25 00 10

SECTION 25 08 00 – BAS COMMISSIONING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section includes:
 - 1. BAS and equipment testing and Start-up.
 - 2. Validation of proper and thorough installation of BAS and equipment.
 - 3. Functional testing of control systems.
 - 4. Documentation of tests, procedures, and installations.
 - 5. Coordination of BAS training.
 - 6. Documentation of BAS Operation and Maintenance materials.
- B. This Section defines responsibilities of the Contractor to commission the BAS.
- C. The term "Owner" shall include a representative from MD ANDERSON Building Automation Services but is not limited to represent the Owner exclusively. Coordinate all activities to include all of the Owner's representatives.
- D. Commissioning is the process of ensuring that all building systems are installed and perform interactively according to the design intent, the systems are efficient and cost effective and meet the Owner's operational needs, the installation is adequately documented, and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
- E. The Contractor shall direct, coordinate, and oversee the Commissioning process and witness functional performance testing.
- F. The Owner's TAB Firm may write the Owner approved control sequence verification sheets for functional performance tests and develop forms using the BAS Provider's point log to test each point back to the graphical interface. The BAS Provider shall furnish the Contractor with an estimated time to complete this task, which Contractor will incorporate in the Project Schedule. In the event Owner's TAB Firm is not under contracted for the Project, the Contractor shall write the Owner approved sequence verification sheets for functional performance tests.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within references.

1.04 CONTRACTOR RESPONSIBILITIES

- A. Completely install and thoroughly inspect, startup, test, adjust, balance, and document all systems and equipment.
- B. Assist Owner and/or TAB Firm in verification and functional performance testing. This will generally include the following:
 - 1. Attend Commissioning progress and coordination meetings.
 - 2. Prepare and submit required draft forms and systems information.
 - 3. Establish trend logs of system operation as specified herein.
 - 4. Demonstrate system operation.
 - 5. Manipulate systems and equipment to facilitate testing.
 - 6. Provide instrumentation necessary for verification and performance testing.
 - 7. Manipulate control systems to facilitate verification and performance testing.
 - 8. Train Owner as specified in this Section.
- C. Not Used
- D. Compensation for Retesting: Contractor shall compensate Owner for Site time necessitated by incompleteness of systems or equipment at time of functional performance testing. All testing failures, which require on-Site time for retesting, will be considered actual damages to the Owner. All parties under Contract with the Owner who are affected by the retesting shall be included in the Contract modification.

1.05 SUBMITTALS

- A. The following list outlines the general sequence of events for submittals and commissioning:
 - 1. Submit product data and Shop Drawings, and receive approval.
 - 2. Submit BAS logic documentation, and receive approval.
 - 3. Submit background graphic screens, and receive approval.

4. Submit Start-Up Checklists and manufacturer's start-up procedures for all equipment provided by the Contractor.
5. Install BAS.
6. Submit BAS Start-Up Test Agenda and Schedule for review.
7. Receive BAS Startup Test Agenda/schedule approval.
8. Submit Training Plan.
9. Simulate sequencing and debug program off-line to the extent practical.
10. Place systems under BAS control where applicable during a scheduled outage.
11. Perform BAS Startup where applicable during a scheduled outage.
12. Prepare and initiate trend log data storage and format trend graphs.
13. Submit completed BAS Start-Up Reports and initial draft of the Operating and Maintenance (O&M) Manuals.
14. Receive BAS Startup Report approval and approval to schedule Demonstrations and Commissioning.
15. Demonstrate systems to Owner.
16. Submit Trend Logs in format specified.
17. Receive demonstration approval and approval to schedule Acceptance Period.
18. Train Owner on BAS operation and maintenance.
19. Substantial Completion.
20. Begin Acceptance Phase.
21. Two-week Operational Test.
22. Perform Functional Performance Testing including point to point verification to graphical interface.
23. Receive Acceptance Period approval, which is Functional Completion for the BAS.
24. Train Owner on final sequences and modes of operation.
25. Install framed control Drawings.
26. Provide Level 1 password access to the Owner.
27. Revise and re-submit Record Drawings and O&M Manuals.
28. Manager of Building Automation Services sign-off required.

- 29. Final Acceptance.
- 30. Begin Warranty Phase.
- 31. Schedule and begin Opposite Season acceptance period.
- 32. Receive Opposite Season acceptance period approval.
- 33. Submit Record Drawings and O&M Manuals.
- 34. Update framed control Drawings.
- 35. Complete Owner Training.
- 36. End-of-Warranty date/period.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 INSTRUMENTATION

- A. Instrumentation required to verify readings and to test the system and equipment performance shall be provided by Contractor and made available to Owner. Generally, no testing equipment will be required beyond that required to perform Contractor's Work under these Contract Documents. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

2.03 TAB AND COMMISSIONING PORTABLE OPERATORS TERMINAL

- A. For new Projects, Contractor shall provide portable operators terminal or hand held device to facilitate Testing, Adjusting, and Balancing (TAB) and calibration. This software or device shall support all functions and allow querying and editing of all parameters required for proper calibration and Start-up.
- B. Connections shall be provided local to the device being calibrated. For instance, for VAV terminal units, connection of the operator's terminal shall be either at the sensor or at the terminal unit. Otherwise a wireless system shall be provided to facilitate this local functionality.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.

3.02 BAS START-UP TESTING, ADJUSTING, CALIBRATION

- A. Work and/or systems installed under this Division shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below:
1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
 2. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
 3. Verify integrity/safety of all electrical connections. [Initially use the control setting that was used by existing control system, unless otherwise indicated]
 4. Not Used
 5. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5 percent accurate, test equipment shall be +/-0.25 percent accurate over same range). Record the measured value and displayed value for each device in the BAS Start-up Report.
 6. Check and set zero and span adjustments for all transducers and transmitters.
 7. Not used
 8. Not Used
 9. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the Operator Interface display. Record the results for each device in the BAS Start-Up Report.
 10. Not Used
 11. Verify proper sequences by using the approved checklists to record results and submit with BAS Start-Up Report. Verify proper sequence and operation of all specified functions.
 12. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
 13. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Start-up Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):
 - a. Duct air temperature: ± 1 degrees F].

- b. Duct or space humidity: [5 percent within 30 minutes].

14. For interface and DDC control panels:

- a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.
- b. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.
- c. Check power supplies for proper voltage ranges and loading.
- d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
- e. Check for adequate signal strength on communication networks.
- f. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
- g. Ensure that all outputs and devices fail to their proper positions/states.
- h. Ensure that buffered and/or volatile information is held through power outage.
- i. With all system and communications operating normally, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
- j. Check for proper grounding of all DDC panels and devices.

15. For Operator Interfaces:

- a. Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
- b. Output all specified BAS reports for review and approval.
- c. Verify that the alarm printing and logging is functional and per requirements.
- d. Verify that trends are archiving to disk and provide a sample to the Owner for review.
- e. Verify that paging/dial-out alarm annunciation is functional.
- f. Verify the functionality of remote Operator Interfaces and that a robust connection can be established consistently.
- g. Verify that required third party software applications required with the bid are installed and are functional.
- h. Start-up and check out control air compressors, air drying, and filtering systems in accordance with the appropriate Section and with manufacturer's instructions.

i. Verify proper interface with fire alarm system.

B. Submit Start-Up Test Report: Report shall be completed, submitted, and approved prior to Substantial Completion.

3.03 SENSOR CHECKOUT AND CALIBRATION

A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2 degrees F of each other for temperature and within a tolerance equal to 2 percent of the reading of each other for pressure. Tolerances for critical applications may be tighter.

B. Calibration: Calibrate all sensors using one of the following procedures:

1. Sensors Without Transmitters - Standard Application: Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gauge or BAS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20 percentage of the expected range.
2. Sensors With Transmitters - Standard Application: Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until the ammeter reads 4 mA. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gauge or BAS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

C. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 25 11 00.

3.04 NOT USED

3.05 NOT USED

3.06 BAS DEMONSTRATION

A. All BAS Demonstration shall take place on the main Control Systems Server and MD ANDERSON WAN. Schedule to add system to main Control Systems Server and MD ANDERSON WAN with Owner at least two (2) weeks in advance to the demonstration. At the time of request, provide all documentation that the following criterions are met:

1. Updated BAS submittals in electronic and hard copy to Owner including the updated riser diagram for the system.

2. Reports on verification of Network Layout Verification including but not limited to Building Controller locations, cable routes with length of cable between controllers and any trunk extenders or trunk isolators.
 3. Reports on verification of electrical characteristics of BAS network, communications and electrical integrity of Building Controllers.
 4. Reports on verification of traffic on BAS Network including but not limited to COVs between Building Controllers, point commands by the operator, point commands by program across the network, alarm reporting on the network, any unresolved points in the system, integrity of the ports on any Building Controller isolator/extender and results of Building Controller tests running at selected baud rate.
 5. Demonstrate to Owner the updates of databases without errors or faults between the temporary Control Systems Server and Building Controllers. If there is no temporary server, demonstrate to Owner after system is added to main Control Systems Server.
 6. Reports on verification of system log files, interruption of log files of system traffic and overall acceptable operation of the system where a temporary Control Systems Server is utilized.
- B. Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the Owner. Schedule the demonstration with the Owner seven (7) calendar days in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved. If the Work fails to conform to the Contract Documents, so as to require scheduling of additional Site visits by the Owner for re-demonstration, Contractor shall reimburse Owner for costs of subsequent Site visits.
- C. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the Project Site.
- D. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner.
- E. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:
1. Demonstrate that required software is installed on BAS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
 2. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
 3. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.

4. Demonstrate correct calibration of input/output devices using the same methods specified for the Start-Up Tests. A maximum of 10 percent of I/O points shall be selected at random by the Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by Owner for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
 5. Demonstrate that all DDC and other software programs exist at respective field panels. The Direct Digital Control (DDC) programming and point database shall be as submitted and approved.
 6. Demonstrate that all DDC programs accomplish the specified sequence of operation.
 7. Demonstrate that the panels and DDC network of panels automatically recover from power failures within five (5) minutes after power is restored.
 8. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
 9. Identify access to equipment selected by the Owner. Demonstrate that access is sufficient to perform required maintenance.
 10. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
- F. BAS Demonstration shall be completed and approved prior to Substantial Completion.
- G. Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be retested.

3.07 BAS ACCEPTANCE PERIOD

- A. After approval of the BAS Demonstration and prior to Contract Close Out Acceptance Phase shall commence. Acceptance Period shall not be scheduled until all HVAC systems are in operation and have been accepted, all required cleaning and lubrication has been performed.
- B. Operational Test: At the beginning of the Acceptance Phase, the system shall operate properly for two (2) weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these Specifications. At the end of the two weeks, Contractor shall forward the trend logs to the Owner for review. Owner shall determine if the system is ready for functional performance testing and document any problems requiring Contractor's attention.
1. If the systems are not ready for functional performance testing, Contractor shall correct problems and provide notification to the Owner that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional one-week period.
 2. This process shall be repeated until Owner issues notice that the BAS is ready for functional performance testing.

- C. During the Acceptance Period, the Contractor shall maintain a hard copy log of all alarms generated by the BAS. For each alarm received, Contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the Contractor's opinion, the cause of the alarm is not the responsibility of the Contractor, Contractor shall immediately notify the Owner.

3.08 TREND LOGS

- A. Contractor shall configure and analyze all trends required under Section 25 15 00.

3.09 TREND GRAPHS

- A. Trend graphs as specified in Section 25 15 00 shall generally be used during the Acceptance Phase to facilitate and document testing. Prepare controller and workstation software to display graphical format trends during the Acceptance Period. Trend graphs shall demonstrate compliance with Contract Documents.
- B. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.

3.10 SOFTWARE OPTIMIZATION ASSISTANCE

- A. The Contractor shall provide the services of a BAS Technician as specified above at the Project Site to be at the disposal of the Owner. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the Owner during the construction and commissioning of the Project and that are beyond the specified Contract Document requirements. The cost for this service shall be included with the bid. Requests for assistance shall be for contiguous or non-contiguous 8-hour days, unless otherwise mutually agreed upon by Contractor and Owner. The Owner shall notify Contractor two (2) days in advance of each day of requested assistance. Refer to Part One of this Section for additional requirements.
- B. The BAS Technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the BAS Technician provided cannot perform every software task requested by the Owner in a timely fashion, Contractor shall provide additional qualified personnel at the Project Site as requested by the Owner, to meet the total specified requirement on-Site. Coordinate training requirements with MD ANDERSON Monitoring Services Department.

3.11 BAS OPERATOR TRAINING AND O&M MANUALS

- A. Provide up to four (4) complete sets of the approved Operations and Maintenance (O&M) Manuals (hard copy and one electronic copy) to be used for training.
- B. Contractor shall submit a Training Plan for the scope of training for which BAS Provider is responsible. Training Plan shall be forwarded to the Contractor who will compile, organize, format, and forward to the Engineer for review.
 - 1. Coordinate requirements of Training with the MD ANDERSON Monitoring Services Department.

- C. On-Site Training: Provide services of BAS Provider's qualified technical personnel for (2) two hours to instruct Owner's personnel in operation and maintenance of BAS. Instruction shall be in classroom setting at the Project Site for appropriate portions of the training. The Owner shall notify Contractor seven (7) calendar days in advance of each day of requested training. The Contractor's designated training personnel shall meet with the Engineer and Owner for the purpose of discussing and fine-tuning the training agenda prior to the first training session. Training agenda shall generally be as follows:
1. Basic Operator Workstation (OWS) Training – For all potential users of the OWS:
 - a. Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of controller portable and built-in operator interface device display capabilities.
 - b. Brief overview of the various parts of the O&M Manuals, including hardware and software programming and operating publications, catalog data, controls installation Drawings, and DDC programming documentation.
 - c. Demonstration of workstation login/logout procedures, password setup, and exception reporting.
 - d. Demonstration of workstation menu penetration and broad overview of the various workstation features.
 - e. Overview of systems installed.
 - f. Present all Site-specific point naming conventions and points lists, open protocol information, configuration databases, back-up sequences, upload/download procedures, and other information as necessary to maintain the integrity of the BAS.
 - g. Overview of alarm features.
 - h. Overview of trend features.
 - i. Overview of workstation reports.
 2. BAS Hardware Training – For Maintenance and Control Technicians:
 - a. Review of installed components and how to install/replace, maintain, commission, and diagnose them.
 3. BAS Technician Training:
 - a. Introduction to controller programming and overview of the programming application interface.
 - b. General review of sequence of operation and control logic for the Project Site, including standalone and fail-safe modes of operation.
 - c. Uploading/Downloading and backing up programs.
 - d. Network administration.

e. Review of setpoint optimization and fine-tuning concepts.

D. Not Used

3.12 NOT USED

END OF SECTION 25 08 00

SECTION 25 11 10 – BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS (RETROFIT)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them. Building automation system requirements may be specified, but not limited to, the following Sections when applicable:
 - 1. Power Ventilators

1.02 SUMMARY

- A. Section Includes:
 - 1. Wiring.
 - 2. Not Used
 - 3. Not Used
 - 4. Control Panels.
 - 5. Sensors.
 - 6. Electric Control Components (Switches, EP Valves, Thermostats, Relays, etc.).
 - 7. Transducers.
 - 8. Current Switches.
 - 9. Nameplates.
 - 10. Testing Equipment.
- B. Refer to Section 25 00 10 for general requirements.
- C. Refer to other Division 20 and Division 23 Sections
- D. Provide the following electrical Work as Work of this Section, complying with requirements of Division 26 sections:
 - 1. Control wiring between field-installed controls, indicating devices, and unit control panels.
 - 2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
 - 3. Not Used

4. All other necessary wiring for fully complete and functional control system as specified.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

1.04 WORK BY OTHERS

- A. Not Used
- B. Not Used
- C. Not Used
- D. Not Used
- E. Controlled Equipment Power Wiring shall be furnished and installed under Division 26. Where control involves 120 volt (V) control devices controlling 120V equipment, Division 26 Contractor shall extend power wiring to the equipment. BAS Provider shall extend it from the equipment to the control device.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MATERIALS AND EQUIPMENT

- A. Not Used
- B. General: Provide electronic and electric control products in sizes and capacities indicated, consisting of dampers, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.
- C. Communication Wiring and BAS low voltage wiring/cables: All wiring shall be in accordance with the latest edition of the National Electrical Code and Division 26. Wiring/cables shall be provided in a customized color jacketing material. Material color shall be as specified in section 27 05 53 (Identification for Low-Voltage Cables).

1. Contractor shall supply all communication wiring between Building Controllers, Routers, Gateways, AAC's, ASC's and local and remote peripherals outside the MD ANDERSON IT infrastructure. (e.g., operator workstations, printers, and modems).
 2. Local Supervisory LAN: For any portions of this network required under this Section of the Specification, Contractor shall comply with Division 27 Communication specifications. Network shall be run with no splices and separate from any wiring over thirty (30) volts.
 3. Secondary Controller LANs: Communication wiring shall be individually 100 percent shielded pairs per manufacturer's recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over thirty (30) volts. Shield shall be terminated and wiring shall be grounded as recommended by building controller manufacturer.
 - a. Wet / Damp Locations – Wiring in underground raceways or raceways which are subject to moderate degrees of moisture shall be listed for installation in wet locations. Direct burial wiring without a raceway is prohibited.
- D. Signal Wiring: Contractor shall run all signal wiring in accordance with the latest edition of the National Electrical Code and Division 26.
1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100 percent shielded pair, minimum 18-gage wire, with PVC cover. Signal wiring shall be run with no splices and separate from any wiring above thirty (30) volts.
 - a. Wet / Damp Locations – Wiring in underground raceways or raceways which are subject to moderate degrees of moisture shall be listed for installation in wet locations. Direct burial wiring without a raceway is prohibited.
 2. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.
- E. Low Voltage Analog Output Wiring: Contractor shall run all low voltage control wiring in accordance with the latest edition of the National Electrical Code and Division 26.
1. Low voltage control wiring shall be 18-gage. Wiring size for RJ-11 and RJ-45 connectors shall be 22-gage, twisted pair, 100 percent shielded, with PVC cover, Class 2 plenum-rated. Low voltage control wiring shall be run with no splices separate from any wiring above thirty (30) volts.
 - a. Wet / Damp Locations – Wiring in underground raceways or raceways which are subject to moderate degrees of moisture shall be listed for installation in wet locations. Direct burial wiring without a raceway is prohibited.
- F. Control Panels: Provide control panels with suitable brackets for wall mounting, unless noted otherwise, for each control system. Locate panel adjacent to systems served. Mount center of control panels [60 inches – confirm with Owner] above finished floor or roof.

1. Interior: Fabricate panels of 16-gage furniture-grade steel, totally enclosed on four sides, with removable perforated backplane, hinged door and keyed lock, with manufacturer's standard shop-painted finish and color. Panel / enclosure shall be sized to provide adequate mounting space for all components plus a minimum of 25% spare backplane capacity. All components shall have a minimum of 2 inch clearance from the four sides of the panel unless factory wired and designed otherwise.
2. Exterior: 16-gage 304 or 316 stainless steel NEMA 4X enclosure. Panel shall have hinged door, keyed lock, and integral, thermostatically controlled heater. Provide hinged deadfront inside panel when flush-mounted control and/or indicating devices are included in panel. Fiberglass or aluminum, as applicable, to be used when gases that are being used in the panel area are corrosive to stainless steel.
3. Provide UL-listed cabinets for use with line voltage devices.
4. Control panel shall be completely factory wired and piped, and all electrical connections made to a terminal strip. Wire nuts are not acceptable in exposed area of panel. High and low voltage cables shall be isolated from each other.
5. All gauges and control components shall be identified by means of nameplates or Owner approved equivalent.
6. Provide a 6 inch x 6 inch minimum wireway (metal wiring/tubing) trough across the entire width of the panel mounted to the top of the panel with close nipples of sufficient size for additional 50 percent wiring and tubing capacity. Wireways shall not be less than 24 inches in length. Control panel wiring shall be installed and distributed in the wireway to minimize routing of wiring and tubing within the control panel. Wireway construction to be the same as the associated control panel.
7. Complete wiring and tubing termination Drawings shall be mounted in, and a second set mounted adjacent to, each panel in a frame with lexan cover of sufficient size to be easily readable.

2.03 NOT USED

2.04 NOT USED

2.05 NOT USED

2.06 GENERAL FIELD DEVICES

- A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.
- B. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

- C. Field devices specified herein are generally 'two-wire' type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, is not designed to work with 'two-wire' type transmitters, if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide 'four-wire' type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.
- D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy and repeatability equal to, or better than, the accuracy and repeatability listed for respective field devices.
- E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, nonrepeatability and hysteresis.

2.07 NOT USED

2.08 TEMPERATURE SENSORS (TS)

- A. Sensor Type Selection
 - 1. Not Used
 - 2. Standard Control and Monitoring sensors shall be utilized for all other sensors not identified as Certified Control and Monitoring sensors.
- B. Sensor resolution: When matched with A/D converter of BC, AAC/ASC, or SD, sensor range shall provide a resolution of no worse than 0.2 degrees F (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25 degrees F over five (5) years.
- C. Room Temperature Sensor: Shall be an element contained within a ventilated cover, suitable for wall mounting, unless noted otherwise. Provide insulated base. Sensor color and type shall match surrounding existing sensor when applicable. Following sensing elements are acceptable:
 - 1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, ± 0.6 degrees F accuracy at calibration point.
 - 2. Provide setpoint adjustment where indicated. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BAS.
 - 3. Provide an occupancy override button on the room sensor enclosure where indicated. This shall be a momentary contact closure.
 - 4. Provide current temperature indication via an LCD or LED readout, where indicated.
- D. Single-Point Duct Temperature Sensor: Application allowed on supply air volumes of 2000 CFM or less and non-critical return air readings. Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated.

1. Sensing element shall be 100 Ohm platinum RTD which transmits a 4 to 20 mA output signal. The accuracy of this sensor shall be ± 0.7 degrees F. This type of sensor does not require field calibration and shall be replaced if tolerance of ± 1.4 degrees F is exceeded.
2. 10,000 ohms sensing element shall be allowed for the auxiliary temperature sensor for air terminal application specific controllers. Temperature range 55-95 Deg F. Mid Range Accuracy + (-) 0.5 Deg F. Sensor shall be secured in place with a minimum of a 2x4 metal enclosure.

E. Not Used

F. Not Used

G. Not Used

H. Not Used

2.09 HUMIDITY TRANSMITTERS

- A. Units shall be suitable for their application. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (% RH) Sensors shall have the following minimum performance and application criteria:

1. Input Range: 0 to 100% RH.
2. Accuracy (% RH): ± 2 percent between 20-90% RH at 77 degrees F, including hysteresis, linearity, and repeatability.
3. Sensor Operating Range: As required by application.
4. Long Term Stability: Less than 1 percent drift per year.

- B. Acceptable Manufacturers: Units shall be Siemens, Vaisala HM Series, General Eastern, Microline, or Hy-Cal HT Series.

2.10 NOT USED

2.11 NOT USED

2.12 NOT USED

2.13 NOT USED

2.14 CURRENT SWITCHES (CS)

- A. Clamp-On Design Current Operated Switch (for Motor Status Indication):

1. Range: 3.5 to 135 amps.
2. Trip Point: Adjustable.
3. Switch: Solid state, normally open, 0.1A @ 30VAC/DC.

4. Trip Indication: LED.
5. Approvals: UL, CSA.
6. Maximum Cable Size: 350 MCM.
7. Manufacturers: Veris Industries H-608, H-904, H-908.
 - a. Veris Model Number H-608 restricted to constant speed motors rated 40 horsepower or less.
 - b. Veris Model Number H-904 required on VFD motors.

B. Not Used

2.15 CURRENT TRANSFORMERS (CT)

A. Clamp-On Design Current Transformer (for Motor Current Sensing)

1. Range: 1-10 amps minimum, 20-200 amps maximum.
2. Trip Point: Adjustable.
3. Output: 0-5 VDC.
4. Accuracy: ± 0.2 percent from 20 to 100 Hz.
5. Acceptable Manufacturers: KELE SA100.

2.16 NOT USED

2.17 ELECTRIC CONTROL COMPONENTS

A. Not Used

B. Not Used

C. Not Used

D. Not Used

E. Low Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT sealed contacts, operating temperature range of 50 to 90 degrees F (10 to 32 degrees C), switch rating of 24 Vac (30 Vac maximum), and both manual and automatic fan operation in both the heat and cool modes.

F. Control Relays: All control relays shall be UL listed, with contacts rated for the application.

1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
 - a. Pilot light indication of power-to-coil. Pilot light shall be visible from a standing position of 5 feet AFF.

- b. Coil rated for 50 and 60 Hz service.
 - c. Relays shall be labeled in a professional manner to identify the function or purpose. Coordinate with owner for approved verbiage of labels
 - d. Acceptable Manufacturers: Relays shall be Functional Devices (RIB), Potter Brumfield, Model KRPA or approved equal.
- 2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 horsepower, and 1/3 horsepower, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC or approved equal.
 - 3. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.
 - 4. All safety circuits shall be installed to operate individual interposing relays located in the associated equipment control panel. Each safety device (i.e. freezestat, DP safety, smoke detector, firestat, etc.) wiring circuit shall be installed with individual homeruns back to the associated control panel. See control Drawings for details.
- G. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA 1 enclosure. Manufacturer shall be Square 'D', Cutler-Hammer or Westinghouse.
- H. Control Transformers: Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be US and CSA listed. 120/24 VAC transformers shall be fused in accordance with the NEC. Transformer shall be properly sized for application, and mounted in minimum NEMA 1 air vented enclosure. Multiple transformers in a single enclosure shall have fan aided ventilation whenever ambient temperature exceeds 140 deg F
- 1. Transformers shall be manufactured by Westinghouse, Square 'D', Jefferson or approved equal.
- I. Not Used
- J. Not Used
- K. Not Used
- L. Not Used
- 2.18 NOT USED NAMEPLATES
- A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 inch thick, black, with white center core, and shall be minimum 1 inch x 3 inch, with minimum 1/4 inch high block lettering. Nameplates for devices smaller than 1 inch x 3 inch shall be attached to adjacent surface.
 - B. Each nameplate shall identify the function for each device.

2.19 TESTING EQUIPMENT

- A. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is ± 0.5 percent accurate, test equipment shall be ± 0.25 percent accurate over same range).

PART 3 - EXECUTION**3.01 INSTALLATION**

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in Drawings and details shown on Drawings. Install electrical components and use electrical products complying with requirements of the latest edition of the National Electrical Code and all local codes.
- D. Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of electric control devices.
1. Wiring System: Install complete wiring system for electric control systems. Conceal wiring exposed in mechanical rooms and areas where other conduit and piping are exposed. Installation of wiring shall generally follow building lines. Install in accordance with the latest edition of the National Electrical Code and Division 26. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.
 2. Control Wiring Conductors: Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with the latest edition of the National Electrical Code and Division 26.
 3. Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.
 4. All WAN and LAN patch cords shall be approved and installed as directed by owner.
 5. BAS low voltage wiring/cables: All cables shall have legible printed sleeve identification labels at each device and the panel termination.
 - a. Labels shall be Brady PermaSleeve TM, part number - "BPSPT-187-175-WT" or owner approved equivalent.
 - b. Each label shall be identified with the entire BAS point name utilized in the BAS database and the point address.

- c. Install RJ11 modular jack plates for the Owner's spare alarm connection points specified on the drawing. The entire point address printed with black text on 1/2" high white labels shall be installed to identify each port of the RJ11 modular jack plate. Contractor shall confirm exact wall location with the Owner prior to installing.
- 6. Terminate all control wiring internal to panels to screw terminals connections or owner approved wire connection equivalent. Wire nuts and/or splices are not allowed in panels. When terminating a wire cable, the cable jacket, cable shielding wire, and cable shielding material shall be finished in a neat consistent workmanlike manner.
- 7. Install all control wiring external to panels in electric metallic tubing or raceway. Installation of wiring shall generally follow building lines. Provide steel type connectors. Install wiring in galvanized rigid steel conduit at all exterior locations and where subjected to moisture. Install in PVC Schedule 40 conduit if encased in concrete. All conduits penetrating partitions, walls or floors shall be sealed with a submitted and approved fire/smoke sealant to prevent migration of air through the conduit system.
- 8. Communication wiring, signal wiring and low voltage control wiring may be run without conduit in concealed, accessible locations if noise immunity is ensured.
 - a. Contractor shall be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.
 - b. Accessible locations are defined as areas inside mechanical equipment enclosures, such as heating and cooling units, instrument panels etc.; in accessible pipe chases with easy access, or suspended ceilings with easy access. Installation of wiring shall generally follow building lines.
 - c. Run in a neat and orderly fashion, bundled where applicable, and completely suspended (strapped to rigid elements or routed through wiring rings) away from areas of normal access. Tie and support conductors neatly with suitable nylon ties and not to exceed five (5) foot intervals.
 - d. Conductors shall not be supported by the ceiling system or ceiling support system. Conductors shall be pulled tight and be installed as high as practically possible in ceiling cavities. Wiring shall not be laid on the ceiling or duct.
 - e. Conductors shall not be installed between the top cord of a joist or beam and the bottom of roof decking.
- 9. Secondary LAN Communication cabling shall be provided in an Owner approved color dedicated to the BAS.
- 10. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation Drawings.

E. Not Used

F. Not Used

G. Not Used

- H. Relative Humidity Sensors: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.
- I. Not Used
- J. Not Used
- K. Not Used
- L. Not Used
- M. Current Switches for Motor Status Monitoring: Adjust so that set point is below minimum operating current and above motor no load current.
- N. Not Used

ND OF SECTION 25 11 10

SECTION 25 14 10 – BAS FIELD PANELS - RETROFIT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section includes:
 - 1. Building Controller (BC).
 - 2. Advance Application Specific Controller (AAC).
 - 3. Application Specific Controller (ASC).
- B. Furnish and install DDC Control units and/or Smart Devices required to support specified building automation system functions.
- C. Refer to Section 25 00 10 for general requirements.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 STAND-ALONE FUNCTIONALITY

- A. General: These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category specified in this Section. This item refers to acceptable paradigms for associating the points with the processor.

B. Functional Boundary:

1. Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single control unit. The boundaries of a standalone system shall be as dictated in the Contract Documents.
2. Systems specified for the Application Category will dictate the boundary of the standalone control functionality. See related restrictions below.
3. When referring to the controller as it pertains to the standalone functionality, reference is specifically made to the processor.
4. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.

C. The following configurations are considered acceptable with reference to a controller's standalone functionality:

1. Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).
2. Controllers with processors and modular back planes that allow plug in point modules as an integral part of the controller.
3. I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.

D. The following configurations are considered unacceptable with reference to a controller's standalone functionality:

1. I/O point expansion devices connected to the main controller board via wiring and as such may be remote from the controller and that communicate via a sub LAN protocol.
2. Multiple controllers enclosed in the same control panel to accomplish the point requirement.

2.03 BUILDING CONTROLLER (BC)

- A. The BC(s) shall provide fully distributed control independent of the operational status of the OWSs and CSS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device. All control strategies performed by the BC(s) shall be both operator definable and modifiable through the Operator Interfaces.
- B. BCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions.
- C. BCs shall share information with the entire network of BCs for full global control directly without requiring other BCs, LAN devices, Local Supervisory LAN gateways, routers etc. to assist, perform, or act as an intermediate device for communicating.

- D. Each controller shall permit multi-user operation from multiple workstations and portable operator terminals connected either locally or over the Primary Controller LAN. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure.
- E. BCs shall be programmable from an operator workstation, portable operator terminal, or hand held operating device. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.
- F. BCs shall be connected to a controller network that qualifies as a Primary Controlling LAN.
- G. All BCs shall be protected from any memory loss due to a loss of power, power surge, or unstable power by one or a combination of the following:
 - 1. Volatile RAM shall have a battery backup using a lithium battery with a rated service life of fifty (50) hours, and a rated shelf life of at least five (5) years. Self-diagnostic routine shall report an alarm for a low battery condition.
 - 2. EEPROM, EPROM, or NOVROM non-volatile memory.
- H. In addition, BCs shall provide intelligent, standalone control of HVAC functions. Each BC shall be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices. Refer to standalone functionality specified above.
- I. For systems requiring end-of-line resistors those resistors shall be located in the BC.
- J. Input-Output Processing:
 - 1. Digital Outputs (DO):
 - a. Outputs shall be rated for a minimum 24 Vac or Vdc, 1 amp maximum current. Each shall be configurable as normally open or normally closed.
 - b. Each output shall have an LED to indicate the operating mode of the output and a manual hand off or auto switch to allow for override. Provide feedback to remotely indicate the HOA is not in the Auto position. If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure.
 - c. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
 - 2. Analog Inputs (AI):
 - a. AI shall be 0-5 Vdc, 0-10 Vdc, 0-20 Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input.
 - b. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise).

- c. A/D converters shall have a minimum resolution of twelve (12) bits.
- 3. Digital Inputs (DI):
 - a. Monitor dry contact closures.
 - b. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.
- 4. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
- 5. Electronic Analog Outputs (AO):
 - a. Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection.
 - b. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable only with Owner approval (Generally these will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.).
 - c. Where these are allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturers board is unacceptable).
 - d. D/A converters shall have a minimum resolution of ten (10) bits.
- 6. Analog Output Pneumatic (AOP), 0-20 psi:
 - a. Pneumatic outputs via an I/P transducer, or digital to pneumatic transducer are acceptable.
 - b. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the BC and provide individual feedback.
 - c. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.
- 7. Pulsed Inputs:
 - a. Capable of counting up to eight (8) pulses per second with buffer to accumulate pulse count.
 - b. Pulses shall be counted at all times.

K. BC Power Loss:

- 1. Upon a loss of power, power surge, or unstable power to any BC, the other units on the primary controlling network shall not in any way be affected.

2. Upon a loss of power, power surge, or unstable power to any BC, the battery backup shall ensure that the energy management control software, the Direct Digital Control software, the database parameters, and all other programs and data stored in the RAM are retained for a minimum of fifty (50) hours. An alarm diagnostic message shall indicate that the BC is under battery power.
3. Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.
4. Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report the condition (upon resumption of power) and be capable of receiving a download via the network, and connected computer. In addition, the Owner shall be able to upload the most current versions of all energy management control programs, Direct Digital Control programs, database parameters, and all other data and programs in the memory of each BC to the operator workstation via the local area network, or via the telephone line dial-up modem where applicable, or to the laptop PC via the local RS-232C port.

L. BC Failure:

1. Building Controller LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer BCs shall recognize the loss, report alarm and reconfigure the LAN.
2. BC Hardware Failure: BC shall cease operation and terminate communication with other devices. All outputs shall go to their specified fail position.

M. BCs may include LAN communications interface functions for controlling secondary controlling LANs Refer to Section 25 30 10 - BAS System Communications Devices for requirements if this function is packaged with the BC.

N. All BC naming conventions shall adhere to the format as established by the Owner's Standard Acronyms document.

O. I/O Point Expansion Devices communicating to BC via a sub LAN protocol:

1. Utilizing any point from a point expansion device communicating to BC via a sub LAN protocol to support the BC's Stand Alone Functionality requirement is not allowed.
2. Point expansion devices shall be mounted in packaged equipment enclosures, or locking wall mounted enclosure in a readily accessible location. Identify panel enclosure with the entire point address of point expansion device(s) on an engraved phenolic or micarta nameplate.
3. The owner shall approve the location of point expansion devices mounted above finished ceiling prior to installation. An owner approved ceiling tag shall identify the specific location of the point expansion device location.

4. Each point expansion device shall be identified in the database with the location of where the device is physically installed to allow the owner to service these devices when needed. The owner shall approve the final method identifying the locations with the available software options.

2.04 ADVANCED APPLICATION SPECIFIC CONTROLLER (AAC) AND APPLICATION SPECIFIC CONTROLLER (ASC)

A. General Requirements:

1. AACs and ASCs shall provide intelligent, standalone control of HVAC equipment. Each unit shall have its own internal RAM, non-volatile memory and will continue to operate all local control functions in the event of a loss of communications on the ASC LAN or sub-LAN.
2. AACs and ASCs shall include sufficient memory to perform the specific control functions required for its application and to communicate with other devices.
3. Each AAC and ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum eight (8) bit A to D conversion, voltage transient and lightning protection devices. All volatile memory shall have a battery backup of at least fifty (50) hours with a battery life of five (5) years.
4. All point data; algorithms and application software within an AAC /ASC shall be modifiable from the Operator Workstation.
5. AAC and ASC Input-Output Processing:
 - a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each DO shall be discrete outputs from the AAC/ASC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
 - b. Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10Vdc, 0-20Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of eight to ten bits depending on application.
 - c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.
 - d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
 - e. Electronic Analog Outputs (AO) as required by application:

- 1) Voltage mode, 0-5VDC and 0-10VDC; current mode (4-20 mA). Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable only with Owner approval (Generally, PWM will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.).
- 2) Where PWM is allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturers board is unacceptable).
- 3) D/A converters shall have a minimum resolution of eight (8) bits.

B. NOT USED

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. All Division 25 installation including but not limited to, cable and wiring, grounding, raceway and conduit, electrical circuit and panel identifications, wiring devices, and lighting shall comply with Division 26 installation requirements. In addition to the Division 26 requirements, contractor shall label panel board name and circuit number in an owner approved manner at each BAS field panel, control cabinet, or point of termination in which a 120VAC control circuit is utilized.

3.02 HARDWARE APPLICATION REQUIREMENTS

- A. General:
 1. The functional intent of this Specification is to allow cost effective application of manufacturers standard products while maintain the integrity and reliability of the control functions.
 2. A Building Controller as specified above is generally fully featured and customizable whereas the AAC/ASC refers to a more cost-effective unit designed for lower-end applications. Specific requirements indicated below are required for the respective application. Manufacturer may apply the most cost-effective unit that meets the requirement of that application.
- B. Standalone Capability:
 1. Each Control Unit shall be capable of performing the required sequence of operation for the associated equipment.

2. All physical point data and calculated values required to accomplish the sequence of operation shall originate within the associated CU with only the exceptions enumerated below. Listed below are functional point data and calculated values that shall be allowed to be obtained from or stored by other CUs or SDs via LAN.
- C. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.
- D. Application Category 0 (Distributed Monitoring):
 1. Applications in this category include the following:
 - a. Monitoring of variables that are not used in a control loop, sequence logic, or safety.
 2. Points on BCs, AACs, and ASCs may be used in these applications as well as SDs and/or general-purpose I/O modules.
 3. Where these points are trended, Contractor shall verify and document that the network bandwidth is acceptable for such trends and is still capable of acceptable and timely control function.
- E. Not Used
- F. Application Category 2 (General Purpose Terminal Controller):
 1. Applications in this category include the following:
 - a. Miscellaneous Equipment (Exhaust Fan , Supply Fan) Start/Stop.
 - b. Miscellaneous Monitoring (not directly associated with a control sequence and where trending is not critical).
 2. Standalone Capability:
 - a. Only the following data (as applicable) may be acquired from other ASCs via LANs.
 - b. In the event of a loss of communications with any other ASCs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC/ASC shall use the last value obtained before the fault occurred.
 - c. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Delay Time	Default Value
Outside Air Temperature	3 minutes	80°F
Outside Air Humidity	3 minutes	60% RH
Outside Air Enthalpy	3 minutes	30 Btu/lb
Trend Data		N/A
Cooling/Heating Requests	3 minutes	None
 3. Mounting:
 - a. Not Used

- b. ASCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the Contractor) or in a near by mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.

- 4. LAN Restrictions: Limit the number of nodes servicing any one of these applications on the AAC/ASC LAN to 80 percent capacity on new installed LANs.

G. Not Used

3.03 CONTROL UNIT REQUIREMENTS

- A. Refer to Section 25 00 10 for requirements pertaining to control unit quantity and location.

END OF SECTION 25 14 10

SECTION 25 15 10 – BAS SOFTWARE AND PROGRAMMING - RETROFIT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section includes:
 - 1. Point Structuring.
 - 2. Alarm.
 - 3. Point Structuring.
 - 4. Graphics.
- B. Fully configure systems and furnish and install all software, programming and dynamic color graphics for a complete and fully functioning system as specified.
- C. Refer to Section 25 00 10, Building Automation System (BAS) General - Retrofit for general requirements as well as requirements for interface with Owner's WAN.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

PART 2 - PRODUCTS

2.01 POINT STRUCTURING AND NAMING

- A. General:
 - 1. The intent of this Section is to require a consistent means of naming points across the Owner's WAN. Configure the systems from the perspective of the Owner's WAN, not solely the local Project.

2. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, and the like.
 3. The convention is tailored towards the Owner's WAN and as such, the interface shall always use this naming convention.
 4. Native BACnet systems shall also use this naming convention. For non-BACnet systems, the naming convention shall be implemented as much as practical, and any deviations from this naming convention shall be approved by the Owner.
 5. Each controller shall have English language descriptors for all system points, variables, parameters etc. located and accessible from the controller memory. All point naming shall match between all system files and record documents.
- B. Point Summary Table:
1. The BAS Provider shall coordinate with the Owner's Building Automation System department to compile and submit a proposed Point Summary Table for review prior to any object programming or project startup. The Contractor shall support and not impede direct negotiations between the BAS Provider and the Owner to allow the customizing necessary for structuring the BAS point names to meet the Owner's needs. The MD ANDERSON Manager of Building Automation will provide the format form of the Point Summary Table to be submitted to the BAS Provider upon request. Contractor shall ensure final BAS point names have the approval of the Owner's Manager of Building Automation System prior to any object programming or project startup.
 2. The Point Summary Table shall be kept current throughout the duration of the Project by the Contractor as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.
- C. Point Naming Convention
1. All proposed point names shall reference the existing MD ANDERSON BAS Acronym Standards which can be located and viewed on the Apogee BAS Server.
- D. Device Addressing Convention:
1. BACnet network numbers and Device Object IDs shall be unique throughout the network.
 2. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner.
 3. Coordinate with the Owner or a designated representative to ensure that no duplicate Device Object IDs occur.
 4. Alternative Device ID schemes or cross project Device ID duplication if allowed shall be approved before Project commencement by the Owner.

PART 3 - EXECUTION

3.01 SYSTEM CONFIGURATION

- A. Contractor shall thoroughly and completely configure BAS system software, supplemental software, network communications, CSS, OWS, remote operator workstation, portable operators terminal, printer, and remote communications.

3.02 SITE-SPECIFIC APPLICATION PROGRAMMING

- A. Provide all database creation and Site-specific application control programming as required by these Specifications, national and local standards and for a fully functioning system. Provide all initial Site-specific application programming and thoroughly document programming. Generally meet the intent of the written sequence of operation. It is the Contractor's responsibility to request clarification on sequence issues that require such clarification.
- B. All Site-specific programming shall be fully documented and submitted for review and approval, both prior to downloading into the panel, at the completion of functional performance testing, and at the end of the Warranty Period. Programs shall utilize comment lines which will also reside in the field panel.
- C. All programming, graphics and data files must be maintained in a logical system of directories. All file names shall adhere to the naming convention format as established in the Owner's Standard Acronyms documentation. All files developed for the Project will be the property of the Owner and shall remain on the workstation(s)/server(s) at the completion of the Project.

3.03 ALARMS

- A. This Section supersedes and over rules all references to building automation alarms in the Contract Documents, including all sequences of operations and other sections of the BAS Specification in regards to alarms. The Contractor shall support and not impede direct negotiations between the BAS Provider and the Owner to allow the customizing necessary for customizing alarms and alarm parameters to meet the Owner's needs.
- B. The BAS Provider is required to submit a point summary to confirm building automation point names as specified herein The BAS Provider shall submit this point summary with the addition of identifying all alarms which includes detail information on the alarm parameters to the MD ANDERSON Manager of Building Automation for approval prior to the beginning of any commissioning process of the building automation system.
- C. The MD ANDERSON Manager of Building Automation will provide the format form to the BAS Provider upon request. The Owner shall grant approval of alarms to be verified through commissioning by issuing the approved alarms to the Contractor. The approved alarms issued to the Contractor shall be used for the Functional Test Procedures alarms tested. The Contractor shall initiate the start of this process immediately after building automation submittal have been approved and monitor the progress to ensure the construction schedule is not delayed.
- D. Analog Input Alarms:

1. Not Used
 2. Duct Air Temperatures:
 - a. Alarm @ $\pm$ 2.0 degrees F from set point for 5 minutes @ Priority 3.
 - b. Normal @ $\pm$ 1.0 degrees F from set point for 5 minutes.
 - c. Alarm is active after fan is proven ON for the minimum time necessary to allow the sensor to be within the alarm parameter.
 - d. Alarm is deactivated after fan is proven OFF.
 3. Space Temperature:
 - a. Typically will not be alarmable.
 - b. Submit as not alarmable and Owner will confirm.
 4. Not Used
 5. Not Used
 6. All other Analog Inputs:
 - a. BAS Provider shall utilize their expertise and recommend not less than three (3) analog input alarms which protect the Owner's best interests.
 - b. Submit at Priority 3 with recommended alarm parameters.
 - c. Identify recommended alarms in submittal.
 - d. Owner will confirm alarm.
- E. Digital Inputs Alarms:
1. Proofs (current sensor, etc).
 - a. Digital inputs paired with BAS digital output will have the ability to alarm at all times @ Priority 3.
 - b. Alarm will delay for the reason time needed when the state of the digital output changes to prevent nuisance alarms.
 - c. Point is in alarmed condition when the value of the digital input does not equal the value of the digital output after the time delay.
 - d. Point is in the Normal condition when the value of the digital input equals the value of the digital output after the time delay.
 - e. Digital input proofs without a paired digital output shall not alarm and be for monitoring purposes only.
 2. Not Used

3. Monitoring Digital Inputs

- a. All digital inputs which "deactivated" is the normal state of planed operations shall alarm when the normal state of planed operation changes.
- b. The digital input shall display "ALARM" at Priority 3 at the Alarm screen when activated.
- c. The digital input shall display "NORMAL" at the Alarm screen when deactivated.

4. Not Used

F. Analog Outputs Alarms:

1. All Analog Outputs:

- a. BAS Provider shall utilize their expertise and recommend any analog output alarms which protect the Owner's best interests.
- b. Identify recommended alarms in submittal.
- c. Owner will confirm any alarms.

G. Digital Outputs Alarms:

1. Refer to digital inputs paired with digital outputs as specified herein.

2. All Digital Outputs:

- a. BAS Provider shall utilize their expertise and recommend any digital output alarms which protect the Owner's best interests.
- b. Identify recommended alarms in submittal.
- c. Owner will confirm any alarms.

H. All alarms shall be enhanced to alarm and display the alarm Priority level at the alarm screen table of the specific Owner approved BAS workstations

I. Not Used

J. Priority 3 Mechanical Critical Alarms: All mechanical equipment alarms, which has been identified by the Owner and is achievable with the I/O point available in the Project, shall report to the Owner specified destinations as a Priority 3 alarm. The Contractor, with Owner approved time delays and triggered points, shall enhance the alarm to prevent nuisance alarming.

K. Not Used

L. Nuisance Alarms: All alarms which have been identified by the Owner as a nuisance alarm due to numerous times in and out of alarm shall be addressed and corrected by the Contractor in a manner that the Owner has approved.

- M. Contractor shall review Owner's current and typical BAS existing alarms. The Contractor shall use this data as a guideline in identifying all alarmable points for this Project. The Contractor shall submit all virtual and physical points involved in the Project with all alarmable points identified for the Owner to review. Contractor is responsible for complying with all alarming requests by the Owner that is achievable with the I/O point available in the Project, with existing BAS database, and with the creation of any necessary virtual points.

3.04 GRAPHIC SCREENS

- A. Background resolution shall be 1280 x 1024 for all graphics.
- B. Floor Plan Screens: The Contract Document Drawings will be made available to the Contractor in AutoCAD LT 2002 format upon request. These Drawings may be used only for developing backgrounds for specified graphic screens; however the Owner does not guarantee the suitability of these Drawings for the Contractor's purpose. Graphic Screens shall be submitted for approval.
1. Provide graphic floor plan screens for each floor of each building.
 - a. Indicate the location of all equipment that is not located on the equipment room screens.
 - b. Indicate the location of temperature sensors associated with each temperature-controlled zone on the floor plan screens.
 - c. Display the space temperature point adjacent to each temperature sensor symbol. Use a distinct line symbol to demarcate each terminal unit zone boundary. Use distinct colors to demarcate each air handling unit zone.
 - d. Mechanical floor plan Drawings will be made available to the Contractor upon request for the purpose of determining zone boundaries. Indicate room numbers as provided by the Owner.
 - e. Provide a drawing link from each space temperature sensor symbol and equipment symbol shown on the graphic floor plan screens to each corresponding equipment schematic graphic screen.
 - f. The Owner may approve the substitution of tabular graphics in lieu of floor plan graphics as circumstances apply. Contractor shall verify with Owner whether to create tabular or floor plan graphics.
 2. Not Used
 3. Provide a graphic for each system of the Project. Contact Owner to identify all systems requiring a graphic.
 4. Provide a graphic for each system of the Project. Contact Owner to identify all systems requiring a graphic.
 5. Link graphic screens to all pertinent graphics and/or pertinent data/ information the Owner has requested.
 - a. Link the appropriate sequence of operations to graphics. (.rtf format).

- b. Link approved schematic control Record Drawing to graphic. (.pdf format)
- 6. Submit all graphics per Section 25 00 10 for Owner approval.

END OF SECTION 25 15 10

SECTION 26 01 00 - BASIC ELECTRICAL REQUIREMENTS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Drawings are necessarily diagrammatic by their nature and are not intended to show every connection in detail or every pipe or conduit in its exact location. Carefully investigate structural and finish conditions and coordinate the separate trades in order to avoid interference between the various phases of Work. Organize and lay out Work so that it will be concealed in furred chases and suspended ceilings, etc., in finished portions of the building, unless specifically noted to be exposed. Install all Work parallel or perpendicular to building lines unless otherwise noted.
- B. The intent of the Drawings is to establish the types of systems and functions; not to set forth each item essential to the functioning of the system. Install the Work complete, including minor details necessary to perform the function indicated. Review pertinent Drawings and adjust the Work to conditions shown. Where discrepancies occur between Drawings, Specifications, and actual field conditions, immediately notify the Owner's Project Manager for Owner's interpretations.
- C. Coordinate the actual locations of electrical equipment with building features and equipment as indicated on architectural, structural, mechanical, and plumbing Drawings. Review any proposed changes in electrical equipment location with the Owner's Project Manager.
- D. All dimensional information related to new structures shall be taken from the appropriate Drawings. All dimensional information related to existing facilities shall be taken from actual measurements made by the Contractor on the Site.
- E. Existing Structures: The building floor slabs, structure, and outer walls are generally existing to remain. The only existing penetrations are openings where indicated on the Drawings. This Contract requires the Contractor to core drill all other floor or wall penetrations as required. All floor penetrations shall include a sleeve that extends two (2) inches above the floor.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the Contract Documents.

1.04 DEFINITIONS

- A. Concealed: Concealed areas are those areas that cannot be seen by building occupants.
- B. Exposed: Exposed areas are all areas that are exposed to view by building occupants, including areas below counter tops, inside cabinets and closets, inside all equipment rooms, and areas outside the building exterior envelope, exposed to the outdoors.

1.05 QUALITY ASSURANCE

- A. Regulations: Work, materials and equipment shall comply with the latest rules and regulations specified in National Fire Protection Association (NFPA).
- B. Discrepancies: The Drawings and Specifications are intended to comply with listed codes, ordinances, regulations and standards. Where discrepancies occur, immediately notify the Owner's Project Manager in writing and ask for an interpretation. Should installed materials or workmanship fail to comply, the Contractor is responsible for correcting the improper installation at no additional cost to the Owner. Additionally, where sizes, capacities, or other such features are required in excess of minimum code or standards requirements, provide those specified or shown.
- C. Contractor Qualifications: An acceptable Contractor for the Work under this Division must have personnel with experience, training and skill to provide a practical working system. The Contractor shall furnish acceptable evidence of having installed not less than three systems of size and type comparable to this Project. All personnel installing equipment under this Division shall possess valid State of Texas licenses for their skill level. Each Journeyman shall supervise no more than two apprentice helpers. Refer also to Owner's Special Conditions.

1.06 SUBMITTALS

- A. Product Data: Provide coordination Drawings with submittals as required by Division 01.
- B. Record Documents: In addition to hard copy format, all material submitted as final record products, including approved Shop Drawings and submittals, shall be submitted to the Owner in its original electronic file format on compact disc or DVD. Material may be scanned into electronic file format where necessary.

1.07 DELIVERY, STORAGE AND HANDLING

- A. All equipment and materials shall be delivered to the Project Site clean and sealed for protection.
- B. Moisture: During construction, protect switchgear and other items from insulation moisture absorption and metallic component corrosion by appropriate use of strip heaters, lamps or other suitable means. Apply protection immediately upon receiving the products and maintain continually.
- C. Damage: Take such precautions as are necessary to protect apparatus and materials from damage. Failure to protect materials is sufficient cause for rejection of the apparatus or material in question.

- D. Finish: Protect factory finish from damage during construction operations until acceptance of the Project. Restore any finishes that become stained or damaged to Owner's satisfaction.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Equipment and control systems should match, integrate, communicate or cooperate with Owner's existing systems, such as building automation, fire alarm, switchgears and breakers,.
- C. Conditions: Provide new products of manufacturers regularly engaged in production of such equipment. Provide the manufacturer's latest standard design for the type of product specified. Products shall be U.S. made. Owner reserves the right to approve or disapprove foreign-made products.
- D. NEC and UL: Products shall conform to requirements of the National Electrical Code. Where Underwriters' Laboratories have set standards, listed products and issued labels, products used shall be listed and labeled by UL.
- E. Space Limitations: Equipment selected shall conform to the building features and shall be coordinated with all components. Do not provide equipment that will not meet arrangement and space limitations.
- F. Factory Finish: Equipment shall be delivered with a hard surface, factory-applied finish so that no additional field painting is required except for touch-up.
- G. Common Source: Equipment specified in Sections 26 28 17 and 26 29 14 shall be provided by the same manufacturer.
- H. Series Ratings: Overcurrent devices shall have fully rated interrupting capacity. Series rating of devices is unacceptable.

2.02 EQUIPMENT AND DEVICE MARKING

- A. Externally mark all equipment, devices, conduits for feeders, branch circuits and similar devices using the same circuit designations as indicated on construction drawings and final Record Documents. Conduit marks shall be made at the point of origin and destination of the conduits, using permanent marker.
- B. Nameplates shall be black laminated rigid phenolic with white core. Nameplate minimum size shall be 1 inch high by 3 inches long with 3/16 inch high engraved white letters. Supply blank nameplates for spare units and spaces.
- C. Nameplate Fasteners: Fasten nameplates to the front of equipment only by means of stainless steel self-tapping screws. Stick-ons or adhesives are not acceptable unless the NEMA enclosure rating is compromised, then only epoxy adhesive shall be used to attach nameplates.
- D. Nameplate Information: The general naming convention shall consist of the following segments:

1. Building name in abbreviated form where equipment is located;
 2. Building floor where electrical equipment is located;
 3. Electrical system type: NP (normal power), EP (emergency power), LS (life safety branch), CB (critical branch), EB (equipment system branch);
 4. System voltage: M (medium voltage), H (277/480V) or L (120/208V);
 5. Individual equipment identification: A, B, C, etc.
- E. In general, provide the following information for the types of electrical equipment as listed:
1. Individual Starters, Contactors, Disconnect Switches and Similar Equipment: Identify the device designation, voltage characteristics source and load served.
- F. Panelboards, Pull, Junction and Outlet Boxes:
1. With ½ inch high permanent lettering, identify conduits connected to panelboards, pull, junction and outlet boxes with the complete circuit number of the conductors contained therein. Neutral conductors shall be identified by wire marker tags in the panelboards, pull, junction and outlet boxes. Where multiple circuits are contained in a box, identify the circuit conductors with permanent tags which indicate circuit designation.
 2. Fire alarm circuits (only) shall be marked with half red covers and "Fire Alarm" marked on the face.
- G. Power receptacles, wall switches and dedicated outlets. Identify circuits as per Specification Section 26 27 26.

2.03 NOT USED

PART 3 - EXECUTION

3.01 NOT USED

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. Installation shall be in accordance with manufacturer's published recommendations.
- C. Fasteners requiring explosive powder (shooting) or pneumatic-driven actuation will not be acceptable under any circumstances.
- D. Cooperation with Other Trades: Cooperate with trades of adjacent, related or affected materials or operations, and with trades performing continuations of this Work in order to effect timely and accurate placing of Work and to coordinate, in proper and correct sequence, the Work of such trades.
- E. Workmanship: Work shall be performed by competent workers skilled in their trade. This installation must be complete.

- F. Setting of Equipment: Equipment must be leveled and set plumb. Sheet metal enclosures mounted against a wall must be separated from the wall not less than 1/4 inch by means of corrosion-resistant spacers or by 3 inches of air for freestanding units. Use corrosion resistant bolts, nuts and washers to anchor equipment. Provide Drawings and layout Work showing exact size and location of sleeves, openings or inserts for electrical equipment in slabs, walls, partitions and chases in sufficient time to be coordinated with Work under other divisions.
- G. Sealing of Equipment: Seal openings into equipment to prevent entrance of animals, birds and insects.
- H. Motors: Electrical Work includes the electrical connection of all motors, except those that are wired as a part of equipment.
- I. Concealed Work: Conceal all electrical Work in walls, floors, chases, under floors, underground, and above ceilings except:
 - 1. Where shown or specified to be exposed. Exposed is open to view.
 - 2. Where exposure is necessary to the proper function.
 - 3. Where size of materials and equipment preclude concealment.
- J. Application: Unless otherwise indicated, power will be utilized as follows:
 - 1. 480 volts, three phase: Motors $\frac{3}{4}$ horsepower and larger and electric heating equipment.
 - 2. 120 volts, single phase: Motors $\frac{1}{2}$ horsepower and smaller.
 - 3. 120 volts, single phase: Incandescent lighting and fluorescent task lighting.
 - 4. 277 volts, single phase: Fluorescent and high-intensity-discharge lighting and electric heating equipment.
 - 5. 120 volts, single phase: Convenience outlets.
 - 6. 208 volts, single and three phase: Power outlets.
- K. Provide final electrical connections to equipment furnished under other divisions and by the Owner. Furnish detailed Shop Drawings of equipment indicating the exact number and location of rough-in points. Such final Shop Drawings may indicate adjustments in total number and exact location of rough-in points, and in equipment dimensions. Making adjustments to field conditions is considered a part of the Work required.
 - 1. Roughing-in: When roughing-in electrical branch circuits to various items of equipment, terminate at proper points as indicated on detailed equipment Shop Drawings or as directed by Owner. Do not rely on Drawings accompanying these Specifications for rough-in locations, only for general routing of circuiting.
- L. Refer to Divisions 07 and 09 for sealing and firestopping requirements where raceways penetrate smoke, fire, and sound rated walls.

- M. All unused openings such as but not limited to, knockouts on panels and boxes, surface wireway openings, busway openings, circuit breaker empty slots shall be covered with approved cover plates.
- N. Temporary power equipment and distribution for construction shall not occupy building spaces or block pathways that are designated for permanent installation of other trades according to design drawings.

3.03 TESTING

A. Test Conditions:

- 1. Place circuits and equipment into service under normal conditions, collectively and separately, as may be necessary to determine satisfactory operation. Perform specified tests in the presence of the Owner's representative(s). Furnish all instruments, wiring, equipment and personnel required for conducting tests. Demonstrate that the equipment operates in accordance with requirements of the Contract Documents. Special tests on certain items are specified hereinafter.
- 2. Testing shall be performed by an independent testing company that is Owner approved, and National Electrical Testing Association (NETA) certified. Submit copies of test reports.
- 3. All instruments required for conducting the tests shall be NIST (National Institute for Standard and Technology) certified or traceable, and calibrated at the time of testing.

B. Test Dates: Schedule final acceptance sufficiently in advance of the Contract date to permit completion of any necessary adjustment or alterations within the number of days allotted for completion of the Contract. Provide written notification to Owner at least fourteen (14) calendar days in advance of Functional Performance Test dates.

C. Retests: If retesting is required due to initial failure, conduct retests of such time duration as may be necessary to assure proper functioning of adjusted or altered parts or items of equipment. Any resultant delay as a result of such necessary retests does not relieve the Contractor of Contractor's responsibility under this Contract.

END OF SECTION 26 01 00

SECTION 26 05 19 – CABLE, WIRE AND CONNECTORS, 600 VOLT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. This Section specifies the requirements for 600-volt cable, wire and connectors. It consists of but is not limited to power distribution circuitry, control system circuitry, lighting circuitry, equipment and motor-branch circuitry and outdoor power and lighting circuitry.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. NEMA WC 3: Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - 2. NEMA WC 5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - 3. Where application of National Electrical Code, appears to be in conflict with the requirements of this section, the Owner shall be asked for an interpretation.

1.04 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's data on cable and wire connectors.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-wrapped waterproof flexible barrier material for covering wire and cable wood reels, where applicable; and weather resistant fiberboard containers for factory-packaging of cable, wire and connectors, to protect against physical damage in transit. Damaged cable, wire or connectors shall be removed from the Project Site.
- B. In their factory-furnished coverings, store cable, wire and connectors in a clean, dry indoor space which provides protection against the weather.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Provide factory-fabricated wire of the size, rating, material and type as indicated for each service. Where not indicated, provide proper selection as required to comply with installation requirements and with NEC standards. The minimum size wire to be used for power or lighting circuits shall be #12 copper stranded with insulation as noted below. Minimum size for control circuits shall be #14 copper stranded.

2.02 MANUFACTURERS

- A. Interstate Wire Company.
- B. American Insulated.
- C. Okonite.
- D. Southwire.
- E. Encore Wire.

2.03 BUILDING WIRE

- A. NEMA WC 70 – Nonshielded 0-2kV Cables
- B. Feeders and Branch Circuits all sizes: 98 percent conductivity copper, stranded conductor, 600-volt insulation, THHN/THWN.
- C. Control Circuits: 98 percent conductivity copper, stranded conductor, 600 volt insulation, THHN, THWN.
- D. Color Coding:

1. Branch Circuit and Feeders:

	<u>280Y/120 Volts</u>	<u>480Y/277 Volts</u>
Phase A	Black	Yellow
Phase B	Red	Brown
Phase C	Blue	Orange
Neutral	White with tracer	Gray with tracer
Ground	Green	Green

- 2. The above colors shall be used unless requirements of code require different colors. When connecting to existing circuits, existing color coding shall be utilized. The neutral tracer color shall match the phase conductor color that it is associated with.
- 3. Conductors No. 8 AWG and larger shall be identified by colored plastic tape that matches the circuit phase color at all visible points when colored insulation is unavailable. Colored tape shall be located and of such a quantity to readily indicate the conductor phase.

2.04 REMOTE CONTROL AND SIGNAL CABLE

- A. Control Cable for Class 1 Remote Control and Signal Circuits: 98 percent conductivity copper conductor, 600-volt insulation, rated 60 degrees C, individual conductors twisted together, shielded and covered with a PVC jacket.
- B. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits: 98 percent conductivity copper conductor, 300-volt insulation, rated 60 degrees C, individual conductors twisted together, shielded and covered with a nonmetallic jacket; UL listed for use in air handling ducts, hollow spaces used as ducts, and plenums.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Installer must examine the areas and conditions under which cable, wire and connectors are to be installed and notify the Contractor and Owner in writing of conditions detrimental to the proper and timely completion of the work.
- B. Inspect wire and cable for physical damage. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. General wiring methods:
 - 1. Install electrical cable, wire and connectors as indicated. All installations, temporary or permanent, shall be in accordance with the manufacturer's written instructions, the applicable requirements of NEC, and as required ensuring that products serve the intended functions.
 - 2. Coordinate cable and wire installation work with electrical raceway and equipment installation work, as necessary for proper interface.
 - 3. Cables shall be selected on the basis of their purpose and UL listing. Generally, use Types THWN, XHHW and THHN in building interiors and other dry locations. Outdoors and in underground in raceways, use Type THWN or THHN. Conductors subject to abrasion, such as in lighting poles, shall be Type THWN or THHN.
 - 4. No conductor smaller than No. 12 wire shall be used for branch circuit wiring. In the case of "homeruns" over 50 feet in length (100 feet for 277 volt), no conductor smaller than a No. 10 wire shall be used. The sizing of all wire except remote control wire shall be accomplished in the case of both feeder and branch circuits by conforming to the following provisions.
 - a. 480 Volt Branch Circuits: The voltage drop in the case of 277/480 volt circuits shall not exceed 1.0 percent at maximum load and 70.0 percent power factor.

b. 120/208 Volt Branch Circuits: The voltage drop in the case of 120/208 volt circuits shall not exceed 2.0 percent at maximum load and 70.0 percent power factor.

5. Remote control wires shall be no smaller than No.14 AWG stranded copper conductors and shielded with drain. Control wires shall be run in separate conduits. Departures from the sizes so determined shall be made only in those cases in which the National Electrical Code requires the use of larger conductors. The sizes as determined from these tables shall be regarded as the acceptable minimum under all other circumstances. In no case, however, shall there be a voltage drop greater than that specified in any feeder or branch circuit. This voltage drop shall be based on the full load, 70 percent power factor, the total impedance drop with 60-hertz alternating current and with the reactance drop in the respective metal conduits duly considered. The Contractor may, if Contractor deems it necessary or advisable, use larger sized conductors than those shown. Under no circumstances, however, shall the Contractor use any conductors sized in a manner which does not conform to the above mentioned tables without having first secured the written approval of the Owner's duly authorized representative.

D. Wiring Installation Raceways:

1. Wire and cable shall be pulled into clean dry conduit.
2. Pull conductors together where more than one is being installed in a raceway.
3. Use UL listed pulling compound or lubricant, when necessary; compound must not deteriorate conductor and insulation.
4. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed. Wires with damaged insulation shall be replaced at no cost to the Owner.
5. Place an equal number of conductors for each phase of a circuit in same raceway.
6. No more than three phase conductors shall be installed in same conduit. Line conductors shall not share the same conduit with load conductors.

E. Wiring Connections and Terminations:

1. Splicing cable or wire is not allowed unless it is explicitly designed by the Engineer, or for equipment connection per equipment manufacturer's recommendation. Where splices are to be implemented, approval of the Owner must be obtained before installation is made. Provide electrical boxes where splices are made.
2. Thoroughly clean wires before installing lugs and connectors.
3. Conductors installed outdoors or in garages, whether in use or spare, shall be installed in conduits and terminated in boxes that are rated for outdoor use with listed connectors that are rated for watertight/rain tight applications. The use of indoor wire nuts with electrical tape is prohibited for installations outdoors or in garages.

F. Field Quality Control:

1. Torque test conductor connections and terminations to manufacturer's recommended values.

2. Perform continuity test on all conductors. Verify proper phasing connections and phase rotation, where applicable.
3. Conductors in vertical conduits or raceways shall be supported in the manner set forth in the appropriate section of the latest revision of the National Electrical Code.

3.03 NOT USED

END OF SECTION 26 05 19

SECTION 26 05 26 – GROUNDING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, auxiliary gutters, boxes, cable armor, cable sheath, ground bus in electrical rooms, grounding conductor in raceways and cables.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All design, materials, installation and testing pertaining to grounding and bonding system shall comply with the latest edition of applicable requirements and standards addressed within the following references:
 - 1. ANSI/IEEE Standard 142 - Recommended Practices for Grounding of Industrial and Commercial Power Systems.
 - 2. UL 467 - Grounding and Bonding Equipment.
 - 3. NFPA 70 - National Electrical Code (NEC).
 - 4. IEEE C2 - National Electrical Safety Code (NESC).

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MATERIALS AND EQUIPMENT

- A. Grounding system components shall be as required to comply with the design and construction of the system indicated. Components shall be as indicated in manufacturer's submittal data.
- B. Ground Conductors:
 - 1. Materials:
 - a. Provide 600-volt insulated conductors having a green-colored insulation for equipment grounding conductors. Use stranded conductors.
 - b. Conduit grounding conductors shall be insulated copper conductor, green in color to size #6 AWG. Insulated conductors larger than #6 AWG shall be same as phase conductors but identified with green tape at each accessible opening or location in raceway.
 - c. Provide bare conductors for bonding jumpers.
- C. Grounding clips shall be O-Z Gedney, Steel City (Thomas & Betts) Type G.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installations shall be in accordance with manufacturer's published recommendations.
- C. Size: When grounding and bonding conductors are not sized on Drawings, size the grounding conductors in accordance with NEC. Size bonding jumper so that minimum cross-sectional area is greater than or equal to that of the equivalent grounding conductor as determined from NEC.
- D. Conduit and raceway systems shall not be considered a ground path. Provide an internal insulated grounding conductor in all conduits and raceways. Size grounding conductors in accordance with the NEC. Where grounding conductor sizes are shown in excess of code requirements, provide conductor sizes as indicated.
- E. In feeder and branch circuits, provide a separate, green, insulated equipment-grounding conductor with the circuit conductors. Terminate each end of the grounding conductor on a grounding lug, bus, or bushing.
- F. Install an insulated grounding conductor internally to all flexible metal conduits. Provide suitable grounding bushing at each end of liquid tight flexible metal conduit at transformers only. The grounding bushing shall contain a bonding jumper and shall be terminated at the equipment ground bus. The grounding conductor shall terminate at the equipment ground bus.

- G. Where accessible, conductor connections shall be made by means of solder-less connectors such as serrated bolted clamps or split bolt and nut type connectors.

3.02 FIELD QUALITY CONTROL

- A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

3.03 EQUIPMENT GROUND

- A. Raceway Systems and Equipment Enclosures:

1. Ground cabinets, junction boxes, outlet boxes, motors, controllers, raceways, fittings, switchgear, transformer enclosures, other electrical equipment and metallic enclosures. Ground equipment and enclosures to the continuous-grounded metallic raceway system in addition to any other specific grounding shown.
2. Provide bonding jumpers and ground wire throughout to ensure electrical continuity of the grounding system,
3. Provide grounding-type insulated bushings for metal conduits 1-1/2 inches and larger terminating in equipment enclosures containing a ground bus and connect the bushing to the ground bus. (NOTE: This applies to conduits containing phase conductors only and not control circuits).
4. Provide a green insulated equipment-grounding conductor for each feeder and branch circuit.

- B. Taps and Connections: Make grounding (earth) conductor approximately 2 inches longer than the ungrounded (phase) conductors at both ends.

3.04 NOT USED

END OF SECTION 26 05 26

SECTION 26 05 33 – RACEWAYS, CABLE TRAYS, AND BOXES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. This Section specifies the requirements for raceways, conduits and boxes.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated.
 - 2. ANSI C80.3 - Electrical Metallic Tubing, Zinc Coated.
 - 3. ANSI/NEMA FB 1 - Fittings and Supports for Conduit and Cable Assemblies.
 - 4. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
 - 5. ANSI/UL 1 - Flexible Metal Conduit.
 - 6. ANSI/UL 360 - Liquid-tight Flexible Steel Conduit.
 - 7. ANSI/UL 467 - Electrical Grounding and Bonding Equipment.
 - 8. ANSI/UL 797 - Electrical Metallic Tubing.
 - 9. ANSI/UL 870 - Wireways, Auxiliary Gutters and Associated Fittings.
 - 10. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
 - 11. UL6 - Standard for Safety, Rigid Metal Conduit.
 - 12. UL514B - Standard for Safety, Fittings for Conduit and Outlet Boxes
 - 13. ANSI/UL 651 - Schedule 40 and 80 Rigid PVC Conduit.

1.04 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. Comply with NFPA 70.

1.05 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's product data for raceways, conduits, outlet boxes, and wireways.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 WIREWAYS AND TERMINAL BOXES

- A. Wireways and terminal boxes shall be of steel construction, oil-tight with knockouts.
- B. Size shall be minimum 4 x 4 inches or as indicated on the Drawings.
- C. Cover shall be hinged.
- D. Fittings shall be so constructed to continue the "lay in" feature throughout the entire installation.
- E. Provide all sheet metal parts with a rust-inhibiting phosphatizing primer coating and finished in gray enamel. All hardware shall be cadmium plated to prevent corrosion.
- F. Inside Terminal Boxes: Provide 25-ampere, 300-volt industrial rated terminal blocks with marking strip. Mark strip with black ink identifying circuit connection. Provide nameplate on exterior of each terminal box indicating panelboard served.

2.03 CONDUIT AND FITTINGS

- A. Manufacturers:
 - 1. Conduit and Electrical Metallic Tubing: Allied Tube & Conduit or equal.
 - 2. Fittings: Appleton Electric, Midwest Electric Products or O-Z/Gedney.
 - 3. Expansion Fittings: O-Z/Gedney Type DX, Crouse-Hinds Type XC, or equal by Midwest Electric Products or Appleton Electric.
 - 4. Flexible Metal Conduit and Fittings: Anaconda Sealtite, Type UA.
- B. Application:
 - 1. Conduit and fittings for all electrical systems on this Project shall include the following:

- a. Electrical power and lighting circuits.
 - b. Building automation systems (BAS).
 - c. Other electrical systems, as identified on the Drawings.
- C. For each electrical wireway system indicated, provide a complete assembly of conduit, tubing or duct with fittings including, but not necessarily limited to, connectors, nipples, couplings, locknuts, bushings, expansion fittings, and other components and accessories as needed to form a complete system of the type indicated.
- D. Conduit fittings shall be designed and approved for the specific use intended. Conduit fittings, including flexible, shall have insulated throats or bushings. Rigid conduits shall have insulated bushings, unless grounding bushings are required by NEC Article 250-28. Grounding bushings shall have insulated throats.
- E. Rigid metal conduit shall be hot-dipped galvanized. Fittings shall be threaded type.
- F. Electrical metallic tubing shall be galvanized. Fittings shall be all steel set screw deep socket UL marked and approved for the application. Compression fittings shall be used in, not limited to, wet, damp and environmental areas.
- G. Flexible metal conduit and fittings shall be zinc-coated steel.
- H. Liquid-tight flexible conduit and fittings shall consist of single strip, continuous, flexible interlocked, double-wrapped steel, galvanized inside and outside, forming smooth internal wiring channel with liquid-tight covering of flexible polyvinyl chloride (PVC).
- I. Crimp type fittings are not acceptable.
- J. Raceways such as electrical nonmetallic tubing (ENT) and liquid-tight flexible nonmetallic conduit (LFNC) are not acceptable for use on any Project.

2.04 WALL AND CEILING OUTLET BOXES

- A. Manufacturers: Appleton Electric, RACO-Hubbell, Thomas & Betts - Steel City, Cooper Crouse-Hinds.
- B. Galvanized 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. Minimum switchbox depth shall be 2 inches. Outlet boxes for electrical power shall be 2-1/8 inches deep.
- 1. 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.
 - 2. Accessories shall be compatible with outlet boxes being used and shall meet requirements of individual situations.
- C. Exterior outlet boxes shall be corrosion-resistant cast-metal weatherproof exterior outlet wiring boxes of the type, shape and size, including depth of box, with threaded conduit ends, cast metal faceplate with spring-hinged waterproof cap and corrosion-proof fasteners.

- D. Outlet boxes in poured concrete shall be plenum type without holes and with reset knockouts. Where extension rings are used to offset conduit between wall reinforcing steel, joint between extension ring and box shall be sealed to prevent concrete from entering box during pour.

2.05 PULL AND JUNCTION BOXES

- A. Boxes shall be galvanized sheet metal with screw-on cover and welded seams, stainless steel nuts, bolts, screws and washers.
- B. Boxes larger than 12 inches in any dimension shall be panelboard code gauge galvanized steel with hinged cover.
- C. Boxes shall be sized in accordance with NEC.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Concrete metal hit anchor and fastener is an unacceptable fastening system for concrete, brick and block.
- D. Support all conduits and J-boxes above ceilings from the building structure. All J-boxes being installed above suspended ceilings must have a minimum of 12-inch working clearance between the bottom of J-boxes and the top of the ceiling grid except where approved by the Owner in writing prior to installation.
- E. Bushings and throats shall be installed for fittings, raceways, boxes or other enclosures prior to installing cables and wiring systems.
- F. Provide raceway support in intervals not exceeding the maximum spacing per NEC.

3.02 INSTALLATION - CONDUIT

- A. Install raceway and conduit system from point of origin in outlets shown, complete with offsets, pull boxes, junction boxes and fittings.
- B. Installation of all new conduits must be minimum 12 inches from ceiling grid except where approved by Owner.
- C. Install rigid wall hot-dipped galvanized steel conduit. Minimum size shall be ½-inch unless noted otherwise on the Drawings. The following exceptions are permitted:

1. Electrical Metallic Tubing (EMT): In sizes ½-inch up to and including 4 inches, may be used inside dry locations where not subject to mechanical damage. ½-inch EMT may only be used for connections between distribution J-boxes in the ceiling and J-boxes in the walls within the same room, serving 15-20 Amp single phase receptacles, lighting occupancy sensors, switches, dimmers, and fire alarm respectively. In such application the length of ½-inch EMT shall not exceed 25 feet. EMT shall be used in air-conditioned spaces, such as accessible ceilings, and dry wall partitions. EMT shall not be used outside, in concrete, underground, in underfloor spaces, in masonry walls and in locations likely to be damp. EMT shall not be used for circuits with system voltage over 480 volts.
 2. Liquid-tight Flexible Metal Conduit:
 - a. Install liquid-tight flexible metal conduit for connections to rotating, vibrating, moving or movable equipment, including dry-type transformers. Install internal ground wire on flexible conduit with grounding bushings.
 - b. Maximum length shall be four (4) feet, minimum two (2) feet; minimum size shall be ½-inch.
 3. Flexible Metal Conduit:
 - a. Where required, install standard flexible steel metal conduit (not liquid-tight) with internal ground wire, in spaces above ceilings.
 - b. Install flexible conduit connection such that vibrations are not transmitted to adjoining conduit or building structure. All flexible conduits shall be supported per NEC except for lighting whips and vibration isolation conduits. Maximum length shall be four (4) feet, minimum two (2) feet; minimum size shall be ½-inch.
 4. PVC Conduit:
 - a. Utilize PVC conduit for underground outdoor installations, minimum size 1-inch. All PVC conduit runs shall have PVC coated rigid steel stub outs from the ground, including the last 90 degree bend.
- D. Multiple Conduit Installation:
1. Install all conduits parallel to or at 90 degrees to the structure. Multiple conduits shall not be installed using a single rod support. Multiple conduits running the same direction with spacing 48 inches apart or less shall be installed on the same trapeze. Conduits shall be installed on metal framing constructed trapeze hangers that have minimum 24-inch width. Trapeze hangers shall be supported on minimum 3/8-inch diameter all-thread rod attached to the structure with coupling nuts and expansion bolts or beam clamps. Conduit straps or other devices specifically designed for the purpose shall be used to secure conduits to the metal framing. Wire ties and hanger wires are not permitted. Conduits shall only be installed on the top surface of the metal framing, with multiple layered trapeze supports if required. Hanger rods shall not extend more than 1 inch past the lower trapeze metal framing. Use double nuts for all-thread rods.
 2. Where parallel conduits are strapped, fastened or anchored, the devices used shall be of the same type and installed on the same plane whether vertical or horizontal.

3. Conduit hangers from drop rod (like Caddy B18 Series) are acceptable only upon prior written approval from the Owner.
- E. Single Conduit Installation:
 1. Install single conduits parallel to or at 90 degrees to the structure and suspended from the structure on all thread rods (1/4-inch minimum) or clamped and/or clipped to the structure with manufactured clamps/clips. When single conduits are suspended from all thread rods, conduit clamps with bolts and nuts shall be used. Through partition wall penetration shall not be construed as a means of conduit support. Wire ties and hanger wires are not permitted. No powder actuated, compressed air, propane or similar powered "shot" anchor systems shall be installed under any circumstance. Wire ties and hanger wires are not permitted. Single conduits may be secured as follows:
 - a. Wood screws on wood.
 - b. Toggle bolts on hollow masonry.
 - c. Bolts and expansion anchors in concrete or brick.
 - d. Machine screws, threaded rods and clamps on steel.
 - e. Conduit clips on steel joists.
 - f. Plastic anchors are not allowed.
 - g. Conduit hangers from drop rod (like Caddy B18 Series) are acceptable only upon prior written approval from the Owner.
- F. Fittings shall be approved for grounding purposes or shall be jumpered with a copper grounding conductor of appropriate ampacity. Leave termination of such jumpers exposed. Conduit and wireway systems shall not serve as branch circuit grounding conductors.
- G. Install expansion fittings in metal conduit as follows:
 1. Conduit Crossing Building Expansion Joints:
 - a. EMT all sizes.
 - b. Rigid Galvanized Steel (RGS) all sizes.
 2. Provide conduit expansion fitting with an integral bonding braid, as in Crouse-Hinds Type XC.
 3. Expansion fittings are not required where offsets, expansion loops, or flexible conduit are placed in conduit runs.
- H. Install conduit concealed in walls, partitions and above ceilings. Install exposed in overhead conduit (at structure) of mechanical rooms and in other similar rooms where ceilings are not provided.
- I. Avoid moisture traps where possible; where unavoidable, provide junction box with drain fitting at conduit low point.
- J. Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture.

- K. Install pull wires in empty conduits. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Jetline 232 or equal by Greenlee. Leave at least 12 inches of slack at each end of pull wire.
- L. The support means for conduit installation, whether threaded rods, trapeze or other system, shall not be shared with non-electrical system. Any deviation from this standard due to space constrain shall be submitted to the Owner. Owner's review does not necessarily guarantee an approval; therefore the Contractor is advised not to start installation prior to final approval.

3.03 INSTALLATION - WIREWAYS AND TERMINAL BOXES

- A. Bolt wireways and terminal boxes to steel channels fastened to the wall or in self-supporting structure. Install level.
- B. Gasket each joint in oil-tight wireway.
- C. Mount rain-tight wireway in horizontal position only.

3.04 INSTALLATION - BOXES

- A. Provide electrical boxes as shown on Drawings, and as required for wire pulling, equipment connection, and code compliance. Electrical box locations shown on Drawings are approximate unless dimensioned. Verify location of outlets prior to rough in. Locate and install boxes to allow access and clearances per NEC.
- B. J-boxes shall be provided for branch circuits in excess of 100 feet.
- C. Provide outlet box accessories as required for each installation, including mounting brackets, wallboard hangers, extension rings, fixture studs, cable clamps, and metal strap for supporting outlet boxes. Accessories shall be compatible with outlet boxes being used and shall meet requirements of individual situations.
- D. Membrane penetration of minimum 1-hour, up to maximum 2-hour fire rating walls and partitions by recessed steel electrical boxes that do not exceed 16 square inches in area are permitted, provided the aggregate area of the openings does not exceed 100 square inches in any 100 square feet of wall area. The annular space between the wall membrane and the box shall not exceed 1/8 inch. Such boxes on opposite sides of the wall or partition shall be either separated by a horizontal distance of not less than 24 inches or separated by protecting both boxes by listed putty pads or other listed materials and methods.
- E. Secure boxes rigidly to the substrate upon which they are being mounted, or solidly imbed boxes in concrete or masonry. Boxes shall not be permitted to move laterally.
- F. Provide knockout plugs for unused openings.
- G. Use multiple-gang boxes where more than one device is mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.
- H. Switch boxes shall not be used as junction boxes.
- I. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.

- J. Support pull and junction boxes independent of conduit. Combination box/conduit hangers from drop rod (like Caddy B18 Series) are acceptable only upon prior written approval from the Owner.

END OF SECTION 26 05 33

SECTION 26 28 17 – MOTOR AND CIRCUIT DISCONNECTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Shop Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. This Section specifies the requirements for disconnect switches, fusible and nonfusible.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. Federal Spec. W-S-865 - Switch, Box (Enclosed), Surface Mounted.
 - 2. NEMA KS 1 - Enclosed Switches.

1.04 SUBMITTALS

- A. Submit manufacturer's product data.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver switches individually wrapped in factory-fabricated water-resistant type containers.
- B. Handle switches carefully to avoid damage to material components, enclosure and finish.
- C. Store switches in a clean, dry space protected from weather.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. General Electric Company.
- B. Square D Company.
- C. Cutler Hammer/Westinghouse.
- D. Siemens.

2.03 FABRICATED SWITCHES

- A. Depending upon the service indicated, use 250 or 600 volt switches, single throw, fusible, or nonfusible, horsepower rated, heavy duty, designed for locking in "ON" or "OFF" position, in code-gage steel cabinets.
- B. Use switches which have number of poles required, dependent upon phase serving equipment.
- C. Switches shall be NEMA 1 Underwriters' approved for duty shown. In wet locations, use NEMA 3R. Where exposed to weather in exterior applications, use NEMA Krylon, corrosion resistant type. NEMA 3R and NEMA Krylon switches shall have weatherproof threaded hubs for all conduit entries into switch.
- D. Use fuse clips that are rejecting type to accept Class RK or L fuses.
- E. Identify switches, as to equipment served, with engraved laminated phenolic name plates. Refer to Section 26 01 00 for nameplate information.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Install safety or disconnect switches for all electrical equipment, in accordance with the applicable requirements of NEC and the National Electrical Contractors Association "Standard of Installation."
- D. For all equipment with motors larger than 1/8 horsepower, provide motor rated disconnect switches within sight of the motor.
- E. Disconnect switches for such equipment shall be mounted independent of the unit to allow for maintenance access.

END OF SECTION 26 28 17

SECTION 26 29 14 – MOTOR STARTERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. This Section specifies the requirements for motor control with full voltage non-reversing and combination magnetic motor starters.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
 - 2. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies.
 - 3. NEMA AB 1 - Molded Case Circuit Breakers.
 - 4. NEMA KS 1 - Enclosed Switches.
 - 5. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

1.04 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's product data.
- B. Record Documents:
 - 1. Submit dimensioned Drawings showing size, circuit breaker, fusible switch and combination starter arrangement and equipment ratings including, but not limited to, voltage, bus ampacity, integrated short circuit ampere rating.
 - 2. Provide data on relays, pilot devices, switching and overcurrent protection.

3. Indicate enclosure NEMA rating and material.
- C. Operation and Maintenance Data:
 1. Provide operating and maintenance manuals.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. General Electric Company.
- B. Square D.
- C. Cutler Hammer/Westinghouse.
- D. Siemens.

2.03 MOTOR STARTERS

- A. Each motor shall be provided with proper starting equipment.
 1. Starting equipment, unless specified or scheduled to the contrary, shall be provided by the trade furnishing the motor.
 2. All motor starting equipment provided by any one trade shall be of the same manufacturer unless such starting equipment is an integral part of the equipment on which the motor is mounted.
 3. The Division 23 Subcontractor shall furnish all starters for Division 23 Work.
- B. Magnetic Motor Starter:
 1. Type: Provide magnetic, full-voltage, nonreversing motor starters unless otherwise indicated.
 2. Overload Relays: Provide solid state overload relay in each phase leg.

3. Contractor:
 - a. Size contactors according to NEMA standards or as shown; however, minimum shall be size 1.
 - b. Provide main pole in each phase leg, the number and type of auxiliary contacts to perform the required functions, and two (2) spare auxiliary contacts, one (1) normally open and one (1) normally closed.
 - c. Use double break contacts of silver-cadmium oxide or similar material to minimize sticking or welding.
 - d. Provide contactor coils suitable for continuous operation at 120 volts, 60 hertz.
 4. Control Power Transformer:
 - a. Voltage: Provide in each enclosure a single-phase control power transformer with a 480-volt primary and a 120-volt secondary.
 - b. Fuses:
 - 1) Fuse both primary lines of the transformer and connect to Line 1 and Line 2.
 - 2) Fuse the secondary line leaving transformer terminal X1.
 - 3) Ground the line leaving terminal X2.
 - 4) Use rejection-type fuse clips and RK-1 type current limiting fuses on the primaries.
 - 5) Coordinate primary fuses with secondary fuse to clear a faulted transformer but not blow on magnetizing in-rush current.
 - c. Size: Provide manufacturer's standard size transformer unless the manufacturer of vibration switches requires a larger size.
 5. Enclosure: Provide a NEMA 1 enclosure unless otherwise indicated on Drawings.
 6. Control Devices: Provide control devices as indicated on the Drawings, in front of enclosure as follows:
 - a. Selector Switches: Heavy-duty, oil-tight, maintained contact, 3-position, with marked nameplate HAND-OFF-AUTOMATIC, unless otherwise indicated on two speed motors provide OFF-LOW-HI selector switch.
 - b. Indicating Lights: Indicating lights shall be heavy-duty LED type. Neon lamps are not acceptable. Provide red (running) lens. On two-speed starters, provide amber (low speed) and red (high speed).
- C. Combination Fused Switch-Starter:
1. Type: Provide combination fused switch and magnetic motor started as indicated on the Drawings.

2. Fuses: Provide fuses sized per the Drawings and in accordance with Section 26 28 13.
3. Starter: Provide magnetic motor starter as specified herein.
4. Enclosure: Provide a NEMA 1 enclosure unless otherwise indicated on Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Anchor assembly to housekeeping pad.
- D. Set overload relays for motor in accordance with manufacturer's recommendations for the voltage and full load amperes listed on the nameplate data of each motor actually installed.
- E. Adjust operating mechanisms for free mechanical movement.
- F. Touch-up scratched or marred surfaces to match original finish.
- G. Individual motor starters are furnished under Section 20 05 13, however, the installation and all connections are to be done under Division 26, similar to the Work done for motors served from a Motor Control Center.

3.02 TESTING

- A. Subsequent to wire and cable connections, energize motor control centers and demonstrate functioning in accordance with manufacturer's requirements.

END OF SECTION 26 29 14

SECTION 31 10 21 - REMOVING CONCRETE AND ASPHALT

PART 1 - GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 DESCRIPTION

- A. Break, remove, and salvage or dispose of existing hydraulic cement concrete and existing asphalt pavement or stabilized base materials.

1.03 REFERENCE STANDARDS

- A. Texas Department of Transportation Standard Specification Item 104 and 105.
- B. City of Austin Specification Item No. 104S Removing Portland Cement Concrete.

PART 2 – PRODUCTS

This section not applicable.

PART 3 - EXECUTION

3.01 Concrete Pavement

- A. Remove existing concrete from locations shown on the plans. Avoid damaging concrete that will remain in place. Saw-cut and remove the existing concrete to neat lines. Replace any concrete damaged by the Contractor at no expense to the Owner. Unless otherwise shown on the plans, accept ownership and properly dispose of broken concrete at permitted site in accordance with federal, state, and local regulations.
- B. Existing p.c. concrete shall be cut to the neat lines by sawing with an appropriate type circular type circular concrete saw to a minimum depth of $\frac{1}{2}$. Any reinforcing steel encountered shall be cut off 1 inch inside of p.c. concrete sawed line. Any existing p.c. concrete, which is damaged or destroyed beyond the neat lines so established, shall be replaced at the Contractor's expense. Remaining p.c. concrete shall be mortared to protect the reinforcing steel and provide a neat clean appearance.
- C. When reinforcement is encountered during the removal of portions of existing structures to be modified, a minimum of 1 foot of steel length shall be cleaned of all old p.c. concrete and left in place to tie into the new construction where applicable. All unsuitable material shall be removed and replaced with approved material. All foundations, walls or

other objectionable material shall be removed to a minimum depth of 18 inches below all structures and 12 inches below areas to be vegetated.

3.02 Asphalt Pavement

- A. Dispose of materials not salvageable at permitted site in accordance with federal, state, and local regulations.

END OF SECTION 31 10 21

SECTION 31 40 00 – HYDRAULIC CEMENT CONCRETE

PART 1 - GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 DESCRIPTION.

- A. Governs quality, storage, handling, proportioning and mixing of materials for hydraulic cement concrete construction of buildings, bridges, culverts, slabs, prestressed concrete and incidental appurtenances.

1.03 REFERENCE STANDARDS

- A. City of Austin Standard Specification Item 403S.
- B. City of Houston Specification 03315.
- C. Texas Department of Transportation Standard Specification Item 421.
- D. TxDOT Departmental Material Specifications are referenced in this Specification as DMS-xxxx where xxxx is the associated item number. DMS sheets can be obtained from <http://www.txdot.gov/inside-txdot/division/construction/dms.html>

1.04 SUBMITTALS

The submittal requirements of this specification item may include:

- A. Mix design option(s) of the class of concrete required on the project,
- B. The supplier of the concrete mix design(s) and type of mixing equipment, and
- C. Type of admixtures to be used with the concrete mixes.

PART 2 – PRODUCTS

2.01 MATERIALS

Concrete shall be composed of hydraulic cement or hydraulic cement and supplementary cementing materials, water, aggregates (fine and coarse), and admixtures proportioned and mixed as hereinafter provided to achieve specified results.

A. Cementitious Materials

Hydraulic cement shall conform to ASTM C 150, Type I (General Purpose), Type II (General Purpose with Moderate Sulfate Resistance) and Type III (High Early Strength). Type I shall be used when none is specified or indicated on the drawings. Type I and Type III cements shall not be used when a Type II cement is specified or indicated on the drawings. Type III cement may be used in lieu of a Type I cement, when the anticipated air temperature for the succeeding 12 hours will not exceed 60°F (15.6°C). A Type III cement shall only be used in precast concrete or when

otherwise specified or allowed. All cement shall be of the same type and from the same source for a monolithic placement.

Unless otherwise specified the cementitious material content shall be limited to no more than 700 lbs. per cubic yard (417 kg per cubic meter). When supplementary cementing materials are used, cement is defined as "cement plus supplementary cementing material." Supplementary cementing materials include fly ash (DMS 4610), ultra-fine fly ash (DMS-4610), ground granulated blast furnace slag grade 100 or 120 (DMS-4620), silica fume (DMS-4630) and metakaolin (DMS-4635).

Supplementary cementing materials shall not be used when white hydraulic cement is specified.

Class C flyash shall not be used in sulfate-resistant concrete.

Hydraulic cement manufactured in a cement kiln fueled by hazardous waste shall be considered as an approved product if the production facility is authorized to operate under regulation of the Texas Commission on Environmental Quality (TCEQ) and the U. S. Environmental Protection Agency (EPA). Supplier shall provide current TNRCC and EPA authorizations to operate the facility.

B. Mixing Water

Water for use in concrete and for curing shall be potable water free of oils, acids, organic matter or other deleterious substances and shall not contain more than 1,000 parts per million of chlorides as Cl or sulfates as SO_4 .

Water from M.D. Anderson will not require testing. Contractor may request approval of water from other sources. Contractor shall arrange for samples to be taken from the source and tested at his expense. When water from other sources is proposed, test reports shall be provided that indicates compliance with Table 1 before use.

Table 1: Chemical Limits for Mix Water		
Contaminant	Test Method	Maximum Concentration (ppm)
Chloride (CL)	ASTM D-512	
Prestressed concrete		500
Bridge decks & superstructure		500
All other concrete		1,000
Sulfate (SO_4)	ASTM D-516	1,000
Alkalies ($Na_2O + 0.658 K_2O$)	ASTM D-4191 & D-4192	600
Total Solids	AASHTO T-26	50,000

Water that has an adverse effect on the air-entraining agent or any other chemical admixture or on strength or time of set of the concrete shall not be used. Water used in white Portland cement concrete shall be free from iron and other impurities, which may cause staining, or discoloration.

C Coarse Aggregate

Coarse aggregate shall consist of durable particles of crushed or uncrushed gravel, crushed blast furnace slag, crushed stone or combinations thereof; free from frozen material or injurious amounts of salt, alkali, vegetable matter or other objectionable material either free or as an adherent coating. When white hydraulic cement is specified, the coarse aggregates used in the concrete shall be light colored. Quality shall be reasonably uniform throughout.

The coarse aggregate from each source shall not contain more than 0.25 percent by weight of clay lumps, nor more than 1.0 percent by weight of shale nor more than 5 percent by weight of laminated and/or friable particles when tested in accordance with TXDOT Test Method TEX-413-A. The coarse aggregate from each source shall have a wear of not more than 40 percent when tested in accordance with TXDOT Test Method TEX-410-A.

Unless otherwise indicated on the drawings, the coarse aggregate from each source shall be subjected to 5 cycles of the soundness test conforming to TXDOT Test Method TEX-411-A. The loss shall not be greater than 12 percent when sodium sulfate is used or 18 percent when magnesium sulfate is used.

Coarse aggregate shall be washed. The Loss by Decantation (TXDOT Test Method TEX-406-A), plus allowable weight of clay lumps, shall not exceed 1 percent or the value indicated on the drawings or in the project manual, whichever is less. If material finer than the # 200 (75 micrometer) sieve is definitely established to be dust of fracture of aggregates made primarily from crushing of stone, essentially free from clay or shale as established by Part III of TXDOT Test Method TEX-406-A, the percent may be increased to 1.5. When crushed limestone coarse aggregate is used in concrete pavements, the decant may exceed 1% but not more than 3% if the material finer than the # 200 (75 micrometer) sieve is determined to be at least 67% calcium carbonate in accordance with TxDOT Test Method Tex-406-A, Part III.

The coarse aggregate factor may not be more than 0.82; however, when voids in the coarse aggregate exceed 48 percent of the total rodded volume, the coarse aggregate factor shall not exceed 0.85. The coarse aggregate factor may not be less than 0.68 except for a Class I machine extruded mix that shall not have a coarse aggregate factor lower than 0.61.

When exposed aggregate surfaces are required, the coarse aggregate shall consist of particles with at least 40 percent crushed faces. Uncrushed gravel, polished aggregates and clear resilient coatings are not acceptable for exposed aggregate finishes.

When tested by approved methods, the coarse aggregate including combinations of aggregates when used, shall conform to the grading requirements shown in Table 2.

Table 2: Coarse Aggregate Gradation Chart (Percent Passing)										
Grade	Nom. Size	2-1/2"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8
1	2"	100	80-100	50-85		20-40			0-5	
2 (467)*	1 1/2"		100	95-100		35-70		10-30	0-5	
3	1"		100	95-100		60-90	25-60		0-5	
4 (57)*	1"			100	95-100		25-60		0-10	0-5
5 (67)*	3/4"				100	90-100		20-55	0-10	0-5
6 (7)*	1/2"					100	90-100	40-70	0-15	0-5
7	3/8"						100	70-95	0-25	
8	3/8"						100	95-100	20-65	0-10

Notes:

1. Recycled crushed concrete fine aggregate shall be limited to a maximum of 20% of the fine aggregate.
2. The use of recycled crushed hydraulic cement concrete as a coarse aggregate shall be limited to Concrete Classes A, B and D (see Table 5).

D. Fine Aggregate

Fine aggregate shall be washed and consist of clean, hard, durable and uncoated particles of natural or manufactured sand or a combination thereof, with or without a mineral filler. When white hydraulic cement is specified, the fine aggregates used in the concrete shall be light colored. Quality shall be reasonably uniform throughout. It shall be free from frozen material or injurious amounts of salt, alkali, vegetable matter or other objectionable material and it shall not contain more than 0.5 percent by weight of clay lumps in accordance with TEX-413-A. When subjected to color test for organic impurities per TXDOT Test Method TEX-408-A, it shall not show a color darker than standard.

Unless indicated otherwise on the drawings the acid insoluble residue of fine aggregate used in slab concrete subject to direct traffic shall not be less than 60 percent by weight (mass) when tested conforming to TXDOT Test Method TEX-612-J.

Unless indicated otherwise on the Drawings, fine aggregate shall be blended, when necessary, to meet the acid insoluble residue requirement.

When blending the following equation shall be used:

$$\text{Acid Insoluble (\%)} = \frac{(A1)(P1) + (A2)(P2)}{100}$$

Where:

- A1 = acid insoluble (%) of aggregate 1,
- A2 = acid insoluble (%) of aggregate 2,
- P1 = % by weight of A1 of the fine aggregate blend, and
- P2 = % by weight of A2 of the fine aggregate blend.

When tested in accordance with TxDoT Test Method Tex-401-A, the fine aggregate, including mineral filler and combinations of aggregates, when used, shall conform to the grading requirements shown in Table 3.

Table 3: Fine Aggregate Gradation Chart¹ (Grade 1 – Percent Passing)							
3/8	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
100	95-100	80-100	50-85	25-65	10-35 ¹	0-10	0-3 ²

Notes:

1. Recycled crushed concrete fine aggregate shall be limited to a maximum of 20% of the fine aggregate.
2. The use of recycled crushed hydraulic cement concrete as a fine aggregate shall be limited to Concrete Classes A, B and D (see Table 5).
3. 6 to 35 when sand equivalent value is greater than 85.
4. 0 to 6 for manufactured sand.

Sand equivalent per TXDOT Test Method TEX-203-F shall not be less than 80 nor less than otherwise indicated on the drawings, whichever is greater.

The fineness modulus will be determined by adding the percentages by weight retained on sieve Nos. 4, 8, 16, 30, 50 and 100 (4.75 mm, 2.36 mm, 1.18mm, 600 µm, 300 µm, and 150 µm) and dividing the sum of the six sieves by 100. For all classes of concrete except K (see Table 5), the fineness modulus shall be between 2.30 and 3.10. For Class K concrete, the fineness modulus shall be between 2.40 and 2.90, unless indicated otherwise on the Drawings.

0 Mineral Filler

Mineral filler shall consist of stone dust, clean crushed sand or other approved inert material. When tested in accordance with TxDoT Test Method Tex-401-A, it shall conform to the following gradation:

Passing the No. 30 (600 µm) Sieve	100 percent
Passing the No. 200 (75 µm) Sieve	65 to 100 percent

F. Mortar and Grout

Unless otherwise specified, indicated on the drawings or approved by the Engineer or designated representative mortar and grout shall consist of 1 part hydraulic cement, 2 parts finely graded sand and enough water to make the mixture plastic. When required to prevent color difference, white cement shall be added to produce color required. When required by the Engineer or designated representative, approved latex adhesive may be added to the mortar. Mortar shall be provided with a consistency such that the mortar can be easily handled and spread by trowel. Grout shall be provided of a consistency that will flow into and completely fill all voids.

G. Admixtures

All chemical admixtures including water reducing, plasticizers and air entrainment shall conform to TxDoT DMS-4640, "Chemical Admixtures for Concrete". Calcium chloride-based admixtures shall not be approved. Admixtures shall be included in the prequalified concrete admixtures list maintained by TxDot's Construction Division.

H. Air Entrainment

Unless indicated otherwise on the drawings, all concrete classes with the exception of Class B shall be air-entrained in accordance with Table 8. If the air content is more than 1-1/2 percentage points below or 3 percentage points above the required air, the load of concrete will be rejected. If the air content is more than 1-1/2 but less than 3 percentage points above the required air, the concrete may be accepted based on strength test results.

PART 3 – EXECUTION

3.01 STORAGE OF MATERIALS

A. Cement, Supplementary Cementing Materials and Mineral Filler

All cement, supplementary cementing materials and mineral filler shall be stored in separate and well ventilated, weatherproof buildings or approved bins, which will protect the material from dampness or absorption of moisture. Storage facilities shall be easily accessible and each shipment of packaged cement shall be kept separated to provide for identification and inspection. The Engineer or designated representative may permit small quantities of sacked cement to be stored in the open for a maximum of 48 hours on a raised platform and under waterproof covering.

B. Aggregates

The method of handling and storing concrete aggregates shall prevent contamination with foreign materials. If the aggregates are stored on the ground, the sites for the stockpiles shall be clear of all vegetation and shall be level. Aggregates shall be stockpiled in sizes to facilitate blending. If the aggregate is not stockpiled on a hard, non-contaminant base, the bottom 6-inch (150 mm) layer of the stockpile shall not be used without recleaning the aggregate.

When conditions require the use of 2 or more grades of coarse aggregates, separate stockpiles shall be maintained to prevent intermixing. Where space is limited, stockpiles shall be separated by walls or other appropriate barriers.

Aggregate shall be stockpiled and protected from the weather a minimum of 24 hours prior to use to minimize free moisture content. When stockpiles are too large to protect from the weather, accurate and continuous means acceptable to the Engineer or designated representative shall be provided to monitor aggregate temperature and moisture. Aggregates shall be stockpiled and handled such that segregation and contamination are minimized.

The stockpiles shall be sprinkled to control moisture and temperature as necessary. A reasonably uniform moisture content shall be maintained in aggregate stockpiles.

C. Admixtures

Admixtures shall be stored in accordance with manufacturer's recommendations and shall be protected against freezing.

D. Hot Weather Concrete Mixes

Ice may be used during hot weather concrete placement per Specification 31 40 05 to lower the concrete temperature; however, the Contractor shall furnish a mix design acceptable to the Engineer or designated representative for class of concrete specified. The addition of ice shall not exceed 50% of the total mix water weight.

3.02 MEASUREMENT OF MATERIALS

Water shall be accurately metered. Fine and coarse aggregates, mineral filler, bulk cement and fly ash shall be weighed separately. Allowances shall be made in the water volume and aggregate weights during batching for moisture content of aggregates and admixtures.

Batch weighing of sacked cement is not required; however, bags, individually and entire shipments, may not vary by more than 3 percent from the specified weight of 94 pounds (42.6 kilograms) per bag. The average bag weight of a shipment shall be determined by weighing 50 bags taken at random.

3.03 MIX DESIGN

The Contractor shall furnish a mix design acceptable to the Engineer or designated representative for the class of concrete required in accordance with Table 5. The mix shall be designed by a qualified commercial laboratory and signed/sealed by a registered Professional Engineer, licensed in the state of Texas to conform with requirements contained herein, to ACI 211.1 or TXDOT Bulletin C-11 (and supplements thereto). The maximum water-to-cementitious material ratio identified in Table 5 for specific classes of concrete shall not be exceeded.

A higher-strength class of concrete with equal or lower water-to-cementitious-material ratio may be substituted for the specified class of concrete.

The mix design shall be over-designed in accordance with Table 5 in order to account for production variability and to ensure minimum compressive strength requirements are met.

Allowable mix design options are presented in Section 3.05.

The Contractor shall perform, at his own expense, the work required to substantiate the design, including testing of strength specimens. Complete concrete design data shall be submitted to the Engineer or designated representative for approval. The mix design will be valid for a period of one (1) year provided that there are no changes to the component materials.

When there are changes in aggregates or in type, brand or source of cement, supplementary cementing material or chemical admixtures, the mix shall be evaluated as a new mix design. A change in vendor does not necessarily constitute a change in materials or source. When only the brand or source of cement is changed and there is a prior record of satisfactory performance of the cement with the ingredients, the submittal of new trial batches may be waived by the Engineer or designated representative.

At the end of one (1) year, a previously approved mix may be resubmitted for approval if it can be shown that no substantial change in the component materials has occurred and that test results confirming the adequacy of the mix designs have been acquired during the previous year. The resubmittal analysis must be reviewed, signed and sealed by a registered Professional Engineer, licensed in the state of Texas. This resubmittal shall include a reanalysis of specific gravity, absorption, fineness modulus, sand equivalent, soundness, wear and unit weights of the aggregates. Provided that the fineness modulus did not deviate by more than 0.20 or that the re-proportioned total mixing water, aggregate and cement (or cement plus fly ash) are within 1, 2, and 3 percent, respectively, of pre-approved quantities, a one-year extension on the approval of the mix may be granted by the Engineer or designated representative. Updated cement, fly ash, and admixture certifications shall accompany the resubmittal.

Approved admixtures that are included in the prequalified concrete admixtures list maintained by TxDot's Construction Division may be used with all classes of concrete at the option of the Contractor provided that specific requirements of the governing concrete structure specification are met. Water reducing and retarding agents shall be required for hot weather, large mass, and

continuous slab placements. Air entraining agents may be used in all mixes but must be used in the classes indicated on Table 5. Unless approved by the Engineer or designated representative, mix designs shall not exceed air contents for extreme exposure conditions as recommended by ACI 211.1 for the various aggregate grades.

3.04 CONSISTENCY AND QUALITY OF CONCRETE

Concrete shall be workable, cohesive, possess satisfactory finishing qualities and of stiffest consistency that can be placed and vibrated into a homogeneous mass within slump requirements specified in Table 4 without the development of segregation or honeycombing. No concrete will be permitted with a slump in excess of the maximums shown unless water-reducing admixtures have been previously approved. Concrete that exceeds the maximum acceptable placement slump at time of delivery will be rejected. Slump values shall be conducted in accordance with TXDOT Test Method TEX-415-A.

Consistency and quality of concrete should allow efficient placement and completion of finishing operations before initial set. Re-tempering (i.e. addition of water and reworking concrete after initial set) shall not be allowed. When field conditions are such that additional moisture is needed for final concrete surface finishing operation, the required water shall be applied to surface by fog spray only and shall be held to a minimum. Excessive bleeding shall be avoided and in no case will it be permissible to expedite finishing and drying by sprinkling the surface with cement powder.

Table 4: Slump Requirements		
Type of Construction	Slump¹, inches	
	Maximum	Minimum
Cased Drilled Shafts	4	3
Reinforced Foundation Caissons and Footings	3	1
Reinforced Footings and Substructure Walls	3	1
Uncased Drilled Shafts	6	5
Thin-walled Sections; 9 inches (225 mm) or less	6 ½	4
Prestressed Concrete Members ¹	6 ½	4
Precast Drainage Structures	6	4
Wall Sections over 9 inches (225 mm)	5	3
Reinforced Building Slabs, Beams, Columns and Walls	4	1
Bridge Decks	4	2
Pavements, Fixed-form	6 ½	4
Pavements, Slip-form	3	1-½
Sidewalks, Driveways and Slabs on Ground	4	2
Curb & Gutter, Hand-vibrated	3	1
Curb & Gutter, Hand-tamped or spaded	4	2
Curb & Gutter, Slip-form/extrusion machine	2	½
Heavy Mass Construction	2	1
High Strength Concrete	4	3
Riprap and Other Miscellaneous Concrete	6	1
Under Water or Seal Concrete	8 ½	6
Pipe Block Fill, Thrust Blocking	7	5

1. Slump values when a high range water reducer (HRWR) is not used.

2. When a high range water reducer (HRWR) is used, maximum acceptable placement slump will be 9 in (225 mm)

Proportioning of all material components shall be checked prior to discharging. Excluding mortar material for pre-coating of the mixer drum and adjustment for moisture content of admixtures and aggregates, material components shall fall within the range of + 1% for water, + 2% for aggregates, + 3% for cement, +2% for fly ash and within manufacturer recommended dosage rates for admixtures except that air entrainment shall be within + 1-1/2 percentage points of the mix design requirements.

Unless otherwise specified or indicated on the drawings, concrete mix temperature shall not exceed 90°F (32°C) except in mixes with high range water reducers where a maximum mix temperature of 100°F (38°C) will be allowed. Cooling an otherwise acceptable mix by addition of water or ice during agitation will not be allowed.

Test cylinders will be required for small placements such as manholes, inlets, culverts, wing walls, etc. The Engineer or designated representative may vary the number of tests to a minimum of 1 for each 25 cubic yards (1 for each 19 cubic meters) placed over a several day period.

A strength test shall be defined as the average breaking strength of 2 cylinders. A minimum of four test cylinders shall be prepared; two each to be tested at 7 and 28 days. Specimens will be tested conforming to TXDOT Test Method TEX-418-A. If required strength or consistency of class of concrete being produced cannot be secured with minimum cementitious material specified or without exceeding maximum water/cementitious material ratio, Contractor will be required to furnish different aggregates, use a water reducing agent, an air entraining agent or increase the cement content in order to provide concrete meeting these specifications.

Slump tests will be performed in accordance with TxDOT Test Method Tex-415-A. Entrained air tests will be performed in accordance with TxDOT Test Method Tex-416-A.

Test specimens shall be cured using the same methods and under the same conditions as the concrete represented. Design strength cylinders shall be cured conforming to TXDOT Bulletin C-11 (and supplements thereto).

When control of concrete quality is by 28-day compressive tests, job control testing will be by 7-day compressive strength tests. The minimum strength requirement for seven (7) day test will be 70 percent of the specified minimum 28-day compressive strength. If the required 7-day strength is not secured with the quantity of cement specified in Table 4, changes in the mix design shall be made and resubmitted for approval. For an occasional failure of the seven-day compressive test, the concrete may be tested at 28 days for final evaluation.

Table 5: Classes of Concrete						
Class	Cement Sks Per CY	Minimum Strength, psi		Maximum W/C Ratio ¹	Coarse Aggr. Grade ^{2,3,4, 7}	Air Entrain
		28 Days	7 Days			
A	5.0	3000	2100	0.6	1,2,3,4, 8	Yes
B	4.0	2000	1400	0.6	2,3,4,5,6,7	No
C ⁵	6.0	3600	2520	0.45	1,2,3,4,5,6	Yes
D	4.5	2500	1750	0.6	2,3,4,5,6,7	No
H ⁵	6.0	As indicated	As Indicated	0.45	3,4,5,6	Yes
I	5.5	3500	2450	0.45	2,3,4,5	Yes

J	2.0	800	560	N/A	2,3,4,5	No
S ⁵	6.0	4000	2800	0.45	2,3,4,5	Yes
P	5.0	4,400	3,500	6.25	2-3	Yes

Notes:

1. Maximum water-cement or water-cementitious ratio by weight
2. Unless otherwise allowed, Grade 1 coarse aggregate shall only be used in massive foundations with 4-in (100-mm) minimum clear spacing between reinforcing steel bars.
3. Grade 1 coarse aggregate grading shall not be used in drilled shafts.
4. Unless otherwise allowed, Grade 8 coarse aggregate shall be used in extruded curbs.
5. Structural concrete classes.
6. When Type II cement is used in Class C, S or A concrete, the 7-day compressive strength requirement will be 2310 psi for Class C, 2570 psi for Class S and 1925 psi for Class A minimum.
7. Grade 8 aggregate for use in extrude curbs using Class A, unless a larger size is approved by the Engineer.
8. Minimum running average for concrete pavement (in accordance with TxDOT bulletin C-11.)

Table 6: Over Design Required to Meet Compressive Strength Requirements¹					
Number Of Tests^{2,3}	Standard Deviation, psi (MPa)				
	300 (2.06)	400 (2.75)	500 (3.44)	600 (4.13)	700 (4.82)
15	470 (3.24)	620 (4.27)	850 (5.85)	1,120 (7.71)	1,390 (9.57)
20	430 (2.96)	580 (3.99)	760 (5.23)	1,010 (6.95)	1,260 (8.67)
30 or more	400 (2.75)	530 (3.65)	670 (4.61)	900 (6.20)	1,130 (7.78)

Notes:

1. When designing the mix, add the tabulated amounts to the minimum design strength in Table 5. Maximum water-cement or water-cementitious ratio by weight
2. Number of tests of a concrete mixture used to estimate the standard deviation of a concrete production facility. Test of another mix within 1,000 psi (6.88 Mpa) of the specified strength may be used.
3. If less than 15 prior tests are available, the overdesign should be 1,000 psi (6.88 Mpa) for specified strength less than 3,000 psi (20.65 Mpa), 1,200 psi (8.26 Mpa) for specified strengths from 3,000 to 5,000 psi (20.65 to 34.42 Mpa) and 1,400 psi (9.64 Mpa) for specified strengths greater than 5,000 psi (34.42 Mpa).

Table 7: Expected Usage of Concrete Classes

Class	General Usage
A	Inlets, manholes, curb, gutter, curb & gutter, concrete retards, sidewalks, driveways, backup walls and anchors
B	Riprap, small roadside signs and anchors, pipe block fill, thrust blocking
C ⁵	Drilled shafts, bridge substructure, bridge railing, culverts except top slab of direct traffic culverts, headwalls, wing walls, approach slabs, and cast-in-place concrete traffic barrier
D	Riprap
H ⁵	Prestressed concrete beams, boxes, piling and precast concrete traffic barrier
J	Utility trench repair
S ⁵	Bridge slabs and top slabs of direct traffic culverts
P	Concrete pavement

Table 8: Air Entrainment¹

Nominal Maximum Aggregate Size In (mm)	% Air Entrainment	
	Moderate Exposure	Severe Exposure
3/8 (9.5)- Grades 7 & 8	6	7-1/2
1/2 (12.5)- Grades 6	5-1/2	7
3/4 (19)- Grades 5	5	6
1 (25)- Grades 4	4-1/2	6
1-1/2 (37.5)- Grades 2 & 3	4-1/2	5-1/2
2 (50)- Grades 2	4	5

1. For specified concrete strengths above 5,000 psi (34.42 MPa) a reduction of 1 percentage point is allowed.

3.05 MIX DESIGN OPTIONS

For the structural concretes identified in Table 5 (Classes C, H and S) and any other class of concrete designed using more than 520 lbs. of cementitious material per cubic yard (310 kgs per cubic meter), one of the mix design options presented below shall be used.

For the non-structural concretes identified in Table 5 (Classes A, B, D and I) and any other class of concrete designed using less than 520 lbs. of cementitious material per cubic yard (310 kgs per cubic meter), one of the mix design options presented below will be used, except that Class C fly ash may be used instead of Class F fly ash for Options 1, 3 and 4 unless a sulfate-resistant concrete is required.

- A. Option 1: Twenty (20) to thirty-five (35) percent of the cement may be replaced with Class F fly ash.
- B. Option 2: Thirty-five (35) to fifty (50) percent of the cement may be replaced with ground granulated blast-furnace slag.

- C. Option 3: Thirty-five (35) to fifty (50) percent of the cement may be replaced with a combination of Class F fly ash, ground granulated blast-furnace slag or silica fume. The combination may not include more than thirty-five (35) percent fly ash and no more than ten (10) percent silica fume.
- D. Option 4: Type IP or Type IS will be used and up to ten (10) percent of the cement may be replaced with Class F fly ash, ground granulated blast-furnace slag or silica fume.
- E. Option 5: Thirty-five (35) to fifty (50) percent of the cement may be replaced with a combination of Class C fly ash and at least six (6) percent of silica fume, ultra fine fly ash or metakaolin. The combination may not include more than thirty-five (35) percent fly ash and no more than ten (10) percent silica fume.
- F. Option 6: A lithium nitrate admixture will be added at a minimum dosage of 0.55 gal. Of thirty (30) percent lithium nitrate solution per pound of alkalis present in the hydraulic cement.
- G. Option 7: When hydraulic cement only is used in the design, the total alkali contribution from the cement in the concrete does not exceed 4.0 lbs. Per cubic yard, when calculated as follows:
- $$\text{alkali (lbs. per CY)} = .01 (\text{lbs cement/CY}) (\% \text{ Na}_2\text{O equivalent in cement})$$
- where (% Na₂O equivalent in cement) is assumed to be the maximum cement alkali content reported on the cement mill certificate.
- H. Option 8: When there are deviations from Options 1 through 7, the following shall be performed:
1. Conduct tests on both coarse and fine aggregate separately in accordance with ASTM C-1260, using 440 g of the proposed cementitious in the same proportions of hydraulic cement to supplementary cementing material to be used in the mix.
 2. Prior to use of the mix, a certified test report signed and sealed by a Professional Engineer, licensed in the state of Texas shall be submitted that demonstrates that ASTM C 1260 test results for each aggregate do not exceed 0.10 percent expansion.

3.06 MIXING AND MIXING EQUIPMENT

All equipment, tools and machinery used for hauling materials and performing any part of the work shall be maintained in such condition to insure completion of the work without excessive delays for repairs and replacement. Mixing shall be done in a mixer of approved type and size that will produce uniform distribution of material throughout the mass and shall be capable of producing concrete meeting requirements of ASTM C 94, Ready-mixed Concrete and these specifications. Mixing equipment shall be capable of producing sufficient concrete to provide required quantities. Entire contents of the drum shall be discharged before any materials are placed therein for a succeeding batch. Improperly mixed concrete shall not be placed in a structure. For all mixers an adequate water supply and an accurate method of measuring the water shall be provided.

The mixer may be batched by either volumetric or weight sensing equipment and shall be equipped with a suitable timing device that will lock the discharging mechanism and signal when specified time of mixing has elapsed.

A. Ready-mixed Concrete

Use of ready-mixed concrete will be permitted provided the batching plant and mixer trucks meet quality requirements specified herein. When ready-mixed concrete is used, additional mortar (1 sack cement, 3 parts sand and sufficient water) shall be added to each batch to coat the mixer drum. Ready-mixed concrete, batching plant and mixer truck operation shall include the following:

1. A ticket system will be used that includes a copy for the Engineer. Ticket will have machine stamped time/date of concrete batch, a mix design designation, weight of cement, fly ash, sand and aggregates; exact nomenclature and written quantities of admixtures and water. Any item missing or incomplete on ticket may be cause for rejection of concrete.
2. Sufficient trucks will be available to support continuous placements. The Contractor will satisfy the Engineer or Owner that adequate standby trucks are available to support monolithic concrete placement requirements. Coordinate standby location and timing of concrete trucks with Owner Project Manager, Harold Goodson, prior to work.
3. A portion of mixing water required by the mix design to produce the specified slump may be withheld and added at the job site, but only with permission of the Engineer. When water is added under these conditions, the concrete batch will be thoroughly mixed before any slump or strength samples are taken. Additional cement shall not be added at the job site to otherwise unacceptable mixes.
4. A metal plate(s) shall be attached in a prominent place on each truck mixer plainly showing the various uses for which it was designed. The data shall include the drum's speed of rotation for mixing and for agitating and the capacity for complete mixing and/or agitating only. A copy of the manufacturer's design, showing dimensions of blades, shall be available for inspection at the plant at all times. Accumulations of hardened concrete shall be removed to the satisfaction of the Engineer or designated representative.
5. The loading of the transit mixers shall not exceed capacity as shown on the manufacturer's plate attached to the mixer or 63 percent of the drum volume, whichever is the lesser volume. The loading of transit mixers to the extent of causing spill-out enroute to delivery will not be acceptable. Consistent spillage will be cause for disqualification of a supplier.
6. Excess concrete remaining in the drum after delivery and wash water after delivery shall not be dumped on the project site unless approval of the dump location is first secured from the Engineer or designated representative.

B. Hand-mixed Concrete

Hand mixing of concrete may be permitted for small placements or in case of an emergency and then only on authorization of the Engineer. Hand-mixed batches shall not exceed a 4 cubic foot (0.113 cubic meters) batch in volume. Material volume ratios shall not be leaner than 1 part cement, 2 parts large aggregate, 1 part fine aggregate and enough water to produce a consistent mix with a slump not to exceed 4 inches (100 mm). Admixtures shall not be used unless specifically approved by the Engineer.

END OF SECTION 31 40 00

SECTION 31 40 05 – CONCRETE STRUCTURES

PART 1 – GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.03 DESCRIPTION

- A. Construct concrete structures.

1.04 REFERENCE STANDARDS

- A. Texas Department of Transportation Standard Specification Item 420.
- B. TxDOT Departmental Material Specifications are referenced in this Specification as DMS-xxxx where xxxx is the associated item number. DMS sheets can be obtained from <http://www.txdot.gov/inside-txdot/division/construction/dms.html>

1.05 SUBMITTALS

The submittal requirements of this specification item may include:

- A. Appropriate mix designs for class of concrete for each type of structure or unit;
- B. Appropriate mortar and grout mix designs;
- C. Product name, description, technical information and supplier of any acrylic-polymer latex admixture;
- D. Type, supplier and certified test results for expansion joint materials;
- E. Type of waterstop and confirmation that the product conforms to TxDOT DMS-6160;
- F. Type and manufacturer of proposed evaporation retardant and confirmation that it meets the requirements of test results for TxDOT DMS-4650;
- G. Type and manufacturer of proposed chemical admixtures and confirmation that it meets the requirements of test results for TxDOT DMS-4640;
- H. Type and manufacturer of proposed curing admixtures and confirmation that it meets the requirements of test results for TxDOT DMS-4640;
- I. Type and manufacturer of proposed chemical admixtures and confirmation that it meets the requirements of test results for TxDOT DMS-4640;
- J. Type and manufacturer of proposed epoxy and/or adhesives and confirmation that it meets the requirements of test results for TxDOT DMS-6100;
- K. Reinforcing steel shall conform to Specification 31 50 10.
- L. Contractors formwork plan for placing and consolidating concrete around wall penetrations and at locations designated as having congested reinforcing steel.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Concrete. Provide concrete conforming to Specification 31 40 00, "Hydraulic Cement Concrete." For each type of structure or unit, provide the class of concrete shown on the plans or in pertinent governing specifications.
- B. Grout or Mortar. Provide grout or mortar conforming to Specification 31 40 00, Part 2.01 F, "Mortar and Grout."
- C. Latex. Provide an acrylic-polymer latex admixture (acrylic resin emulsion per DMS-4640, "Chemical Admixtures for Concrete") suitable for producing polymer-modified concrete or mortar. Do not allow latex to freeze.
- D. Reinforcing Steel. Provide reinforcing steel conforming to Specification 31 50 10, "Reinforcing Steel."
- E. Expansion Joint Material. Provide materials that conform to the requirements of DMS-6310, "Joint Sealants and Fillers":
 - Provide preformed fiber expansion joint material that conforms to the dimensions shown on the plans. Provide preformed bituminous fiber material unless otherwise specified.
 - Provide a Class 4, 5, or 7 low-modulus silicone sealant unless otherwise directed.
 - Provide asphalt board that conforms to dimensions shown on the plans.
 - Provide re-bonded neoprene filler that conforms to the dimensions shown on the plans.
- F. Waterstop. Provide rubber or polyvinyl chloride (PVC) waterstops that conform to DMS-6160, "Waterstops, Nylon Reinforced Neoprene Sheet, and Elastomeric Pads," unless otherwise shown on the plans.
- G. Evaporation Retardants. Provide evaporation retardants that conform to the requirements of DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."
- H. Curing Materials. Provide membrane curing compounds that conform to the requirements of DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."
 - Provide cotton mats that consist of a filling material of cotton "bat" or "bats" (at least 12 oz. per square yard) completely covered with unsized cloth (at least 6 oz. per square yard) stitched longitudinally with continuous parallel rows of stitching spaced at less than 4 in., or tuft both longitudinally and transversely at intervals less than 3 in. Provide cotton mats that are free from tears and in good general condition. Provide a flap at least 6 in. wide consisting of 2 thicknesses of the covering and extending along 1 side of the mat.
 - Provide polyethylene sheeting that is at least 4 mils thick and free from visible defects. Provide only clear or opaque white sheeting when the ambient temperature during curing exceeds 60°F or when applicable to control temperature during mass pours.
 - Provide burlap-polyethylene mats made from burlap impregnated on 1 side with a film of opaque white pigmented polyethylene, free from visible defects. Provide laminated mats that have at least 1 layer of an impervious material such as polyethylene, vinyl plastic, or other acceptable material (either as a solid sheet or impregnated into another fabric) and are free of visible defects.
- I. Epoxy. Unless otherwise specified, provide epoxy materials that conform to DMS-6100, "Epoxy and Adhesives."

2.02 EQUIPMENT

- A. Fogging Equipment. Use fogging equipment that can apply water in a fine mist, not a spray. Produce the fog using equipment that pumps water or water and air under high pressure through a suitable atomizing nozzle. Use hand-held mechanical equipment portable enough to use in the direction of any prevailing wind and adaptable for intermittent use to prevent excessive wetting of the concrete.
- B. Transporting and Placing Equipment. Use appropriate transporting and placing equipment such as buckets, chutes, buggies, belt conveyors, pumps, or other equipment as necessary. Do not transport or convey concrete through equipment made of aluminum. Use carts with pneumatic tires for carting or wheeling concrete over newly placed slabs.
- C. Vibrators. Use immersion-type vibrators for consolidation of concrete. Provide at least 1 standby vibrator for emergency use.
- D. Temperature Recording Equipment. For mass concrete operations or as otherwise specified, use strip chart temperature recording devices, recording maturity meters in accordance with Tex-426-A, or other approved devices that are accurate to within $\pm 2^{\circ}\text{F}$ within the range of 32 to 212°F.
- E. Artificial Heating Equipment. Use artificial heating equipment as necessary for maintaining the concrete temperatures as specified in this specification, "Placing Concrete in Cold Weather."
- F. Sawing Equipment. Use sawing equipment capable of cutting grooves that are 1/8 to 3/16 in. deep and nominally 1/8 in. wide. Groove spacing may range from 5/8 to 1 in. Use sawing equipment capable of cutting grooves in hardened concrete to within 18 in. of the curb.
- G. Spraying Equipment. Use mechanically powered pressure sprayers, either air or airless, with appropriate atomizing nozzles for the application of membrane curing. Ensure that the spray from each nozzle overlaps the spray from adjacent nozzles by approximately 50%.

PART 3 – EXECUTION

3.01 CONSTRUCTION

Before starting work, obtain approval for proposed construction methods. Approval of construction methods and equipment does not relieve the Contractor's responsibility for safety or correctness of methods, adequacy of equipment, or completion of work in full accordance with the Contract.

- A. Unless otherwise shown on the plans, it is the Contractor's option to perform testing on structural concrete (structural classes of concrete are identified in Table 5 of Specification 31 40 00 "Hydraulic Cement Concrete" to determine the in-situ strength to address the schedule restrictions below per "Schedule Restrictions." The Engineer may require the Contractor to perform this testing for concrete placed in cold weather. For Contractor-performed testing, make enough test specimens to ensure that strength requirements are met for the operations listed in Section 3.01 C. Make at least 1 set of test specimens for each element cast each day. Cure these specimens under the same conditions as the portion of the structure involved for all stages of construction. Ensure safe handling, curing, and storage of all test specimens. Provide testing personnel, and sample and test the hardened concrete in accordance with approved methods. The maturity method, Tex-426-A, may be used for in-situ strength

determination for schedule restrictions if approved. Coring will not be allowed for in-situ strength determination for schedule restrictions. Provide the Engineer the opportunity to witness all testing operations. Report all test results to the Engineer.

- B. If the Contractor does not wish to perform schedule restriction testing, 7-day lab-cured tests will be used for schedule restriction determinations. The Engineer may require additional time for strength gain to account for field curing conditions such as cold weather.
- C. Schedule Restrictions. Unless otherwise shown on the plans, construct and open completed structures to traffic with the following limitations:
 - 1. Setting Forms. Place concrete only after the forms and reinforcing steel have been inspected by the Engineer.
 - 2. Placement of Equipment and Machinery. Do not place erection equipment or machinery on the structure until the concrete has attained the design strength specified in Table 5 of Specification 31 40 00 unless otherwise approved.
 - 3. Carting of Concrete. Once the concrete has attained a compressive strength of 3,000 psi, it may be carted, wheeled, or pumped over completed slabs. Maintain curing during these operations.
 - 4. Opening to Traffic. Pavement may be opened to the traveling public when the design strength has been attained for all structural elements subject to impact from traffic, when curing has been completed for all slabs, and when the concrete surface treatment has been applied in accordance with Specification 31 40 40, "Concrete Surface Treatment." Other noncritical structural and nonstructural concrete may be opened for service upon the completion of curing unless otherwise specified or directed.
 - 5. Backfilling. Backfill in accordance with Specification 31 10 30, "Backfill."

D. Forms.

1. General.

Except where otherwise specified or permitted, provide forms of either timber or metal. Design forms for the pressure exerted by a liquid weighing 150 pcf. Take the rate of concrete placement into consideration in determining the depth of the equivalent liquid. Include a liveload allowance of 50 psf of horizontal surface for job-fabricated forms. Do not exceed 125% of the allowable stresses for the design of structures.

For commercially produced structural units used for forms, do not exceed the manufacturer's maximum allowable working loads for moment and shear or end reaction. Include a liveload allowance of 35 psf of horizontal form surface in determining the maximum allowable working load for commercially produced structural units.

Provide forming systems that are practically mortar-tight, rigidly braced, and strong enough to prevent bulging between supports, and maintain them to the proper line and grade during concrete placement. Maintain forms in a manner that prevents warping and shrinkage. Do not allow offsets at form joints to exceed 1/16 in.

For forms to be left in place, use only material that is inert, nonbiodegradable, and nonabsorptive.

Construct all forms to permit their removal without marring or damaging the concrete. Clean all forms and footing areas of any extraneous matter before placing concrete. Provide openings in forms if needed for the removal of laitance or foreign matter.

Treat the facing of all forms with bond-breaking coating of composition that will not discolor or injuriously affect the concrete surface. Take care to prevent coating of the reinforcing steel.

Complete all preparatory work before requesting permission to place concrete.

If the forms show signs of bulging or sagging at any stage of the placement, cease placement and remove the portion of the concrete causing this condition immediately if necessary. Reset the forms and securely brace them against further movement before continuing the placement.

2. Timber Forms.

Provide properly seasoned good-quality lumber that is free from imperfections that would affect its strength or impair the finished surface of the concrete. Provide timber or lumber that meets or exceeds the requirements for species and grade in the submitted formwork plans.

Maintain forms or form lumber that will be reused so that it stays clean and in good condition. Do not use any lumber that is split, warped, bulged, or marred or that has defects that will produce inferior work, and promptly remove such lumber from the work.

Provide form lining for all formed surfaces except:

- the inside of culvert barrels, inlets, manholes, and box girders;
- the bottom of bridge slabs between beams or girders;
- surfaces that are subsequently covered by backfill material or are completely enclosed; and
- any surface formed by a single finished board or by plywood.

Provide form lining of an approved type such as masonite or plywood. Do not provide thin membrane sheeting such as polyethylene sheets for form lining.

Use plywood at least 3/4 in. thick. Place the grain of the face plies on plywood forms parallel to the span between the supporting studs or joists unless otherwise indicated on the submitted form drawings.

Use plywood for forming surfaces that remain exposed that meets the requirements for B-B Plyform Class I or Class II Exterior of the U.S. Department of Commerce Voluntary Product Standard PS 1.

Space studs and joists so that the facing form material remains in true alignment under the imposed loads. Space wales closely enough to hold forms securely to the designated lines, scabbed at least 4 ft. on each side of joints to provide continuity. Place a row of wales near the bottom of each placement.

Place facing material with parallel and square joints, securely fastened to supporting studs.

For surfaces exposed to view and receiving only an ordinary surface finish as defined in Section 3.01 L, "Ordinary Surface Finish," place forms with the form panels symmetrical (long dimensions set in the same direction). Make horizontal joints continuous.

Make molding for chamfer strips or other uses of materials of a grade that will not split when nailed and that can be maintained to a true line without warping. Dress wood molding on all faces. Unless otherwise shown on the plans, fill forms at all sharp corners and edges with triangular chamfer strips measuring 3/4 in. on the sides.

To hold forms in place, use metal form ties of an approved type or a satisfactory substitute of a type that permits ease of removal of the metal. Cut back wire ties at least 1/2 in. from the face of the concrete.

Use devices to hold metal ties in place that are able to develop the strength of the tie and adjust to allow for proper alignment.

Entirely remove metal and wooden spreaders that separate the forms as the concrete is being placed.

Provide adequate clean-out openings for narrow walls and other locations where access to the bottom of the forms is not readily attainable.

3. Metal Forms.

Requirements for timber forms regarding design, mortar-tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and wetting also apply to metal forms except that metal forms do not require lining unless specifically noted on the plans.

Use form metal thick enough to maintain the true shape without warping or bulging. Countersink all bolt and rivet heads on the facing sides. Design clamps, pins, or other connecting devices to hold the forms rigidly together and to allow removal without damage to the concrete. Use metal forms that present a smooth surface and that line up properly. Keep metal free from rust, grease, and other foreign materials.

E. Drains.

Install and construct weep holes and roadway drains as shown on the plans.

F. Placing Reinforcement.

Place reinforcement as provided in Specification 31 50 10, "Reinforcing Steel."

G. Placing Concrete.

Give the Engineer sufficient advance notice before placing concrete in any unit of the structure to permit the inspection of forms, reinforcing steel placement, and other preparations.

Follow the sequence of placing concrete shown on the plans or specified.

Do not place concrete when impending weather conditions would impair the quality of the finished work. If conditions of wind, humidity, and temperature are such that concrete cannot be placed without the potential for shrinkage cracking, place concrete in early morning or at night or adjust the placement schedule for more favorable weather. Consult the evaporation rate nomograph in the Portland Cement Association's Design and Control of Concrete Mixtures for shrinkage cracking potential. When mixing, placing, and finishing concrete in non-daylight hours, adequately illuminate the entire placement site as approved.

If changes in weather conditions require protective measures after work starts, furnish adequate shelter to protect the concrete against damage from rainfall or from freezing temperatures as outlined in this Item. Continue operations during rainfall only if approved. Use protective coverings for the material stockpiles. Cover aggregate stockpiles only to the extent necessary to control the moisture conditions in the aggregates.

Allow at least 1 curing day after the concrete has achieved initial set before placing strain on projecting reinforcement to prevent damage to the concrete.

1. Placing Temperature.

Place concrete according to the following temperature limits for the classes of concrete defined in Table 5 of Specification 31 40 00:

- Place Class C or H concrete only when its temperature at time of placement is between 50 and 95°F. Increase the minimum placement temperature to 60°F if ground-granulated blast furnace (GGBF) slag is used in the concrete.
- Place Class A, B, and D concrete only when its temperature at the time of placement is greater than 50°F.

2. Transporting Time.

Place concrete delivered in agitating trucks within 60 min. after batching. Place concrete delivered in non-agitating equipment within 45 min. after batching. Revise the concrete mix design as necessary for hot weather or other conditions that contribute to quick setting of the concrete. Submit for approval a plan to demonstrate that these time limitations can be extended while ensuring the concrete can be properly placed, consolidated, and finished without the use of additional water.

3. Workability of Concrete.

Place concrete with a slump as specified Specification 31 40 00 Section 3.04. Concrete that exceeds the maximum slump will be rejected. Water may be added to the concrete before discharging any concrete from the truck to adjust for low slump provided that the maximum mix design water– cement ratio is not exceeded. After introduction of any additional water or chemical admixtures, mix concrete in

accordance with Specification 31 40 00 Section 3.06, "Mixing and Mixing Equipment."
Do not add water or chemical admixtures after any concrete has been discharged.

4. Transporting Concrete.

Use a method and equipment capable of maintaining the rate of placement shown on the plans or required by this Item to transport concrete to the forms. Transport concrete by buckets, chutes, buggies, belt conveyors, pumps, or other methods.

Protect concrete transported by conveyors from sun and wind to prevent loss of slump and workability. Shade or wrap with wet burlap pipes through which concrete is pumped as necessary to prevent loss of slump and workability.

Arrange and use chutes, troughs, conveyors, or pipes so that the concrete ingredients will not be separated. When necessary to prevent segregation, terminate such equipment in vertical downspouts. Extend open troughs and chutes, if necessary, down inside the forms or through holes left in the forms.

Keep all transporting equipment clean and free from hardened concrete coatings. Discharge water used for cleaning clear of the concrete.

5. Preparation of Surfaces.

Thoroughly wet all forms, prestressed concrete panels, T-beams, and concrete box beams on which concrete is to be placed before placing concrete on them. Remove any remaining puddles of excess water before placing concrete. Provide surfaces that are in a moist, saturated surface-dry condition when concrete is placed on them.

Ensure that the subgrade or foundation is moist before placing concrete for bridge approach slabs or other concrete placed on grade. Lightly sprinkle the subgrade if dry.

6. Expansion Joints.

Construct joints and devices to provide for expansion and contraction in accordance with plan details and the requirements of this Section.

Prevent bridging of concrete or mortar around expansion joint material in bearings and expansion joints.

Use forms adaptable to loosening or early removal in construction of all open joints and joints to be filled with expansion joint material. To avoid expansion or contraction damage to the adjacent concrete, loosen these forms as soon as possible after final concrete set to permit free movement of the span without requiring full form removal.

When the plans show a Type A joint, provide preformed fiber joint material in the vertical joints of the roadway slab, curb, median, or sidewalk, and fill the top 1 in. with the specified joint sealing material unless noted otherwise. Install the sealer in accordance with Specification 31 40 30, "Cleaning and Sealing Joints and Cracks" and the manufacturer's recommendations.

Use light wire or nails to anchor any preformed fiber joint material to the concrete on 1 side of the joint.

Ensure that finished joints conform to the plan details with the concrete sections completely separated by the specified opening or joint material.

Remove all concrete within the joint opening soon after form removal and again where necessary after surface finishing to ensure full effectiveness of the expansion joint.

7. Construction Joints.

A construction joint is the joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set. Monolithic placement means that the manner and sequence of concrete placing does not create a construction joint.

Make construction joints of the type and at the locations shown on the plans. Additional joints in other members are not permitted without approval from Engineer. Place authorized additional joints using details equivalent to those shown on the plans for joints in similar locations.

Unless otherwise required, make construction joints square and normal to the forms. Use bulkheads in the forms for all vertical joints.

Thoroughly roughen the top surface of a concrete placement terminating at a horizontal construction joint as soon as practical after initial set is attained.

Thoroughly clean the hardened concrete surface of all loose material, laitance, dirt, and foreign matter, and saturate it with water. Remove all free water and moisten the surface before concrete or bonding grout is placed against it.

Draw forms tight against the existing concrete to avoid mortar loss and offsets at joints.

Coat the joint surface with bonding mortar, grout, epoxy, or other material as indicated in the plans or other Items. Provide Type V epoxy per DMS-6100, "Epoxy and Adhesives," for bonding fresh concrete to hardened concrete.

Place the bonding epoxy on a clean, dry surface, and place the fresh concrete while the epoxy is still tacky. Place bonding mortar or grout on a surface that is saturated surface-dry, and place the concrete before the bonding mortar or grout dries. Place other bonding agents in accordance with the manufacturer's recommendations.

8. Handling and Placing.

Minimize segregation of the concrete and displacement of the reinforcement when handling and placing concrete. Produce a uniform dense compact mass.

Do not allow concrete to free-fall more than 5 ft. except in the case of drilled shafts, thin walls such as in culverts, or as allowed by other Items. Remove any hardened concrete splatter ahead of the plastic concrete.

Fill each part of the forms by depositing concrete as near its final position as possible. Do not deposit large quantities at 1 point and run or work the concrete along the forms.

Deposit concrete in the forms in layers of suitable depth but not more than 36 in. deep unless otherwise permitted.

Avoid cold joints in a monolithic placement. Sequence successive layers or adjacent portions of concrete so that they can be vibrated into a homogeneous mass with the previously placed concrete before it sets. When re-vibration of the concrete is shown on the plans, allow at most 1 hr. to elapse between adjacent or successive placements of concrete except as otherwise allowed by an approved placing procedure. This time limit may be extended by 1/2 hr. if the concrete contains at least a normal dosage of retarding admixture.

Use a TxDoT approved retarding agent to control stress cracks and cold joints in placements where differential settlement and setting time may induce cracking.

9. Consolidation.

Carefully consolidate concrete and flush mortar to the form surfaces with immersion type vibrators. Do not use vibrators that operate by attachment to forms or reinforcement except where approved on steel forms.

Vibrate the concrete immediately after deposit. Systematically space points of vibration to ensure complete consolidation and thorough working of the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Insert the vibrator vertically where possible except for slabs where it may be inserted in a sloping or horizontal position. Vibrate the entire depth of each lift, allowing the vibrator to penetrate several inches into the preceding lift. Do not use the vibrator to move the concrete to other locations in the forms. Do not drag the vibrator through the concrete. Thoroughly consolidate concrete along construction joints by operating the vibrator along and close to but not against the joint surface. Continue the vibration until the concrete surrounding reinforcements and fixtures is completely consolidated. Hand-spade or rod the concrete if necessary to ensure flushing of mortar to the surface of all forms.

10. Installation of Dowels and Anchor Bolts.

Install dowels and anchor bolts by casting them in-place or by grouting with grout, epoxy, or epoxy mortar unless noted otherwise. Form or drill holes for grouting.

Drill holes for anchor bolts to accommodate the bolt embedment required by the plans. Make holes for dowels at least 12 in. deep unless otherwise shown on the plans. When using grout or epoxy mortar, make the diameter of the hole at least twice the dowel or bolt diameter, but the hole need not exceed the dowel or bolt diameter plus 1-1/2 in. When using epoxy, make the hole diameter 1/16 to 1/4 in. greater than the dowel or bolt diameter.

Thoroughly clean holes of all loose material, oil, grease, or other bond-breaking substance, and blow them clean with filtered compressed air. Ensure that holes are in a surface dry condition when epoxy type material is used and in a surface moist condition when hydraulic cement grout is used. Develop and demonstrate for

approval a procedure for cleaning and preparing the holes for installation of the dowels and anchor bolts. Completely fill the void between the hole and dowel or bolt with grouting material. Follow exactly the requirements for cleaning outlined in the product specifications for prepackaged systems.

For cast-in-place or grouted systems, provide hydraulic cement grout in accordance with Specification 31 40 00 2.01 F, "Mortar and Grout," epoxy, epoxy mortar, or other prepackaged grouts as approved. Provide a Type III epoxy per DMS-6100, "Epoxy and Adhesives," when neat epoxy is used for anchor bolts or dowels. Provide Type VIII epoxy per DMS-6100 when an epoxy grout is used. Provide grout, epoxy, or epoxy mortar as the binding agent unless otherwise indicated on the plans.

Provide other anchor systems as required in the plans.

11. Placing Concrete in Cold Weather.

Protect concrete placed under weather conditions where weather may adversely affect results. Permission given by the Engineer for placing during cold weather does not relieve the Contractor of responsibility for producing concrete equal in quality to that placed under normal conditions. If concrete placed under poor conditions is unsatisfactory, remove and replace it as directed at Contractor's expense.

Do not place concrete in contact with any material coated with frost or having a temperature of 32°F or lower. Do not place concrete when the ambient temperature in the shade is below 40°F and falling unless approved. Concrete may be placed when the ambient temperature in the shade is 35°F and rising or above 40°F.

Provide and install recording thermometers, maturity meters, or other suitable temperature measuring devices to verify that all concrete is effectively protected as follows:

- Maintain the temperature of the top surface of bridge slabs and top slabs of direct-traffic culverts at 50°F or above for 72 hr. from the time of placement and above 40°F for an additional 72 hr.
- Maintain the temperature at all surfaces of concrete in bents, piers, culvert walls, retaining walls, parapets, wingwalls, bottoms of bridge slab or culvert top slabs, and other similar formed concrete at 40°F or above for 72 hr. from the time of placement.
- Maintain the temperature of all other concrete, including the bottom slabs (footings) of culverts, placed on or in the ground above 32°F for 72 hr. from the time of placement.

Use additional covering, insulated forms, or other means and, if necessary, supplement the covering with artificial heating. Avoid applying heat directly to concrete surfaces. Cure as specified in Section 3.01 I of this Specification, "Curing Concrete," during this period until all requirements for curing have been satisfied.

When impending weather conditions indicate the possible need for temperature protection, have on hand all necessary heating and covering material, ready for use, before permission is granted to begin placement.

12. Placing Concrete in Hot Weather.

When the temperature of the air is above 85°F (29°C), a TxDOT approved retarding agent will be required in all exposed concrete, concrete used in superstructures, top slabs of direct traffic culverts and all cased drilled shafts regardless of temperatures. Concrete mix temperatures shall not exceed 90°F (32°C) except for mixes that include high range water reducers where a maximum mix temperature of 100°F (38°C) will be allowed.

If the concrete mix temperature is expected to exceed 90°F (32°C) (or 100°F (38°C) in mixes with high range water reducers) ice may be utilized to lower the concrete mix temperature. Ice may be added to the concrete mix as a portion by weight of the mix water. However the addition of ice shall not exceed 50% of the total mix water weight.

When weather conditions are such that the addition of ice at 50% of the mix water is not sufficient to reduce the concrete mix temperature to an acceptable temperature, concrete work shall not be allowed.

H. Treatment and Finishing of Horizontal Surfaces.

Strike off to grade and finish all unformed upper surfaces. Do not use mortar topping for surfaces constructed under this Section. After the concrete has been struck off, float the surface with a suitable float. Give the concrete a smooth trowel finish.

I. Curing Concrete.

Obtain approval of the proposed curing methods, equipment, and materials before placing concrete. The Engineer may require the same curing methods for like portions of a single structure. Inadequate curing or facilities may delay all concrete placement on the job until remedial action is taken.

A curing day is a calendar day when the temperature, taken in the shade away from artificial heat, is above 50°F for at least 19 hr. or, on colder days if the temperature of all surfaces of the concrete is maintained above 40°F, for the entire 24 hr. The required curing period begins when all concrete has attained its initial set. Tex-440-A may be used to determine when the concrete has attained its initial set.

Cure all concrete for 4 consecutive days.

For the top surface of any concrete unit upon which concrete is to be placed and bonded at a later interval (stub walls, risers, etc.) and other superstructure concrete (curbs, wingwalls, parapet walls, etc.), use only water curing in accordance with this Section.

Cure all other concrete as specified in the pertinent Items. Use the following methods for curing concrete, subject to the requirements of this Specification.

1. Form Curing. When forms are left in intimate contact with the concrete, other curing methods are not required except for exposed surfaces and for cold weather protection. If forms are removed before the 4-day required curing period, use another approved curing method.

2. Water Curing. Keep all exposed surfaces of the concrete wet continuously for the required curing time. Use water curing that meets the requirements for concrete mixing water in Specification 31 40 00. Do not use seawater or water that stains or leaves an unsightly residue.
 - a. Wet Mats. Keep the concrete continuously wet by maintaining wet cotton mats in direct contact with the concrete for the required curing time. If needed, place damp burlap blankets made from 9-oz. stock on the damp concrete surface for temporary protection before applying cotton mats. Then place the dry mats and wet them immediately after they are placed. Weight the mats adequately to provide continuous contact with all concrete. Cover surfaces that cannot be cured by direct contact with mats, forming an enclosure well anchored to the forms or ground so that outside air cannot enter the enclosure. Provide sufficient moisture inside the enclosure to keep all surfaces of the concrete wet.
 - b. Water Spray. Overlap sprays or sprinklers to keep all unformed surfaces continuously wet.
 - c. Ponding. Cover the surfaces with at least 2 in. of clean granular material, kept wet at all times, or at least 1 in. deep water. Use a dam to retain the water or saturated granular material.
3. Membrane Curing. Unless otherwise shown on the plans, choose either Type 1-D or Type 2 membrane-curing compound when membrane curing is permitted. Type 1-D (Resin Base Only) is required for interim curing bridge slabs and top slabs of direct-traffic culverts and all other surfaces that require a higher grade of surface finish. For substructure concrete provide only 1 type of curing compound on any 1 structure.

Apply membrane curing just after free moisture has disappeared at a rate of approximately 180 sq. ft. per gallon. Do not spray curing compound on projecting reinforcing steel or concrete that will later form a construction joint. Do not apply membrane curing to dry surfaces. Dampen formed surfaces and surfaces that have been given a first rub so that they are moist at the time of application of the membrane.

When membrane is used for complete curing, leave the film unbroken for the minimum curing period specified. Correct damaged membrane immediately by reapplication of membrane. Polyethylene sheeting, burlap-polyethylene mats, or laminated mats in close contact with the concrete surfaces are equivalent to membrane curing.

J. Removal of Forms.

Remove forms for inside curb faces whenever removal can be done without damage to the curb. Remove forms for other structural components as necessary.

Forms or parts of forms may be removed only if constructed to permit removal without disturbing forms required to be left in place for a longer period on other portions of the structure.

Remove all metal appliances used inside forms for alignment to a depth of at least 1/2 in. from the concrete surface. Make the appliances so that metal may be removed without undue chipping or spalling of the concrete, and so that it leaves a smooth opening in the concrete surface when removed. Do not burn off rods, bolts, or ties.

Remove all forms unless otherwise directed.

- K. Defective Work. Repair defective work as soon as possible. Remove and replace at the expense of the Contractor any defect that cannot be repaired to the satisfaction of the Engineer.
- L. Ordinary Surface Finish. Apply an ordinary surface finish to all concrete surfaces as follows:
- Chip away all loose or broken material to sound concrete where porous, spalled, or honeycombed areas are visible after form removal.
 - Repair spalls by saw-cutting and chipping at least 1/2 in. deep, perpendicular to the surface to eliminate feather edges. Repair shallow cavities using a latex adhesive grout, cement mortar, or epoxy mortar as approved. Repair large areas using concrete as directed or approved.
 - Clean and fill holes or spalls caused by the removal of form ties, etc., with latex grout, cement grout, or epoxy grout as approved. Fill only the holes. Do not blend the patch with the surrounding concrete.
 - Remove all fins, runs, drips, or mortar from surfaces that will be exposed. Smooth all form marks and chamfer edges by grinding or dry-rubbing.
 - Ensure that all repairs are dense, well bonded, and properly cured. Finish exposed large repairs to blend with the surrounding concrete where a higher class of finish is not specified.

END OF SECTION 31 40 05

SECTION 31 40 12 - SIDEWALKS

PART 1 - GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 DESCRIPTION.

- A. Construct Portland cement concrete sidewalks as herein specified, on an approved subgrade and in conformance with the lines, grades and details indicated on the Drawings or as established by the Engineer or designated representative.

1.03 REFERENCE DOCUMENTS

- A. Texas Department of Transportation Standard Specification Item 531.
- B. City of Austin Standard Specification 411S for exposed aggregate surface finish.
- C. City of Austin Standard Specification 432S.

1.04 SUBMITTALS

- A. Portland cement concrete mix design,
- B. Type of Installation (i.e. Type I, Type II, etc.) and construction details (i.e. cushion layer, base, reinforcing steel, joints, curing membrane),

PART 2 - PRODUCTS

2.01 Materials.

Furnish materials conforming to the following:

- A. Specification 31 40 00 "Hydraulic Cement Concrete"
- B. Specification 31 40 05 "Concrete Structures"
- C. Specification 31 50 10 "Reinforcing Steel."

Use Class A concrete or other concrete as specified. Use Grade 8 course aggregate for extruded Class A concrete. Use other grades if approved by the Engineer.

PART 3 - EXECUTION

3.01 CONSTRUCTION

- A. The subgrade shall be excavated and prepared, shaped to the lines, grades and cross section as indicated on the Drawings or as directed by the Engineer or designated representative and thoroughly compacted.
- B. A granular cushion of a minimum thickness of 2 inches (50 mm) but maximum thickness of 5 inches (125 mm), composed of crusher screenings, gravel and sand, crushed rock or coarse sand, shall be spread, wetted thoroughly, tamped and leveled. The granular cushion shall be moist at the time the Portland cement concrete is placed.
- C. If the subgrade is undercut by more than 4 inches (100 mm) or the elevation of the natural ground is more than 4 inches (100 mm) below "top of subgrade", then a necessary backfill/embankment layer of an approved material shall be placed and compacted with a mechanical tamper. Hand tamping will not be permitted.
- D. Sidewalk forms shall be constructed of metal or well-seasoned wood not less than 2 inches (50 mm) in thickness, with a section satisfactory to the Engineer or designated representative. The forms shall be clean, straight, and free from warp with a depth equal to the thickness of the finished work. All forms shall be securely staked to line and grade and maintained in a true position during the deposition of Portland cement concrete. Before p.c. concrete is placed, the forms shall be thoroughly oiled with a light form oil.
- E. Expansion joint material 3/4 inch (19 mm) thick, shall be provided where the new construction abuts an existing structure, sidewalk or driveway. Similar expansion material shall be placed around all obstructions protruding through the sidewalk. The expansion joint material shall be placed vertically and shall extend the full depth of the p.c. concrete. Maximum spacing of expansion joints shall be 40 feet (12 meters) as indicated on the Drawings or as directed by the Engineer or designated representative. Weakened plane joints shall be spaced at 5 feet (1.5 meters) on center. Normal dimensions of the weakened plane joints shall be 1/4 inch wide and 3/4 inch deep (6 mm wide and 19 mm deep). All joints shall be constructed perpendicular (90 degrees) to the centerline of walk and shall match any previously placed concrete joints. For sidewalks with widths exceeding 6 feet (1.83 meters) longitudinal weakened-plane tooled joints shall be provided as indicated on the Drawings or as directed by the Engineer or designated representative.
- F. Reinforcement for sidewalks shall consist one layer #3 (10M) reinforcing bars, placed no more than 18 inches (450 mm) on center both directions. Welded wire fabric is not permitted. All reinforcement shall be accurately placed at slab mid-depth, equidistant from the top and bottom of the p.c. concrete and held firmly in place by means of bar supports of adequate strength and number that will prevent displacement and keep the steel at its proper position during the placement of the p.c. concrete. In no instance shall the steel be placed directly on the subgrade or sand cushion layer.
- G. Prior to placement of the concrete, the reinforcement installation shall be inspected by the Engineer or designated representative to insure conformance with the drawings, specifications and this item. In addition care shall be exercised to keep all steel in its proper position during placement of the p.c. concrete. If during placement of the

concrete, the reinforcement is observed to loose bar support, float upward or move in any direction, the placement shall be stopped until corrective action is taken.

- H. Splices in the #3 (10M) bars shall have a minimum lap of 12 inches (300 mm).
- I. Where driveways cross sidewalks, additional reinforcing shall be placed in the sidewalk as indicated on the Drawings.
- J. Portland cement concrete shall be placed in the forms and spaded, tamped and thoroughly consolidated until it covers the entire surface with a monolithic finish. The top surface shall be floated and troweled to a uniform smooth surface; then finished with a broom or wood float to a gritty texture unless indicated otherwise on the Drawings or as directed by the Engineer or designated representative. The outer edges and joints shall be rounded with approved tools to a 1/4-inch (6 mm) radius. Care will be exercised to prevent loss of dummy joints or rounded edges when applying the brush finish.
- K. Portland cement concrete sidewalk ramps shall be formed to produce a finished surface with detectable warnings in accordance with the requirements of the American Disabilities Act and Texas Accessibility Standards (TAS), including Sections 4.29.2 and A4.29.2.
- L. Detectable warning for the ramps shall consist of raised truncated domes with a diameter of nominal 0.9 inch (23 mm), a height of nominal 0.2 inch (5 mm) and center-to-center spacing of nominal 2.35 inches (60 mm) and shall contrast visually with adjoining surfaces, either light on dark or dark-on-light. The material used to provide contrast shall be an integral part of the walking surface.
- M. When indicated on the Drawings or as directed by the Engineer or designated representative, the construction of the sidewalk ramp shall include the installation of interlocking concrete paving units. At the proper time after finishing, the surface shall be protected by a membrane, compound curing agent or by wetted cotton or burlap mats, conforming to Specification 31 40 15, "Membrane Curing". The sides of the p.c. concrete shall be cured in the forms. If the forms are removed during the curing process, the curing shall be continued by the placement of fill against the exposed concrete edges or by other procedures conforming to Specification 31 40 00, "Concrete Structures". The top 4 inches (100 mm) of fill shall be clean topsoil conforming to Specification 32 29 11, "Topsoil".
- N. Existing sidewalk that is scheduled for removal and replacement shall be removed and the underlying material shaped to the lines, grades and cross section as indicated in the drawings or as directed by the Engineer or designated representative. The removal and/or relocation of obstructions, including but not limited to signs, trash cans and benches on concrete pads, abandoned manholes, sprinkler control valves and landscaping, shall be performed, as indicated on the drawings, in a manner acceptable to the Engineer or designated representative. Removal and/or relocation of obstructions will be considered incidental work to this item and will not be paid for directly.
- O. All necessary excavation, filling and grading of the slopes adjacent to the completed concrete sidewalks will be considered incidental work pertaining to this item and will not

be paid for directly. The adjacent excavation and grading of the slopes shall be done in a manner acceptable to the Engineer or designated representative.

- P. Provide finished work with a well-compacted mass, a surface free from voids and honeycomb, and the required true-to-line shape and grade. Cure for at least 72 hr. in accordance with Specification 31 40 00, "Concrete Structures."
1. Conventionally Formed Concrete. Provide sidewalk sections separated by premold or board joint of the thickness shown on the plans in lengths greater than 8 ft. but less than 40 ft., unless otherwise directed. Terminate workday production at an expansion joint.
 2. Broom Finish. Handfinishing is allowed for any method of construction. Finish exposed surfaces to a uniform transverse broom finish surface. Brush all exposed surfaces to a smooth and uniform surface. Ensure that abrupt changes in sidewalk elevation do not exceed 1/4 inch, sidewalk cross slope does not exceed 2%, curb ramp grade does not exceed 8.3%. Where a sidewalk crosses a concrete driveway, ensure that the sidewalk depth and reinforcement are not less than the driveway crosssectional details shown on the plans..
 3. Exposed Aggregate Finish. When exposed aggregate surfaces are required for sidewalks, driveways and/or medians, the coarse aggregate shall consist of particles with at least 40 percent crushed faces. Uncrushed gravel, polished aggregates and clear resilient coatings are not acceptable. Grade 5 coarse aggregates shall be used for exposed aggregate finishes for sidewalks, driveways and/or medians.

END OF SECTION 31 40 12

SECTION 31 50 10 – REINFORCING STEEL

PART 1 - GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 DESCRIPTION

- A. Furnish and place reinforcing steel of the sizes and details shown on the plans

1.03 REFERENCE STANDARDS

- A. Texas Department of Transportation Standard Specification Item 440.
- B. TxDOT Departmental Material Specifications are referenced in this Specification as DMS-xxxx where xxxx is the associated item number. DMS sheets can be obtained from <http://www.txdot.gov/inside-tdot/division/construction/dms.html>

1.04 SUBMITTALS

- A. Evidence that the steel reinforcement producer is included on the list of approved producing mills maintained by the Construction Division of the State of Texas Department of Transportation.
- B. Listing of the size, grade, type and quantity of reinforcing steel proposed for the project.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Approved Mills.
 - 1. Reinforcing steel must be sourced from a producing mill included on the list of approved producing mills maintained by the Construction Division of the State of Texas Department of Transportation. Reinforcing steel obtained from unapproved sources will not be accepted.
- B. Deformed Bar and Wire Reinforcement.
 - 1. Unless otherwise shown on the plans, reinforcing steel must be Grade 60, and bar reinforcement must be deformed. Reinforcing steel must conform to one of the following:

- ASTM A 615, Grades 40 or 60;
- ASTM A 996, Type A, Grades 40 or 60;
- ASTM A 996, Type R, Grade 60, permitted in concrete pavement only (Furnish ASTM A 996, Type R bars as straight bars only and do not bend them. Bend tests are not required.); or
- ASTM A 706. The provisions of this Item take precedence over ASTM provisions. The nominal size, area, and weight of reinforcing steel bars covered by this Item are shown in Table 1. Designate smooth bars up to No. 4 by size number and above No. 4 by diameter in inches.

Table 1
Size, Area, and Weight of Reinforcing Steel Bars

Bar Size Number (in.)	Bar Size Number (mm)	Diameter (in.)	Area (Sq. in.)	Weight per Ft.
3	10	0.375	0.11	0.376
4	13	0.500	0.20	0.668
5	16	0.625	0.31	1.043
6	19	0.750	0.44	1.502
7	22	0.875	0.60	2.044
8	25	1.000	0.79	2.670
9	29	1.128	1.00	3.400
10	32	1.270	1.27	4.303
11	36	1.410	1.56	5.313
14	43	1.693	2.25	7.650
18	57	2.257	4.00	13.60

Note: Bar size numbers (in.) are based on the number of eighths of an inch included in the nominal diameter of the bar. Bar size numbers (mm) approximate the number of millimeters included in the nominal diameter of the bar.

C. Smooth Bar and Spiral Reinforcement.

1. Smooth bars and dowels for concrete pavement must have a minimum yield strength of 60 ksi and meet ASTM A 615. For smooth bars that are larger than No. 3, provide steel conforming to ASTM A 615 or meet the physical requirements of ASTM A 36.
2. Spiral reinforcement may be smooth or deformed bars or wire of the minimum size or gauge shown on the plans. Bars for spiral reinforcement must comply with ASTM A 615, Grade 40; ASTM A 996, Type A, Grade 40; or ASTM A 675, Grade 80, meeting dimensional requirements of ASTM A 615. Smooth wire must comply with ASTM A 82, and deformed wire must comply with ASTM A 496.

D. Weldable Reinforcing Steel.

1. Reinforcing steel to be welded must comply with ASTM A 706 or have a carbon equivalent (C.E.) of at most 0.55%. A report of chemical analysis showing the

percentages of elements necessary to establish C.E. is required for reinforcing steel that does not meet ASTM A 706 to be structurally welded. These requirements do not pertain to miscellaneous welds on reinforcing steel as defined in Section 448.4.B.1.a, "Miscellaneous Welding Applications."

2. Calculate C.E. using the following formula:

$$C.E. = \%C + \frac{\%Mn}{6} + \frac{\%Cu}{40} + \frac{\%Ni}{20} + \frac{\%Cr}{10} - \frac{\%Mo}{50} - \frac{\%V}{10}$$

E. Epoxy Coating.

1. Epoxy coating will be required as shown on the plans. Before furnishing epoxy-coated reinforcing steel, an epoxy applicator must be pre-approved in accordance with DMS-7330, "Qualification Procedure for Reinforcing Steel Epoxy Coating Applicators." The Construction Division maintains a list of approved applicators.
2. Coat reinforcing steel in accordance with Table 3.

Table 3
Epoxy Coating Requirements for Reinforcing Steel

Material	Specification
Bar	ASTM A 775 or A 934
Wire or fabric	ASTM A 884 Class A or B
Mechanical couplers	As shown on the plans
Hardware	As shown on the plans

3. Use epoxy coating material and coating repair material that complies with DMS-8130, "Epoxy Powder Coating for Reinforcing Steel." Do not patch more than 1/4 in. total length in any foot at the applicator's plant.
4. Epoxy-coated reinforcement will be sampled and tested in accordance with Tex-739-I.
5. Maintain identification of all reinforcing throughout the coating and fabrication and until delivery to the project site.
6. Furnish 1 copy of a written certification that the coated reinforcing steel meets the requirements of this Item and 1 copy of the manufacturer's control tests.

F. Mechanical Couplers.

1. When mechanical splices in reinforcing steel bars are shown on the plans, use the following types of coupler:
 - sleeve-filler,
 - sleeve-threaded,
 - sleeve-swaged, or
 - sleeve-wedge.

2. Furnish only couplers that have been produced by a manufacturer that has been prequalified in accordance with DMS-4510, "Mechanical Couplers." Sleeve-wedge type couplers will not be permitted on coated reinforcing. Couplers for use on individual projects must be sampled and tested in accordance with DMS-4510. Furnish couplers only at locations shown on the plans.

PART 3 - EXECUTION

3.01 CONSTRUCTION

A. Bending.

1. Cold-bend the reinforcement accurately to the shapes and dimensions shown on the plans. Fabricate in the shop if possible. Field-fabricate, if permitted, using a method approved by the Engineer. Replace improperly fabricated, damaged, or broken bars at no additional expense to the Owner. Repair damaged or broken bars embedded in a previous concrete placement using a method approved by the Engineer.
2. Unless otherwise shown on the plans, the inside diameter of bar bends, in terms of the nominal bar diameter (d), must be as shown in Table 4.

Table 4
Minimum Inside Diameter of Bar Bends

Bend	Bar Size Number (in.)	Bar Size Number (mm)	Diameter
Bends of 90° and greater in stirrups, ties, and other secondary bars that enclose another bar in the bend	3, 4, 5	10, 13, 16	4d
	6, 7, 8	19, 22, 25	6d
Bends in main bars and in secondary bars not covered above	3 through 8	10 through 25	6d
	9, 10, 11	29, 32, 36	8d
	14, 18	43, 57	10d

Note: Bar size numbers (in.) are based on the number of eighths of an inch included in the nominal diameter of the bar. Bar size numbers (mm) approximate the number of millimeters included in the nominal diameter of the bar.

3. Where bending No. 14 or No. 18 Grade 60 bars is required, bend-test representative specimens as described for smaller bars in the applicable ASTM specification. Make the required 90° bend around a pin with a diameter of 10 times the nominal diameter of the bar.

B. Tolerances. Fabrication tolerances for bars are shown in Figure 1.

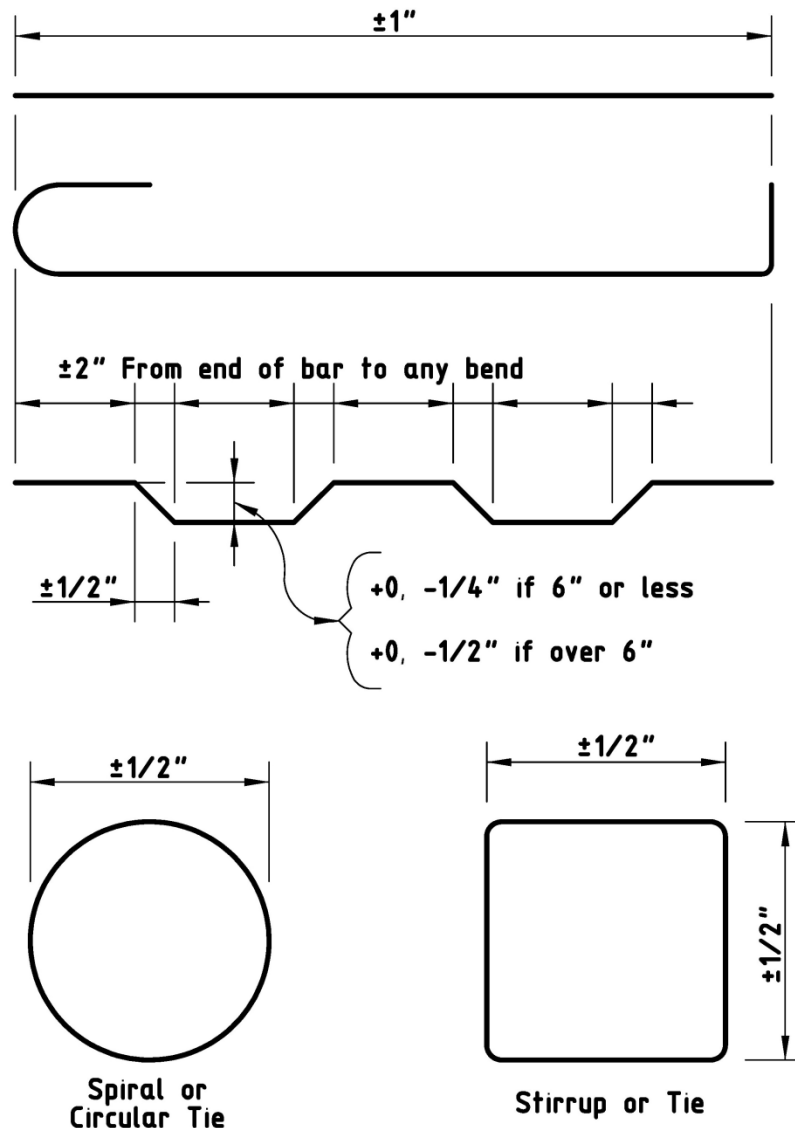


Figure 1
Fabrication tolerances for bars.

C. Storage.

1. Store steel reinforcement above the ground on platforms, skids, or other supports, and protect it from damage and deterioration. Ensure that reinforcement is free from dirt, paint, grease, oil, and other foreign materials when it is placed in the work. Use reinforcement free from defects such as cracks and delaminations. Rust, surface seams, surface irregularities, or mill scale will

not be cause for rejection if the minimum cross-sectional area of a hand wire-brushed specimen meets the requirements for the size of steel specified.

D. Splices.

1. Lap-splice, weld-splice, or mechanically splice bars as shown on the plans. Additional splices not shown on the plans will require approval. Splices not shown on the plans will be permitted in slabs 15 in. or less in thickness, columns, walls, and parapets.
 - a. Unless otherwise approved, splices will not be permitted in bars 30 ft. or less in plan length. For bars exceeding 30 ft. in plan length, the distance center-to-center of splices must be at least 30 ft. minus 1 splice length, with no more than 1 individual bar length less than 10 ft. Make lap splices not shown on the plans, but otherwise permitted, in accordance with Table 5. Maintain the specified concrete cover and spacing at splices, and place the lap-spliced bars in contact, securely tied together.

Table 5
Minimum Lap Requirements for Bar Sizes through No. 11

Bar Size Number (in.)	Bar Size Number (mm)	Uncoated Lap Length	Coated Lap Length
3	10	1 ft. 4 in.	2 ft. 0 in.
4	13	1 ft. 9 in.	2 ft. 8 in.
5	16	2 ft. 2 in.	3 ft. 3 in.
6	19	2 ft. 7 in.	3 ft. 11 in.
7	22	3 ft. 5 in.	5 ft. 2 in.
8	25	4 ft. 6 in.	6 ft. 9 in.
9	29	5 ft. 8 in.	8 ft. 6 in.
10	32	7 ft. 3 in.	10 ft. 11 in.
11	36	8 ft. 11 in.	13 ft. 5 in.

Note: Bar size numbers (in.) are based on the number of eighths of an inch included in the nominal diameter of the bar. Bar size numbers (mm) approximate the number of millimeters included in the nominal diameter of the bar.

- b. Do not lap No. 14 or No. 18 bars.
- c. Lap spiral steel at least 1 turn.
- d. Splice welded wire fabric using a lap length that includes the overlap of at least 2 cross wires plus 2 in. on each sheet or roll. Splices using bars that develop equivalent strength and are lapped in accordance with Table 5 are permitted.
- e. For box culvert extensions with less than 1 ft. of fill, lap the existing longitudinal bars with the new bars as shown in Table 3. For extensions with more than 1 ft. of fill, lap at least 1 ft. 0 in.

- f. Ensure that welded splices are performed by a qualified welder is an experienced welder who is capable of making welds of sound quality and is competent to use the proper classification and size of electrode, arc length, voltage, and amperage for the thickness of the material, type of groove, welding positions, and other circumstances of the work. Submit qualifications of welder to Engineer for approval. Field-prepare ends of reinforcing bars if they will be butt-welded. Delivered bars must be long enough to permit weld preparation
- g. Install mechanical coupling devices in accordance with the manufacturer's recommendations at locations shown on the plans. Protect threaded male or female connections, and make sure the threaded connections are clean when making the connection. Do not repair damaged threads.
- h. Mechanical coupler alternate equivalent strength arrangements, to be accomplished by substituting larger bar sizes or more bars, will be considered if approved in writing before fabrication of the systems.

E. Placing.

- 1. Unless otherwise shown on the plans, dimensions shown for reinforcement are to the centers of the bars. Place reinforcement as near as possible to the position shown on the plans. In the plane of the steel parallel to the nearest surface of concrete, bars must not vary from plan placement by more than 1/12 of the spacing between bars. In the plane of the steel perpendicular to the nearest surface of concrete, bars must not vary from plan placement by more than 1/4 in. Cover of concrete to the nearest surface of steel must be at least 1 in. unless otherwise shown on the plans.
- 2. Locate the reinforcement accurately in the forms, and hold it firmly in place before and during concrete placement by means of bar supports that are adequate in strength and number to prevent displacement and to keep the steel at the proper distance from the forms. Support bars by standard bar supports with plastic tips, approved plastic bar supports, or precast mortar or concrete blocks when supports are in contact with removable or stay-in-place forms. Use bright basic bar supports to support reinforcing steel placed in slab overlays on concrete panels or on existing concrete slabs. Bar supports in contact with soil or subgrade must be approved.
- 3. For bar supports with plastic tips, the plastic protection must be at least 3/32 in. thick and extend upward on the wire to a point at least 1/2 in. above the formwork.
- 4. All accessories such as tie wires, bar chairs, supports, or clips used with epoxy-coated reinforcement must be of steel, fully coated with epoxy or plastic. Plastic supports approved by the Engineer may also be used with epoxy-coated reinforcement.

5. Cast mortar or concrete blocks to uniform dimensions with adequate bearing area. Provide a suitable tie wire in each block for anchoring to the steel. Cast the blocks to the thickness required in approved molds. The surface placed adjacent to the form must be a true plane, free of surface imperfections. Cure the blocks by covering them with wet burlap or mats for a period of 72 hr. Mortar for blocks should contain approximately 1 part hydraulic cement to 3 parts sand. Concrete for blocks should contain 850 lb. of hydraulic cement per cubic yard of concrete.
6. Place individual bar supports in rows at 4-ft. maximum spacing in each direction. Place continuous type bar supports at 4-ft. maximum spacing. Use continuous bar supports with permanent metal deck forms.
7. The exposure of the ends of longitudinals, stirrups, and spacers used to position the reinforcement in concrete pipe and in precast box culverts or storm drains is not cause for rejection.
8. Before concrete placement, clean mortar, mud, dirt, debris, oil, and other foreign material from the reinforcement. Do not place concrete until authorized.
9. If reinforcement is not adequately supported or tied to resist settlement, reinforcement is floating upward, truss bars are overturning, or movement is detected in any direction during concrete placement, stop placement until corrective measures are taken.

F. Handling, Placement, and Repair of Epoxy-Coated Reinforcing Steel.

1. Handling. Provide systems for handling coated reinforcement with padded contact areas. Pad bundling bands or use suitable banding to prevent damage to the coating. Lift bundles of coated reinforcement with a strongback, spreader bar, multiple supports, or a platform bridge. Transport the bundled reinforcement carefully, and store it on protective cribbing. Do not drop or drag the coated reinforcement.
2. Construction Methods.
 - a. Do not flame-cut coated reinforcement. Saw or shear-cut only when approved. Coat cut ends as specified in Section 3.01.F.3, "Repair of Coating."
 - b. Do not weld or mechanically couple coated reinforcing steel except where specifically shown on the plans. Remove the epoxy coating at least 6 in. beyond the weld limits before welding and 2 in. beyond the limits of the coupler before assembly. After welding or coupling, clean the steel of oil, grease, moisture, dirt, welding contamination (slag or acid residue), and rust to a near-white finish. Check the existing epoxy for damage. Remove any damaged or loose epoxy back to sound epoxy coating.
 - c. After cleaning, coat the splice area with epoxy repair material to a thickness of 7 to 17 mils after curing. Apply a second application of repair

material to the bar and coupler interface to ensure complete sealing of the joint.

3. Repair of Coating.

- a. For repair of the coating, use material that complies with the requirements of this Item and ASTM D 3963. Make repairs in accordance with procedures recommended by the manufacturer of the epoxy coating powder. For areas to be patched, apply at least the same coating thickness as required for the original coating. Repair all visible damage to the coating.
- b. Repair sawed and sheared ends, cuts, breaks, and other damage promptly before additional oxidation occurs. Clean areas to be repaired to ensure that they are free from surface contaminants. Make repairs in the shop or in the field as required.

END OF SECTION 31 50 10

SECTION 316329 - DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Dry-installed drilled piers.
2. Slurry displacement-installed drilled piers.
3. Dry-installed or slurry displacement-installed drilled piers at Contractor's choice.

1.03 UNIT PRICES

- A. Drilled Piers: Actual net volume of drilled piers in place and approved. Actual length, shaft diameter, and bell diameter if applicable, may vary, to coincide with elevations where satisfactory bearing strata are encountered. These dimensions may also vary with actual bearing value of bearing strata determined by an independent testing and inspecting agency. Adjustments are made on net variation of total quantities, based on design dimensions for shafts and bells.
 1. Base bids on indicated number of drilled piers and, for each pier, the design length from top elevation to bottom of shaft, extended through the bell, if applicable, and the diameter of shaft and bell.
 2. Unit prices include labor, materials, tools, equipment, and incidentals required for excavation, trimming, shoring, casings, dewatering, reinforcement, concrete fill, testing and inspecting, and other items for complete drilled-pier installation.
- B. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed outside dimensions of drilled piers cast against rock. Unit prices for rock excavation include replacement with approved materials.
- C. Trial Drilled Pier: Same unit price as indicated for drilled pier, including backfilling.

1.04 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to drilled piers including, but not limited to, the following:
 - a. Review geotechnical report.

- b. Discuss existing utilities and subsurface conditions.
- c. Review coordination with temporary controls and protections.
- d. Review measurement and payment of unit prices.

1.05 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Design Mixtures: For each concrete mixture. Submit alternative design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
 - 1. Indicate amounts of mixing water to be withheld for later addition at Project site.
- C. Shop Drawings: For concrete reinforcement, detailing fabricating, bending, supporting, and placing.

1.06 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and testing agency.
- B. Welding certificates.
- C. Material Certificates: From manufacturer, for the following:
 - 1. Cementitious materials.
 - 2. Admixtures.
 - 3. Steel reinforcement and accessories.
- D. Material Test Reports: For each material below, by a qualified testing agency:
 - 1. Aggregates:[Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.]
- E. Field quality-control reports.

1.07 CLOSEOUT SUBMITTALS

- A. Record drawings.

1.08 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer that has specialized in drilled-pier work.
- B. Testing Agency Qualifications: Qualified according to ASTM C 1077, ASTM D 3740, and ASTM E 329 for testing indicated.
- C. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

2. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

1.09 TRIAL DRILLED PIER

- A. Trial Drilled Pier: Construct trial drilled pier of diameter and depth and at location indicated or, if not indicated, of same diameter and depth as largest drilled piers, located at least three diameters clear of permanent drilled piers, to demonstrate Installer's construction methods, equipment, standards of workmanship, and tolerances.
1. Install reinforcement, fill with concrete, remove temporary casings, and terminate trial drilled pier 24 inches below subgrade and leave in place.
 2. Install permanent casings, excavate bell, excavate rock socket, and place slurry, as required for permanent drilled piers.
 3. If Engineer determines that trial drilled pier does not comply with requirements, excavate for and cast another until it is accepted.

1.10 FIELD CONDITIONS

- A. Existing Utilities: Locate existing underground utilities before excavating drilled piers. If utilities are to remain in place, provide protection from damage during drilled-pier operations.
1. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities. Cooperate with Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities to satisfaction of utility owner.
- B. Interruption of Existing Utilities: Do not interrupt any utility to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
1. Notify Owner no fewer than seven days in advance of proposed interruption of utility.
 2. Do not proceed with interruption of utility without Owner's written permission.
- C. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.
1. Make additional test borings and conduct other exploratory operations necessary for drilled piers.
 2. The geotechnical report is included elsewhere in the Project Manual.
- D. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.

1. Record and maintain information pertinent to each drilled pier and indicate on record Drawings. Cooperate with Owner's testing and inspecting agency to provide data for required reports.

PART 2 - PRODUCTS**2.01 PERFORMANCE REQUIREMENTS**

- A. Drilled-Pier Standard: Comply with ACI 336.1 except as modified in this Section.

2.02 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
- C. Plain-Steel Wire: ASTM A 82/A 82M, as drawn.
- D. Deformed-Steel Wire: ASTM A 496/A 496M.
- E. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain. Cut bars true to length with ends square and free of burrs.

2.03 CONCRETE MATERIALS

- A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:
 1. Portland Cement: ASTM C 150, Type I/II
 - a. Fly Ash: ASTM C 618, Class C or Class F.
 - b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
- B. Normal-Weight Aggregate: ASTM C 33, graded, 3/4-inch nominal maximum coarse-aggregate size. Provide aggregate from a single source with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.
 1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- C. Water: ASTM C 94 and potable.
- D. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 1. Water-Reducing Admixture: ASTM C 494, Type A.
 2. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.
 3. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494, Type G.

4. Plasticizing and Retarding Admixture: ASTM C 1017, Type II.

2.04 STEEL CASINGS

- A. Steel Pipe Casings: ASTM A 283/A 283M, Grade C, or ASTM A 36/A 36M, carbon-steel plate, with joints full-penetration welded according to AWS D1.1/D1.1M.
- B. Corrugated-Steel Pipe Casings: ASTM A 929/A 929M, steel sheet, zinc coated.
- C. Liners: Comply with ACI 336.1.

2.05 SLURRY

- A. Slurry: Pulverized bentonite mixed with water to form stable colloidal suspension; complying with ACI 336.1 for density, viscosity, sand content, and pH.

2.06 CONCRETE MIXTURES

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.
- C. Limit water-soluble, chloride-ion content in hardened concrete to 0.08 percent by weight of cement.
- D. Proportion normal-weight concrete mixture as follows:
 1. Compressive Strength (28 Days): 4000 psi
 2. Maximum Water-Cementitious Materials Ratio: 0.45.
 3. Minimum Slump: Capable of maintaining the following slump until completion of placement:
 - a. 4 inches for dry, uncased, or permanent-cased drilling method.
 - b. 6 inches for temporary-casing drilling method.
 - c. 7 inches for slurry displacement method.
 4. Air Content: Do not air entrain concrete.

2.07 REINFORCEMENT FABRICATION

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.08 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.

1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by drilled-pier operations.

3.02 EXCAVATION

- A. Unclassified Excavation: Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.
 1. Obstructions: Unclassified excavation may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. No changes in the Contract Sum or the Contract Time are authorized for removal of obstructions.
 2. Obstructions: Unclassified excavated materials may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. Payment for removing obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work is according to Contract provisions for changes in the Work.
- B. Classified Excavation: Excavation is classified as standard excavation, special excavation, and obstruction removal and includes excavation to bearing elevations as follows:
 1. Standard excavation includes excavation accomplished with conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work.
 2. Special excavation includes excavation that requires special equipment or procedures where drilled-pier excavation equipment used in standard excavation, operating at maximum power, torque, and downthrust, cannot advance the shaft.
 - a. Special excavation requires use of special rock augers, core barrels, air tools, blasting, or other methods of hand excavation.
 - b. Earth seams, rock fragments, and voids included in rock excavation area are considered rock for full volume of shaft from initial contact with rock.
 3. Obstructions: Payment for removing unanticipated boulders, concrete, masonry, or other subsurface obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work is according to Contract provisions for changes in the Work.

- C. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.
- D. Excavate shafts for drilled piers to indicated elevations. Remove loose material from bottom of excavation.
 - 1. Excavate bottom of drilled piers to level plane within 1:12 tolerance.
 - 2. Remove water from excavated shafts before concreting.
 - 3. Excavate rock sockets of dimensions indicated.
 - 4. Cut series of grooves about perimeter of shaft to height from bottom of shaft, vertical spacing, and dimensions indicated.
- E. Notify and allow testing and inspecting agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by Architect.
 - 1. Do not excavate shafts deeper than elevations indicated unless approved by Architect.
 - 2. Payment for additional authorized excavation is according to Contract provisions for changes in the Work.
- F. End-Bearing Drilled Piers: Probe with auger to a depth below bearing elevation, equal to diameter of the bearing area of drilled pier. Determine whether voids, clay seams, or solution channels exist.
 - 1. Test first three drilled piers and one of every six drilled piers thereafter.
 - 2. Fill auger-probe holes with grout.
- G. End-Bearing Drilled Piers: Probe with auger to a depth of 96 inches below bottom elevation of shaft, and visually inspect and classify soil. Verify continuity and thickness of strata.
 - 1. Test first three drilled piers and one of every six drilled piers thereafter.
- H. Excavate shafts for closely spaced drilled piers and for drilled piers occurring in fragile or sand strata only after adjacent drilled piers are filled with concrete and allowed to set.
- I. Slurry Displacement Method: Stabilize excavation with slurry maintained a minimum of 60 inches above ground-water level and above unstable soil strata to prevent caving or sloughing of shaft. Maintain slurry properties before concreting.
 - 1. Excavate and complete concreting of drilled pier on same day, or redrill, clean, and test slurry in excavation before concreting.
- J. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.
 - 1. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete.

- K. Bells: Excavate bells for drilled piers to shape, base thickness, and slope angle indicated. Excavate bottom of bells to level plane and remove loose material before placing concrete.
 - 1. Shore bells in unstable soil conditions to prevent cave-in during excavation, inspection, and concreting.
- L. Tolerances: Construct drilled piers to remain within ACI 336.1 tolerances.
 - 1. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit corrective construction proposals to Architect for review before proceeding.

3.03 PERMANENT STEEL CASING INSTALLATION

- A. Install permanent steel casings of minimum wall thickness indicated and of diameter not less than diameter of drilled pier.
 - 1. Install casings as excavation proceeds, to maintain sidewall stability.
 - 2. Fabricate bottom edge of lowest casing section with cutting shoe capable of penetrating rock and achieving water seal.
 - 3. Connect casing sections by continuous penetration welds to form watertight, continuous casing.
 - 4. Remove and replace or repair casings that have been damaged during installation and that could impair strength or efficiency of drilled pier.
 - 5. Fill annular void between casing and shaft wall with grout.
- B. Corrugated-Steel Casings: Provide corrugated-steel casings formed from zinc-coated steel sheet.
 - 1. Corrugated casings may be delivered in sections or panels of convenient length and field connected according to manufacturer's written instructions.

3.04 STEEL REINFORCEMENT INSTALLATION

- A. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
- C. Fabricate and install reinforcing cages symmetrically about axis of shafts in a single unit.
- D. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover over reinforcement.
- E. Use templates to set anchor bolts, leveling plates, and other accessories furnished in work of other Sections. Provide blocking and holding devices to maintain required position during final concrete placement.

- F. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

3.05 CONCRETE PLACEMENT

- A. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by a qualified testing agency.
 - 1. Construct a construction joint if concrete placement is delayed more than one hour. Level top surface of concrete and insert joint dowel bars. Before placing remainder of concrete, clean surface laitance, roughen, and slush concrete with commercial bonding agent or with sand-cement grout mixed at ratio of 1:1.
- B. Dry Method: Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.
 - 1. Where concrete cannot be directed down shaft without striking reinforcement, place concrete with chutes, tremies, or pumps.
 - 2. Vibrate top 60 inches of concrete.
- C. Slurry Displacement Method: Place concrete in slurry-filled shafts by tremie methods or pumping. Control placement operations to ensure that tremie or pump pipe is embedded no less than 60 inches into concrete and that flow of concrete is continuous from bottom to top of drilled pier.
- D. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a 60-inch head of concrete above bottom of casing.
 - 1. Vibrate top 60 inches of concrete after withdrawal of temporary casing.
- E. Screed concrete at cutoff elevation level and apply scoured, rough finish. Where cutoff elevation is above the ground elevation, form top section above grade and extend shaft to required elevation.
- F. Protect concrete work, according to ACI 301, from frost, freezing, or low temperatures that could cause physical damage or reduced strength.
 - 1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 - 2. Do not use calcium chloride, salt, or other mineral-containing antifreeze agents or chemical accelerators.
- G. If hot-weather conditions exist that would seriously impair quality and strength of concrete, place concrete according to ACI 301 to maintain delivered temperature of concrete at no more than 90 deg F.
 - 1. Place concrete immediately on delivery. Keep exposed concrete surfaces and formed shaft extensions moist by fog sprays, wet burlap, or other effective means for a minimum of seven days.

3.06 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 - 1. Drilled piers.
 - 2. Excavation.
 - 3. Concrete.
 - 4. Steel reinforcement welding.
- B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- C. Concrete Tests and Inspections: ASTM C 172/C 172M except modified for slump to comply with ASTM C 94/C 94M.
 - 1. Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test but no fewer than one test for each concrete load.
 - 2. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and 80 deg F and above, and one test for each set of compressive-strength specimens.
 - 3. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
 - 4. Compressive-Strength Tests: ASTM C 39/C 39M; one set for each drilled pier but not more than one set for each truck load. Test one specimen at seven days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.
 - 5. If frequency of testing provides fewer than five strength tests for a given class of concrete, conduct tests from at least five randomly selected batches or from each batch if fewer than five are used.
 - 6. If strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
 - 7. Strength of each concrete mixture is satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
 - 8. Report test results in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. List Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests in reports of compressive-strength tests.

9. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but not be used as sole basis for approval or rejection of concrete.
10. Additional Tests: Testing and inspecting agency to make additional tests of concrete if test results indicate that slump, compressive strengths, or other requirements have not been met, as directed by Architect.
 - a. Continuous coring of drilled piers may be required, at Contractor's expense, if temporary casings have not been withdrawn within specified time limits or if observations of placement operations indicate deficient concrete quality, presence of voids, segregation, or other possible defects.
11. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
12. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- D. An excavation, concrete, or a drilled pier will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports for each drilled pier as follows:
 1. Actual top and bottom elevations.
 2. Actual drilled-pier diameter at top, bottom, and bell.
 3. Top of rock elevation.
 4. Description of soil materials.
 5. Description, location, and dimensions of obstructions.
 6. Final top centerline location and deviations from requirements.
 7. Variation of shaft from plumb.
 8. Shaft excavating method.
 9. Design and tested bearing capacity of bottom.
 10. Depth of rock socket.
 11. Levelness of bottom and adequacy of cleanout.
 12. Properties of slurry and slurry test results at time of slurry placement and at time of concrete placement.
 13. Ground-water conditions and water-infiltration rate, depth, and pumping.

14. Description, purpose, length, wall thickness, diameter, tip, and top and bottom elevations of temporary or permanent casings. Include anchorage and sealing methods used and condition and weather tightness of splices if any.
 15. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
 16. Bell dimensions and variations from original design.
 17. Date and time of starting and completing excavation.
 18. Inspection report.
 19. Condition of reinforcing steel and splices.
 20. Position of reinforcing steel.
 21. Concrete placing method, including elevation of consolidation and delays.
 22. Elevation of concrete during removal of casings.
 23. Locations of construction joints.
 24. Concrete volume.
 25. Concrete testing results.
 26. Remarks, unusual conditions encountered, and deviations from requirements.
- 3.07 DISPOSAL OF SURPLUS AND WASTE MATERIALS
- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 31 63 29

SECTION 32 00 11– SILT FENCE

PART 1 - GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 DESCRIPTION

- A. The Work described in this Section is applicable to any and all Sections of the Contract Documents. Any and all Work that would disturb the existing Site conditions or present the potential for site run-off shall adhere fully to this Specification Section.

1.03 REFERENCE STANDARDS

- A. M.D. Anderson Temporary Storm Water Pollution Control Section 01 57 23.

1.04 SUBMITTALS

The submittal requirements for this specification item shall include:

- A. Source, manufacturer, characteristics, and test data for the silt fence fabric,
- B. Manufacturer, characteristics and test data for the posts and wire fence.

PART 2 - PRODUCTS

2.01 Silt Fences: implemented to filter, and remove sediment from storm water shall be composed of the following materials:

- A. Geotextile fabric – a non-woven, polypropylene, polyethylene, or polyamide fabric with non- raveling edges. It shall be non-biodegradable, inert to most soil chemicals, ultraviolet resistant, unaffected by moisture and other weather conditions, and permeable to water while retaining sediment. Fabric shall be 36 inches wide, with a minimum weight of 4.5 oz/yd.
- B. Posts –steel fence posts shall be made of hot rolled steel, galvanized or painted, a minimum of 4 feet long, with a Y-bar or TEE cross-section of sufficient strength to withstand forces implied.
- C. Wire Backing – a galvanized, 2"x4", welded wire fencing, 12 gauge minimum. Width shall be sufficient to support geotextile fabric 24 inches above adjacent grades. Chain link fences located along the same lines as silt fences, may be use to support geotextile fabric. In this circumstance, the geotextile fabric shall be firmly attached to fence.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Silt fences shall be attached to wire fabric backing to support the geotextile. Attach geotextile fabric to fence with shoat or standard cable/wire ties, leaving a "toe" of fabric at the bottom of the fence of not less than 6 (six) inches.
- B. Steel posts as specified shall be driven to a depth of 1 (one) foot minimum, and spaced not more than 6 (six) feet on center. Tilt posts slightly, in an "uphill" direction for additional strength. Attach fencing to posts with standard cable/wire ties.
- C. Dig a 6 (six) inch deep by 6 (six) inch wide trench on the disturbed side of the fence, bury geotextile fabric in trench, backfill and tamp. Abutting ends of geotextile fabric shall be overlapped a minimum of 12 (twelve) inches.
- D. Remove silt fence when the disturbed areas protected by silt fence have been completely stabilized as specified. Minimize site disturbance while removing silt fence and posts.

3.02 INSPECTIONS

- A. Contractor shall inspect all BMP's on 7-day intervals and within 24-hours at the end of a major storm event totaling 0.5 inches of rainfall or greater and take appropriate action to correct any deficiencies.

3.03 MAINTENANCE

- A. All erosion and sediment control measures and other protective measures identified in the SWPPP must be maintained in effective operating condition. If through inspections the permittee determines that BMP's are not operating effectively, maintenance must be performed before the next anticipated storm event or as necessary to maintain the continued effectiveness of storm water controls.
- B. If maintenance prior to the next anticipated storm event is impracticable, maintenance must be scheduled and accomplished as soon as practicable. Erosion and sediment controls that have been intentionally disabled, run-over, removed or otherwise rendered ineffective must be replaced or corrected immediately upon discovery.
- C. Maintain silt fence daily as necessary to repair breaches in geotextile fabric. Maintain steel posts as specified in tilted condition. When siltation has occurred, it shall be removed when it has reached a depth of 6 (six) inches. Silt that has been removed shall be disposed of off-site.

END OF SECTION 32 00 11

SECTION 32 10 00 – SODDING

PART 1 - GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 DESCRIPTION

- A. Planting of Bermuda grass; Zoysia or other acceptable grass sod at locations indicated on the Drawings or as directed by the Engineer or designated representative in accordance with this Standard Specification Item

1.03 REFERENCE STANDARDS

- A. City of Austin Standard Specification 602S.

1.04 SUBMITTALS

- A. Identification of the type and source of sodding.

PART 2 - PRODUCTS

2.01 Materials.

- A. Block Sod
 - 1. The sod shall consist of live, growing Bermuda Grass or Zoysia Grass when shown on the Drawings, or other acceptable grass sod indicated on the Drawings secured from sources that are approved by the Engineer or designated representative. Sod shall have a healthy, virile root system of dense, thickly matted roots throughout the soil of the sod for a minimum thickness of 1 inch (25 millimeters). The thickness measure does not include grass. The sod shall be cut in rectangular pieces with its shortest side not less than 12 inches (300 mm). The Contractor shall not use sod from areas where the grass is thinned out nor where the grass roots have been dried out by exposure to the air and sun to such an extent as to damage its ability to grow when transplanted.
 - 2. The sod shall be substantially free from noxious weeds, Johnson grass or other grasses and shall not contain any matter deleterious to its growth or which might affect its subsistence or hardiness when transplanted. Unless the area has been closely pastured, it shall be closely mowed and raked to remove all weeds and long standing stems. Sources from which sod is to be secured shall be approved by the Engineer or designated representative.

3. Care shall be taken at all times to retain the native soil of the roots of the sod during the process of excavating, hauling and planting. Sod material shall be kept moist from the time it is dug until it is planted. The sod existing at the source shall be watered to the extent required by the Engineer or designated representative prior to excavating.

B. Fertilizer

1. Fertilizer and the rate of application shall conform to the requirements of Specification 32 90 01 Fertilizer.

C. Water

1. Water shall be furnished by the Contractor and shall be clean and free of industrial wastes and other substances harmful to the growth of sod or to the area irrigated.

PART 3 - EXECUTION

3.01 CONSTRUCTION

A. General

After the designated areas have been completed to the lines, grade and cross sections indicated on the Drawings, the surface shall be worked to a depth of not less than 4 inches with a disc, tiller or other equipment approved by the Engineer or designated representative. Fertilizer nutrients shall be applied and tilled. Areas that become crusted shall be reworked to an acceptable condition before sodding. Sodding of the type specified shall conform to the requirements of this Specification Item. The Contractor shall give continuous care to the sodded area until the sod is accepted.

B. Placement

The sod shall be placed on the prepared surface with the edges in close contact and alternate courses staggered. In ditches the sod shall be placed with the longer dimension perpendicular to the flow of water in the ditch. On slopes, starting at the bottom of the slope, the sod shall be placed with the longer dimension parallel to the contours of the ground. The exposed edges of sod shall be buried flush with the adjacent soil. On slopes exceeding 3:1 or where the sod may be displaced, the sod shall be pegged with not less than 4 stakes or ground staples per square yard (square meter) with at least 1 stake or ground staple for each piece of sod.

Pegs shall be of wood lath or similar material, pointed and driven with the flat side against the slope, 6 inches (150 mm) into the ground, leaving approximately 1/2 inch (12.5 mm) of the top above the ground. Ground staples shall not be less than 13 inches (330 mm) in length and shall be constructed of No. 11 gage (3 mm) wire that is bent to form a "U" approximately 1 inch (25 mm) in width.

C. Watering

Immediately after the area is sodded, it shall be watered with a minimum of 5 gallons of water per square yard (22.5 liters per square meter) and at 10 day intervals as needed and as directed by the Engineer or designated representative. Subsequent to the initial application water shall be applied at a minimum rate of 3 gallons per square yard (13.5 liters per square meter), as required on the Drawings or as directed by the Engineer or designated representative until final acceptance by the Owner or until the grass uniformly reaches a height of 2 1/2 inches (62.5 mm).

D. Finishing

Where applicable, the shoulders, slopes and ditches shall be smoothed after planting has been completed and shaped to conform to the desired cross sections shown on the Drawings. Any excess soil from planting operations shall be spread uniformly over adjacent areas or disposed of as directed by the Engineer or designated representative so that the completed surfaces will present a neat appearance. All sodded areas shall be rolled after the initial watering application, when sufficiently dry.

E. Block Sodding

At locations indicated on the Drawings or where directed by the Engineer or designated representative, sod blocks shall be carefully placed on the prepared areas. The fertilizer shall then be applied in accordance with the applicable provisions of Specification 32 90 01, "Fertilizer" and thoroughly watered. When sufficiently dry, the sodded area shall be rolled or tamped to form a thoroughly compacted, solid mat. Any voids left in the block sodding shall be filled with additional sod and tamped. Surfaces of block sod which, in the opinion of the Engineer or designated representative may slide due to the height and slope of the surface or nature of the soil, shall be pegged with wooden pegs driven through the sod blocks into firm earth sufficiently close to hold the block sod firmly in place. Edges along curbs and drives, walkways, etc., shall be carefully trimmed and maintained until the sodding is accepted.

END OF SECTION 32 10 00

SECTION 32 29 11 – TOPSOIL

PART 1 – GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 DESCRIPTION

- A. Furnishing and placing topsoil for finish grading and for seeding, sodding, and planting.

1.03 REFERENCE STANDARDS

- A. City of Houston Specification 02911.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Topsoil
 - 1. Topsoil shall be fertile, friable, natural sandy loam surface soil obtained from excavation or borrow operations having following characteristics:
 - pH value of between 5.5 and 6.5
 - Liquid limit: 50 or less
 - Plasticity index: 20 or less
 - Gradation: maximum of 10 percent passing No. 200 sieve
 - 2. Topsoil shall be reasonably free of subsoil, clay lumps, weeds, non-soil materials, and other litter or contamination. Topsoil shall not contain roots, stumps, and stones larger than 2 inches.
 - 3. Obtain topsoil from naturally well-drained areas where topsoil occurs at minimum depth of 4 inches and has similar characteristics to that found at placement site. Do not obtain topsoil from areas infected with growth of, or reproductive parts of nut grass or other noxious weeds.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Excavate topsoil for areas to receive grass or landscaping from areas to be further excavated. Stockpile in staging area shown on plans. Soil stockpile shall not interfere with stormwater flow paths.
- B. Stockpile topsoil to depth not exceeding 8 feet. Cover to protect from erosion.

3.02 TOPSOIL EXCAVATION

- A. Conform to excavation and stockpiling requirements of Specification 31 10 30 "Excavation & Backfill for Concrete Structures"

3.03 PLACEMENT

- A. Place no topsoil until subgrade has been approved. For areas to be seeded or sodded, scarify or plow existing material to minimum depth of 4 inches, or as indicated on Drawings. Remove vegetation and foreign inorganic material. Place 4 inches of topsoil on loosened material and roll lightly with appropriate lawn roller to consolidate topsoil.
- B. Increase depth of topsoil to 6 inches when placed over sand bedding and backfill materials specified in Specification 33 23 20 - Utility Backfill Material.
- C. For areas to receive shrubs or trees, excavate existing material and place topsoil to depth and dimensions shown on Drawings.
- D. Remove spilled topsoil from curbs, gutters, and, paved areas and dispose of excess topsoil in accordance with federal, state, and local requirements.
- E. Place topsoil to promote good drainage and compact with light roller. Water topsoil after placement until saturated for minimum depth 6 inches, fill in and recompact areas of settlement.

3.04 PROTECTION

- A. Protect topsoil from wind and water erosion until planting is completed.

END OF SECTION 32 29 11

SECTION 33 23 17 – EXCAVATION AND BACKFILL FOR UTILITIES

PART 1 – GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 DESCRIPTION

- A. Excavation, trenching, foundation, embedment, and backfill for installation of utilities, including manholes and other pipeline structures.

1.04 DEFINITIONS

- A. Pipe Foundation: Suitable and stable native soils that are exposed at trench subgrade after excavation to depth of bottom of bedding as shown on Drawings, or foundation backfill material placed and compacted in over-excavations.
- B. Pipe Bedding: Portion of trench backfill that extends vertically from top of foundation up to level line at bottom of pipe, and horizontally from one trench sidewall to opposite sidewall.
- C. Haunching: Material placed on either side of pipe from top of bedding up to springline of pipe and horizontally from one trench sidewall to opposite sidewall.
- D. Initial Backfill: Portion of trench backfill that extends vertically from springline of pipe (top of haunching) up to level line 12 inches above top of pipe, and horizontally from one trench sidewall to opposite sidewall.
- E. Pipe Embedment: Portion of trench backfill that consists of bedding, haunching and initial backfill.
- F. Trench Zone: Portion of trench backfill that extends vertically from top of pipe embedment up to pavement subgrade or up to final grade when not beneath pavement.
- G. Unsuitable Material: Unsuitable soil materials are the following:
 - 1. Materials that are classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.
 - 2. Materials that cannot be compacted to required density due to gradation, plasticity, or moisture content.
 - 3. Materials that contain large clods, aggregates, stones greater than 4 inches in any dimension, debris, vegetation, waste or any other deleterious materials.
 - 4. Materials that are contaminated with hydrocarbons or other chemical contaminants.
 - 5. Crushed stone.

- H. Suitable Material: Suitable soil materials are those meeting specification requirements. Materials mixed with lime, fly ash, or cement that can be compacted to required density and meeting requirements for suitable materials may be considered suitable materials, unless otherwise indicated.
- I. Backfill: Suitable material meeting specified quality requirements placed and compacted under controlled conditions.
- J. Ground Water Control Systems: Installations external to trench, such as well points, eductors, or deep wells. Ground water control includes dewatering to lower ground water, intercepting seepage which would otherwise emerge from side or bottom of trench excavation, and depressurization to prevent failure or heaving of excavation bottom.
- K. Surface Water Control: Diversion and drainage of surface water runoff and rain water away from trench excavation. Rain water and surface water accidentally entering trench shall be controlled and removed as part of excavation drainage.
- L. Excavation Drainage: Removal of surface and seepage water in trench by sump pumping and using drainage layer, as defined in ASTM D 2321, placed on foundation beneath pipe bedding or thickened bedding layer of Class I material.
- M. Trench Conditions are defined with regard to stability of trench bottom and trench walls of pipe embedment zone. Maintain trench conditions that provide for effective placement and compaction of embedment material directly on or against undisturbed soils or foundation backfill, except where structural trench support is necessary.
 - 1. Dry Stable Trench: Stable and substantially dry trench conditions exist in pipe embedment zone as result of typically dry soils or achieved by ground water control (dewatering or depressurization) for trenches extending below ground water level.
 - 2. Stable Trench with Seepage: Stable trench in which ground water seepage is controlled by excavation drainage.
 - a. Stable Trench with Seepage in Clayey Soils: Excavation drainage is provided in lieu of or to supplement ground water control systems to control seepage and provide stable trench subgrade in predominately clayey soils prior to bedding placement.
 - b. Stable Wet Trench in Sandy Soils: Excavation drainage is provided in embedment zone in combination with ground water control in predominately sandy or silty soils.
 - 3. Unstable Trench: Unstable trench conditions exist in pipe embedment zone if ground water inflow or high water content causes soil disturbances, such as sloughing, sliding, boiling, heaving or loss of density.
- N. Sub-trench: Sub-trench is special case of benched excavation. Sub-trench excavation below trench shields or shoring installations may be used to allow placement and compaction of foundation or embedment materials directly against undisturbed soils. Depth of sub-trench depends upon trench stability and safety as determined by Contractor.
- O. Trench Dam: Placement of low permeability material in pipe embedment zone or foundation to prohibit ground water flow along trench.

- P. Over-excavation and Backfill: Excavation of subgrade soils with unsatisfactory bearing capacity or composed of otherwise unsuitable materials below top of foundation as shown on Drawings, and backfilled with foundation bedding.
- Q. Foundation Bedding: Natural soil or manufactured aggregate of controlled gradation, and geotextile filter fabrics as required, to control drainage and material separation. Foundation bedding is placed and compacted as backfill to provide stable support for bedding. Foundation bedding materials may include concrete seal slabs.
- R. Trench Safety Systems, if required, shall meet OSHA requirements.
- S. Trench Shield (Trench Box): Portable worker safety structure moved along trench as work proceeds, used as protective system and designed to withstand forces imposed on it by cave in, thereby protecting persons within trench. Trench shields may be stacked if so designed or placed in series depending on depth and length of excavation to be protected.
- T. Shoring System: Structure that supports sides of an excavation to maintain stable soil conditions and prevent cave-ins, or to prevent movement of ground affecting adjacent installations or improvements.
- U. Special Shoring: Shoring system meeting special shoring as specified in Paragraph 1.08, Special Shoring Design Requirements, for locations identified on Drawings.
- V. Vacuum Excavation: An excavation technique performed by an experienced subcontractor in which water or air jetting is used to slough off and vacuum away soil.

1.05 REFERENCE STANDARDS

- A. City of Houston Standard Specification 02317.
- B. ASTM D 558 -Standard Test Methods for Moisture-Density Relations of Soil Cement

1.06 SCHEDULING

- A. Schedule work so that pipe embedment can be completed on same day that acceptable foundation has been achieved for each section of pipe installation, manhole, or other structures.
- B. Unless otherwise approved by the Owner, perform construction activities between 7 AM and 6 PM, Monday through Friday per Specification 00 25 00 1.04 H.

1.07 SUBMITTALS

- A. Submit planned typical method of excavation, backfill placement and compaction including:
 - 1. Trench widths.
 - 2. Procedures for foundation and pipe zone bedding placement, and trench backfill compaction.
 - 3. Procedures for assuring compaction against undisturbed soil when pre-manufactured trench safety systems are proposed.
- B. Submit backfill material sources and product quality information in accordance with requirements of Specification 33 23 20 -Utility Backfill Materials.
- C. Prepare document summarizing procedures discussed with Owner in the event of a water emergency. Submit the document, including the following, to the Owner or Engineer prior to commencing Work.

1. Emergency Action Plan (EAP) to address contingency plans in the event of damage to or failure of water line. Include the following:
 - a. Contact personnel including primary and secondary telephone numbers,
 - b. Contractor's hierarchy of responsible personnel,
 - d. Identification of resources to be available on or near project site in event of damage to or failure of existing water service.

1.08 TESTS

- A. Testing and analysis of backfill materials for soil classification and compaction during construction will be performed by an independent laboratory provided by Owner in accordance with requirements of Specification 33 14 54 -Testing Laboratory Services and as specified in this Section.
- B. Perform backfill material source qualification testing in accordance with requirements of Specification 33 23 20- Utility Backfill Materials.

1.09 SPECIAL SHORING DESIGN REQUIREMENTS

- A. Have special shoring designed or selected by Contractor's Professional Engineer to provide support for sides of excavations, including soils and hydrostatic ground water pressures as applicable, and to prevent ground movements affecting adjacent installations or improvements such as structures, pavements and utilities. Special shoring may be a premanufactured system selected by Contractor's Professional Engineer to meet project site requirements based on manufacturer's standard design.

PART 2 – PRODUCTS

2.01 EQUIPMENT

- A. Perform excavation with hydraulic excavator or other equipment suitable for achieving requirements of this Section.
- B. Use only hand-operated tamping equipment until minimum cover of 12 inches is obtained over pipes, conduits, and ducts. Do not use heavy compacting equipment until adequate cover is attained to prevent damage to pipes, conduits, or ducts.
- C. Use trench shields or other protective systems or shoring systems which are designed and operated to achieve placement and compaction of backfill directly against undisturbed native soil.
- D. Use special shoring systems where required which may consist of braced sheeting, braced soldier piles and lagging, slide rail systems, or other systems meeting requirements as specified in Paragraph 1.08, Special Shoring Design Requirements.

2.02 MATERIAL CLASSIFICATIONS

- A. Embedment and Trench Zone Backfill Materials: Conform to classifications and product descriptions of Specification 33 23 20 -Utility Backfill Materials ~~and Specification 33 23 21- Cement Stabilized Sand.~~
- B. Concrete Backfill: Conform to requirements for Class B concrete as specified in Specification 31 40 00 -Hydraulic Cement Concrete.
- C. Geotextile (Filter Fabric): Conform to requirements of Specification 33 26 21-Geotextile.

PART 3 – EXECUTION

3.01 STANDARD PRACTICE

- A. Install flexible pipe, including "semi-rigid" pipe, to conform to standard practice described in ASTM D 2321, and as described in this Section. Where an apparent conflict occurs between standard practice and requirements of this Section, this Section governs.
- B. Install rigid pipe to conform to standard practice described in ASTM C 12 or C76 as applicable, and as described in this Section. Where an apparent conflict occurs between standard practice and requirements of this Section, this Section governs.

3.02 PREPARATION

- A. Perform work to conform to applicable safety standards and regulations. Employ OSHA compliant trench safety system, if required.
- B. Immediately notify owner or company owning any existing utility line which is damaged, broken, or disturbed. Obtain approval from Project Manager and agency for any repairs or relocations, either temporary or permanent.
- C. Remove existing pavements and structures, including sidewalks and driveways, to conform to requirements of Section 31 10 21-Removing Concrete and Asphalt, as applicable.
- D. Maintain permanent benchmarks, monumentation, and other reference points. Unless otherwise directed in writing, replace those which are damaged or destroyed.

3.03 UTILITY LOCATION INVESTIGATION

- A. Horizontal and vertical location of various underground lines shown on Drawings, including but not limited to water lines, gas lines, storm sewers, sanitary sewers, telecommunication lines, electric lines or power ducts, pipelines, concrete and debris, are based on best information available but are only approximate locations.
 - 1. Verify location of existing utilities in advance of pipe laying activities. Use extreme caution and care when uncovering utilities as the continued function of existing utilities is critical to the campus operations.
 - 2. Notify Owner in writing immediately upon identification of obstruction. In event of failure to identify obstruction, Contractor will not be entitled to extra cost for downtime including, but not limited to, payroll, equipment, overhead, demobilization and remobilization, unless approved by Owner.
- B. Survey vertical and horizontal locations of obstructions relative to project baseline and datum.
- C. Existing Prelocate Requirements:
 - 1. When needed, field-locate existing utilities through use of non-probing method such as a vacuum truck (non-water jetting method) at no greater than 50 foot intervals and mark in field so that lines are visible to Contractor. Locate upstream and downstream of proposed work or utility installation.

3.04 PROTECTION

- A. Protect trees, shrubs, lawns, existing structures, and other permanent objects within an near work area.
- B. Protect and support above-grade and below-grade utilities which are to remain.
- C. Restore damaged permanent facilities to pre-construction conditions unless replacement or abandonment of facilities is indicated on Drawings.

- D. Take measures to minimize erosion of trenches. Do not allow water to pond in trenches. Where slides, washouts, settlements, or areas with loss of density or pavement failures or potholes occur, repair, re-compact, and pave those areas at no additional cost to Owner.

3.05 EXCAVATION

- A. Except as otherwise specified or shown on Drawings, install underground utilities in open cut trenches with vertical sides.
- B. Perform excavation work so that pipe, conduit, and ducts can be installed to depths and alignments shown on Drawings. Avoid disturbing surrounding ground and existing facilities and improvements.
- C. Determine trench excavation widths using following schedule as related to pipe outside diameter (O.D.). Excavate trench so that pipe is centered in trench.

Nominal	Minimum Trench
Pipe Size, Inches	Width, Inches
Less than 18	O.D. + 18

Do not obstruct sight distance for vehicles utilizing roadway or detours with stockpiled materials.

- D. Provide sufficient space between shoring cross braces to permit equipment operations and handling of forms, pipe, embedment and backfill, and other materials.
- E. Upon discovery of unknown utilities, badly deteriorated utilities not designated for removal, or concealed conditions, discontinue work at that location. Notify Project Manager and obtain instructions before proceeding.
- F. Shoring of Trench Walls.
 - 1. Install Special Shoring in advance of trench excavation or simultaneously with trench excavation, so that soils within full height of trench excavation walls will remain laterally supported at all times.
 - 2. For all types of shoring, support trench walls in pipe embedment zone throughout installation. Provide trench wall supports sufficiently tight to prevent washing trench wall soil out from behind trench wall support.
 - 3. Leave sheeting driven into or below pipe embedment zone in place to preclude loss of support of foundation and embedment materials, unless otherwise directed by Project Manager. Leave rangers, walers, and braces in place as long as required to support sheeting, which has been cut off, and trench wall in vicinity of pipe zone.
 - 4. Employ special methods for maintaining integrity of embedment or foundation material. Before moving supports, place and compact embedment to sufficient depths to provide protection of pipe and stability of trench walls. As supports are moved, finish placing and compacting embedment.
 - 5. If sheeting or other shoring is used below top of pipe embedment zone, do not disturb pipe foundation and embedment materials by subsequent removal. Maximum thickness of removable sheeting extending into embedment zone shall be equivalent of 1-inch-thick steel plate. As sheeting is removed, fill in voids left with grouting material.

- G. Use of Trench Shields. When trench shield (trench box) is used as worker safety device, the following requirements apply:
 - 1. Make trench excavations of sufficient width to allow shield to be lifted or pulled freely, without damage to trench sidewalls.
 - 2. Move trench shields so that pipe, and backfill materials, after placement and compaction, are not damaged nor disturbed, nor degree of compaction reduced. Re-compact after shield is moved if soil is disturbed.
 - 3. When required, place, spread, and compact pipe foundation and bedding materials beneath shield. For backfill above bedding, lift shield as each layer of backfill is placed and spread. Place and compact backfill materials against undisturbed trench walls and foundation.
 - 4. Maintain trench shield in position to allow sampling and testing to be performed in safe manner.
 - 5. Conform to applicable Government regulations.
- H. Voids under paving area outside shield caused by Contractor's work will require removal of pavement, consolidation and replacement of pavement in accordance with Contract Documents. Repair damage resulting from failure to provide adequate supports.
- I. Place sand or soil behind shoring or trench shield to prevent soil outside shoring from collapsing and causing voids under pavement. Immediately pack suitable material in outside voids following excavation to avoid caving of trench walls.
- J. Coordinate excavation within 15 feet of utilities within easements with company's representative. Support pipeline with methods agreed to by pipeline company's representative. Use small, rubber-tired excavator, such as backhoe, to do exploratory excavation. Bucket that is used to dig in close proximity to utilities shall not have teeth or shall have guard installed over teeth to approximate bucket without teeth. Excavate by hand within 1 foot of the utilities line. Do not use larger excavation equipment than normally used to dig trench in vicinity of utility until pipelines have been uncovered and fully exposed. Do not place large excavation and hauling equipment directly over pipelines unless approved by Utility Company representative.
- K. When, during excavation to uncover utility company's lines, screwed collar or an oxy-acetylene weld is exposed, immediately notify Utility Company.
- L. Excavation and shoring requirements for proposed work or utility installation adjacent to or across an existing water line:
 - 1. Identify existing utility line area.
 - 2. Employ a groundwater control system, if necessary, when performing excavation activities within ten feet of existing water line to:
 - a. Effectively reduce hydrostatic pressure affecting excavations,
 - b. Develop substantially dry and stable subgrade for subsequent construction operations,
 - c. Prevent loss of fines, seepage, boils, quick condition or softening of foundation strata, and
 - d. Maintain stability of sides and bottom of excavations.

3. When edge of proposed trench or shoring is adjacent to existing water line, valve or appurtenance:
 - a. Open Cut Construction and Auger pits
 - i. Perform hand excavation when within four (4) feet of existing water line.
 - ii. Employ hydraulic or pneumatic shoring system. Do not use vibratory or impact driven shoring or piling.
 - iii. Expose no more than 30-feet of trench prior to backfilling.
 - iv. A maximum of one (1) foot of vertical trench shall be un-braced at a time to maintain constant pressure on face of excavated soil.
 - v. Upon removal of shoring system, inject flowable fill into void space left behind by shoring system. Comply with Standard Specification 33 23 22 -Flowable Fill.

3.06 HANDLING EXCAVATED MATERIALS

- A. Use only excavated materials, which are suitable as defined in this Section and conforming to Specification 33 23 20 -Utility Backfill Materials. Place material suitable for backfilling in stockpiles at distance from trench to prevent slides or cave-ins.
- B. When required, provide additional backfill material conforming to requirements of Specification 33 23 20 -Utility Backfill Materials.
- C. Place stockpiles of excess excavated materials in locations shown on plans or designated by Owner. Protect backfill material to be used on site. Excavate trench so that pipe is centered in trench. Do not obstruct sight distance for vehicles utilizing roadway or detours with stockpiled materials.

3.07 TRENCH FOUNDATION

- A. Excavate bottom of trench to uniform grade to achieve stable trench conditions and satisfactory compaction of foundation or bedding materials. Pipe or bedding shall not be placed where the ground water invades the trench or the trench bottom is of unstable material.
- B. When wet soil is encountered on trench bottom and dewatering system is not required, over excavate an additional 6 inches. Place non-woven geotextile fabric and then compact 12 inches of crushed stone in one lift on top of fabric. Compact crushed stone with four passes of vibratory-type compaction equipment.
- C. Perform over excavation in accordance with Paragraph 3.07B above. Removal of unstable or unsuitable material may be required;
 1. Even though Contractor has not determined material to be unsuitable, or
 2. If unstable trench bottom is encountered and an adequate ground water control system is installed and operating.

3.08 PIPE EMBEDMENT, PLACEMENT, AND COMPACTION

- A. Remove loose, sloughing, caving, or otherwise unsuitable soil from bottoms and sidewalls of trenches immediately prior to placement of embedment materials.
- B. Place embedment including bedding, haunching, and initial backfill as shown on Drawings.
- C. For pipe installation, manually spread embedment materials around pipe to provide uniform bearing and side support when compacted. Protect flexible pipe from damage during placing of pipe zone bedding material. Perform placement and compaction directly against undisturbed soils in trench sidewalls, or against sheeting which is to remain in place.

- D. Do not place trench shields or shoring within height of embedment zone unless means to maintain density of compacted embedment material are used. If moveable supports are used in embedment zone, lift supports incrementally to allow placement and compaction of material against undisturbed soil.
- E. Place geotextile to prevent particle migration from in-situ soil into open-graded (Class I) embedment materials or drainage layers.
- F. Do not damage coatings or wrappings of pipes during backfilling and compacting operations.
- G. Do not use crushed stone or other sharp, angular aggregates.
- H. Place haunching material manually around pipe and compact it to provide uniform bearing and side support. If necessary, hold small-diameter or lightweight pipe in place during compaction of haunch areas and placement beside pipe with sand bags or other suitable means.
- I. Place electrical conduit, if used, directly on foundation without bedding.
- J. Shovel in-place and compact embedment material using pneumatic tampers in restricted areas, and vibratory-plate compactors or engine-powered jumping jacks in unrestricted areas. Compact each lift before proceeding with placement of next lift. Water tamping is not allowed.

3.09 TRENCH ZONE BACKFILL PLACEMENT AND COMPACTION

- A. Place backfill for pipe or conduits and restore surface as soon as practicable. Leave only minimum length of trench open as necessary for construction.
- B. For storm sewer pipes, use backfill materials described by trench limits. Backfill from 12 inches above top of pipe with suitable on-site material or select backfill. For backfill materials reference Specification 33 23 20 -Utility Backfill Materials.
- C. Where damage to completed pipe installation work is likely to result from withdrawal of sheeting, leave sheeting in place. Cut off sheeting 1.5 feet or more above crown of pipe. Remove trench supports within 5 feet from ground surface.
- D. Unless otherwise shown on Drawings. Use one of the following trench zone backfills under pavement and to within one foot of edge of pavement. Place trench zone backfill in lifts and compact. Fully compact each lift before placement of next lift.
 - 1. Class I, II, or III or combination thereof:
 - a. Place in maximum 12-inch thick loose layers.
 - b. Compact by vibratory equipment to minimum of 95 percent of maximum dry density determined according to ASTM D 698.
 - c. Moisture content within zero percent to 2 percent above optimum determined according to ASTM D 698, unless otherwise approved by Engineer.
 - 2. Cement-Stabilized Sand:
 - a. Maximum lift thickness determined by Contractor to achieve uniform placement and required compaction, but do not exceed 12 inches.

- b. Compact by vibratory equipment to minimum of 95 percent of maximum dry density determined according to ASTM D 558.
 - c. Moisture content on dry side of optimum determined according to ASTM D 558 but sufficient for cement hydration.
 - 3. Class IVA and IVB (Clay Soils):
 - a. Place in maximum 8-inch thick loose lifts.
 - b. Compaction by vibratory Sheepfoot roller to minimum of 95 percent of maximum dry density determined according to ASTM D 698.
 - c. Moisture content within zero percent to 2 percent above optimum determined according to ASTM D 698, unless approved by Engineer.
 - E. Unless otherwise shown on Drawings, for trench excavations not under pavement, random backfill of suitable material may be used in trench zone. This provision does not apply to HDPE storm sewers.
 - 1. Fat clays (CH) may be used as trench zone backfill outside paved areas at Contractor's option. At no additional cost to Owner, use lime stabilization or other approved methods to achieve compaction requirements, or use different suitable material.
 - 2. Maximum 9-inch compacted lift thickness for clayey soils and maximum 12-inch lift thickness for granular soils.
 - 3. Compact to minimum of 90 percent of maximum dry density determined according to ASTM D 698.
 - 4. Moisture content as necessary to achieve density.
 - F. For electric conduits, remove form work used for construction of conduits before placing trench zone backfill.
- 3.10 Not Used.
- 3.11 FIELD QUALITY CONTROL
- A. Test for material source qualifications as defined in Specification 33 23 20 -Utility Backfill Materials.
 - B. Provide excavation and trench safety systems at locations and to depths required for testing and retesting during construction at no additional cost to Owner.
 - C. Tests will be performed on minimum of three different samples of each material type for plasticity characteristics, in accordance with ASTM D 4318, and for gradation characteristics, in accordance with Tex-101-E and Tex-110-E. Additional classification tests will be performed whenever there is noticeable change in material gradation or plasticity, or when requested by Project Manager.
 - D. At least three tests for moisture-density relationships will be performed initially for backfill materials in accordance with ASTM D 698, and for cement-stabilized sand in accordance with ASTM D 558. Perform additional moisture-density relationship tests once a month or whenever there is noticeable change in material gradation or plasticity.

- E. In-place density tests of compacted pipe foundation, embedment and trench zone backfill soil materials will be performed according to ASTM D 1556, or ASTM D 2922 and ASTM D 3017, and at following frequencies and conditions.
 - 1. For open cut construction projects and auger pits: Unless otherwise approved by Engineer, successful compaction to be measured by one test per 40 linear feet measured along pipe for compacted embedment and two tests per 40 linear feet measured along pipe for compacted trench zone backfill material. Length of auger pits to be measured to arrive at 40 linear feet.
 - 2. A minimum of three density tests for each full shift of Work.
 - 3. Density tests will be distributed among placement areas. Placement areas are: foundation, bedding, haunching, initial backfill and trench zone.
 - 4. The number of tests will be increased if inspection determines that soil type or moisture content are not uniform or if compacting effort is variable and not considered sufficient to attain uniform density, as specified.
 - 5. Density tests may be performed at various depths below fill surface by pit excavation. Material in previously placed lifts may therefore be subject to acceptance/rejection.
 - 6. Two verification tests will be performed adjacent to in-place tests showing density less than acceptance criteria. Placement will be rejected unless both verification tests show acceptable results.
 - 7. Recompacted placement will be retested at same frequency as first test series, including verification tests.
 - 8. Identify elevation of test with respect to natural ground or pavement.
 - F. Recondition, re-compact, and retest at Contractor's expense if tests indicate Work does not meet specified compaction requirements. For hardened soil cement with nonconforming density, core and test for compressive strength at Contractor's expense.
- 3.12 DISPOSAL OF EXCESS MATERIAL
- A. Dispose of excess materials at a permitted site in accordance with federal, state, and local regulations.

END OF SECTION 33 23 17

SECTION 33 23 20 – UTILITY BACKFILL MATERIALS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SECTION INCLUDES

A. Material Classifications.

B. Utility Backfill Materials:

1. Select trench material
2. Concrete, gem, or bank run sand
3. Pea gravel (not used for pipe embedment)
4. Crushed stone (not used for pipe embedment)
5. Crushed concrete (not used for pipe embedment)
6. Select backfill

C. Material Handling and Quality Control Requirements.

1.03 DEFINITIONS

A. Unsuitable Material:

1. Materials classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.
2. Materials that cannot be compacted to required density due to gradation, plasticity, or moisture content.
3. Materials containing large clods, aggregates, or stones greater than 4 inches in any dimension; debris, vegetation, or waste; or any other deleterious materials.
4. Materials contaminated with hydrocarbons or other chemical contaminants.

B. Suitable Material:

1. Materials meeting specification requirements.
2. Unsuitable materials meeting specification requirements for suitable soils after treatment with lime or cement.

1.04 REFERENCES

A. City of Houston Standard Specification 02320.

1.06 SUBMITTALS

- A. Submit description of source, material classification and product description, production method, gradation analysis, and application of backfill materials.
- B. Before stockpiling materials, coordinate location with Owner.
- C. Provide delivery ticket which includes source location for each delivery of material that is obtained from off-site sources or is being paid as specific bid item.

PART 2 – PRODUCTS

2.01 MATERIAL CLASSIFICATIONS

- A. Classify materials for backfill for purpose of quality control in accordance with Unified Soil Classification Symbols as defined in ASTM D 2487. Material use and application is defined in utility installation specifications and Drawings either by class, as described in Paragraph 2.01B, or by product descriptions, as given in Paragraph 2.02.
- B. Class Designations Based on Laboratory Testing:
 - 1. Class I: Well-graded gravels and sands, gravel-sand mixtures, crushed well-graded rock, little or no fines (GW, SW):
 - a. Plasticity index: non-plastic.
 - b. Gradation: D60/D10 -greater than 4 percent; amount passing No. 200 sieve -less than or equal to 5 percent.
 - 2. Class II: Poorly graded gravels and sands, silty gravels and sands, little to moderate fines (GM, GP, SP, SM):
 - a. Plasticity index: non-plastic to 4.
 - b. Gradations:
 - 1) Gradation (GP, SP): amount passing No. 200 sieve -less than 5 percent.
 - 2) Gradation (GM, SM): amount passing No. 200 sieve -between 12 percent and 50 percent.
 - 3) 3) Borderline gradations with dual classifications (e.g., SP-SM): amount passing No. 200 sieve -between 5 percent and 12 percent.
 - 3. Class III: Clayey gravels and sands, poorly graded mixtures of gravel, sand, silt, and clay (GC, SC, and dual classifications, e.g., SP-SC):
 - a. Plasticity index: greater than 7.
 - b. Gradation: amount passing No. 200 sieve -between 12 percent and 50 percent.
 - 4. Class IVA: Lean clays (CL).
 - a. Plasticity Indexes: 1) Plasticity index: greater than 7, and above A line. 2) Borderline plasticity with dual classifications (CL-ML): PI between 4 and 7.
 - b. Liquid limit: less than 50.
 - c. Gradation: amount passing No. 200 sieve -greater than 50 percent.
 - d. Inorganic.
 - 5. Class IVB: Fat clays (CH)
 - a. Plasticity index: above A line.
 - b. Liquid limit: 50 or greater.
 - c. Gradation: amount passing No. 200 sieve -greater than 50 percent.
 - d. Inorganic.
 - 6. Use soils with dual class designation according to ASTM D 2487, and which are not defined above, according to more restrictive class.

2.02 PRODUCT DESCRIPTIONS

- A. Soils classified as silt (ML) silty clay (CL-ML with PI of 4 to 7), elastic silt (MH), organic clay and organic silt (OL, OH), and organic matter (PT) are not acceptable as backfill materials. These soils may be used for site grading and restoration in unimproved areas as approved by Project Manager. Soils in Class IVB, fat clay (CH) may be used as backfill materials where allowed by applicable backfill installation specification. Refer to Section 33 23 17 -Excavation and Backfill for Utilities.

- B. Provide backfill material that is free of stones greater than 6 inches, free of roots, waste, debris, trash, organic material, unstable material, non-soil matter, hydrocarbon or other contamination, conforming to following limits for deleterious materials:
1. Clay lumps: Less than 0.5 percent for Class I, and less than 2.0 percent for Class II, when tested in accordance with ASTM C 142.
 2. Lightweight pieces: Less than 5 percent when tested in accordance with ASTM C 123.
 3. Organic impurities: No color darker than standard color when tested in accordance with ASTM C 40.
- C. Manufactured materials, such as crushed concrete, may be substituted for natural soil or rock products where indicated in product specification, and approved by Project Manager, provided that physical property criteria are determined to be satisfactory by testing.
- D. Bank Run Sand: Durable bank run sand classified as SP, SW, or SM by Unified Soil Classification System (ASTM D 2487) meeting following requirements:
1. Less than 15 percent passing number 200 sieve when tested in accordance with ASTM D 1140. Amount of clay lumps or balls may not exceed 2 percent.
 2. Material passing number 40 sieve shall meet the following requirements when tested in accordance with ASTM D 4318: Plasticity index: not exceeding 7.
- E. Concrete Sand: Natural sand, manufactured sand, or combination of natural and manufactured sand conforming to requirements of ASTM C 33 and graded within following limits when tested in accordance with ASTM C 136:

Sieve	Percent Passing
3/8"	100
No. 4	95 to 100
No. 8	80 to 100
No. 16	50 to 85
No. 30	25 to 60
No. 50	10 to 30
No. 100	2 to 10

- F. Gem Sand: Sand conforming to requirements of ASTM C 33 for course aggregates specified for number 8 size and graded within the following limits when tested in accordance with ASTM C 136:

Sieve	Percent Passing
3/8"	95 to 100
No. 4	60 to 80
No. 8	15 to 40

- ~~G. Pea Gravel: Durable particles composed of small, smooth, rounded stones or pebbles and graded within the following limits when tested in accordance with ASTM C 136:~~

Sieve	Percent Passing
1/2"	100

3/8"	85 to 100
No. 4	10 to 30
No. 8	0 to 10
No. 16	0 to 5

- H. Select Backfill: Class III clayey gravel or sand or Class IV lean clay with plasticity index between 7 and 20 or clayey soils treated with lime to meet plasticity criteria.
- ~~I. Cement Stabilized Sand: Conform to requirements of Specification 33 23 21 Cement Stabilized Sand.~~
- ~~J. Concrete Backfill: Conform to Class B concrete as specified in Specification 33 40 00 Hydraulic Cement Concrete.~~
- ~~K. Flexible Base Course Material: Conform to requirements of applicable portions of Specification 31 20 20 Flexible Base.~~

PART 3 – EXECUTION

3.01 SOURCES

- A. Use of existing material in trench excavations is acceptable, provided applicable specification requirements are satisfied.
- B. Identify off-site sources for backfill materials at least 14 days ahead of intended use so that Owner may obtain samples for verification testing.
- C. Materials may be subjected to inspection or additional verification testing after delivery. Materials which do not meet requirements of specifications will be rejected. Do not use material which, after approval, has become unsuitable for use due to segregation, mixing with other materials, or by contamination.
- D. Owner does not represent or guarantee that any soil found in excavation work will be suitable and acceptable as backfill material.

3.02 MATERIAL HANDLING

- A. Establish temporary stockpile locations for practical material handling and control in advance of final placement.

END OF SECTION 33 23 20

SECTION 33 25 06 – POLYVINYL CHLORIDE PIPE

PART 1 – GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 DESCRIPTION

- A. Polyvinyl chloride sewer pipe for gravity sewers in nominal diameters 4 inches through 12 inches.

1.03 REFERENCES

- A. City of Houston Standard Specification 02506.

1.04 SUBMITTALS

- A. Submit shop drawings showing design of new pipe and fittings indicating alignment and grade, laying dimensions, fabrication, fittings, flanges, and special details.

1.05 QUALITY CONTROL

- A. Submit manufacturer's certifications that PVC pipe and fittings meet requirements of this Section and ASTM D3034, ASTM D3212, ASTM F477 for specified for gravity storm pipe.

PART 2 - PRODUCTS

2.01 MATERIAL

- A. Use PVC compounds in manufacture of pipe that contain no ingredient in amount that has been demonstrated to migrate into water in quantities considered to be toxic.
- B. Furnish PVC pipe manufactured from Class 12454-A or Class 12454-B virgin PVC compounds as defined in ASTM D 3034. Use compounds qualifying for rating of 4000 psi for water at 73.4 F per requirements of PPI TR3. Provide pipe which is homogeneous throughout, free of voids, cracks, inclusions, and other defects, uniform as commercially practical in color, density, and other physical properties. Deliver pipe with surfaces free from nicks and scratches with joining surfaces of spigots and joints free from gouges and imperfections which could cause leakage.
- C. PVC Pipe:
 - 1. Pipe Material: SDR 26
- D. Gaskets:
 - 1. Gaskets shall meet requirements of ASTM F 477. Use elastomeric factory-installed gaskets to make joints flexible and watertight.
 - 2. Flat Face Mating Flange: Full faces 1/8-inch-thick ethylene propylene (EPR) rubber.
 - 3. Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EDR) rubber, with filler gasket between OD of raised face and flange OD to protect flange from bolting moment.

- E. Lubricant for rubber-gasketed joints: Water soluble, non-toxic, non-objectionable in taste and odor imparted to fluid, non-supporting of bacteria growth, having no deteriorating effect on PVC or rubber gaskets.
- F. Do not use PVC in potentially or known contaminated areas.
- G. Do not use PVC in areas exposed to direct sunlight.

2.03 GRAVITY STORM SEWER PIPE

- A. PVC gravity storm sewer pipe shall be in accordance with provisions in following table:

WALL CONSTRUCTION	ASTM DESIGNATION	SDR (MAX.)/ STIFFNESS (MIN.)	DIAMETER SIZE RANGE
Solid	D3034	SDR 26 / PS 115	4" to 12"

- B. Joints: Spigot and integral wall section bell with solid cross section elastomeric or rubber ring gasket conforming to requirements of ASTM D 3212 and ASTM F 477, or ASTM D 3139 and ASTM F 477. Gaskets shall be factory-assembled and securely bonded in place to prevent displacement. Manufacturer shall test sample from each batch conforming to requirements ASTM D 2444.
- A. Fittings: All fitting for PVC pipe shall conform to ASTM D3212. PVC pipe fittings shall be full-bodied, either injection molded or factory fabricated. Saddle-type tee or wye fittings are not acceptable.
- C. Conditioning. Conditioning of samples prior to and during tests is subject to approval by Project Manager. When referee tests are required, condition specimens in accordance with Procedure A in ASTM D 618 at 73.4 degrees F plus or minus 3.6 degrees F and 50 percent relative humidity plus or minus 5 percent relative humidity for not less than 40 hours prior to test. Conduct tests under same conditions of temperature and humidity unless otherwise specified.
- D. Pipe Stiffness. Determine pipe stiffness at 5 percent deflection in accordance with Test Method D 2412. Minimum pipe stiffness shall be 115 psi. For diameters 4 inches through 18 inches, test three specimens, each a minimum of 6 inches (152 mm) in length.
- E. Flattening. Flatten three specimens of pipe in suitable press until internal diameter has been reduced to 60 percent of original inside diameter of pipe. Rate of loading shall be uniform. Test specimens, when examined under normal light and with unaided eye, shall show no evidence of splitting, cracking, breaking, or separation of pipe walls or bracing profiles. Perform the flattening test in conjunction with pipe stiffness test.
- F. Joint Tightness. Test for joint tightness in accordance with ASTM D 3212, except that joint shall remain watertight at minimum deflection of 5 percent. Manufacturer will be required to provide independent third party certification for joint testing each diameter of storm sewer pipe.
- G. Purpose of Tests. Flattening and pipe stiffness tests are intended to be routine quality control tests. Joint tightness test is intended to qualify pipe to specified level of performance.

PART 3 – EXECUTION

3.01 PROTECTION

- A. Store pipe under cover out of direct sunlight and protect from excessive heat or harmful chemicals in accordance with manufacturer's recommendations.

3.02 INSTALLATION

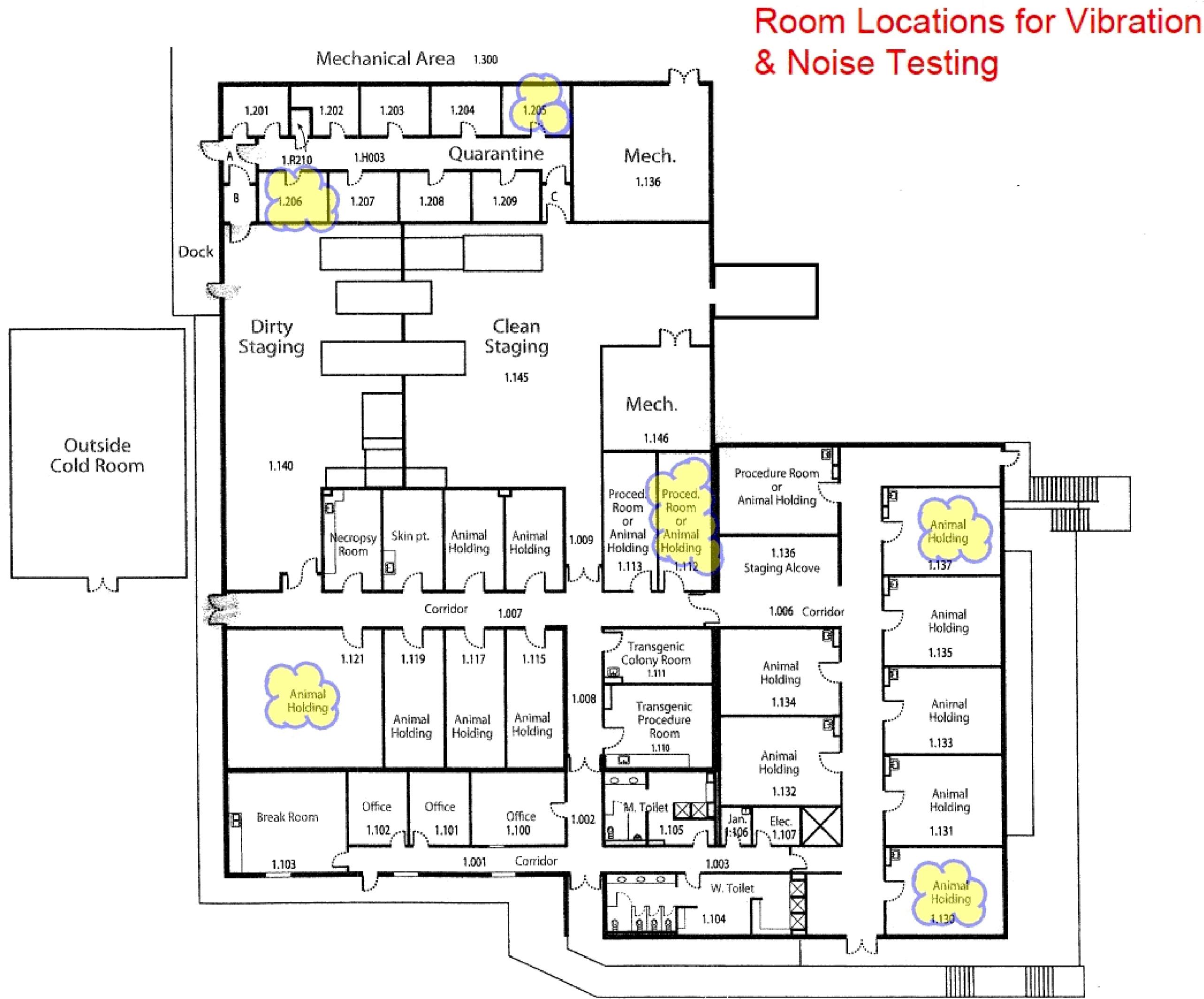
- A. Install PVC pipe in accordance with Specification 33 23 17 -Excavation and Backfill for Utilities and manufacturer's recommendations.
- B. Install PVC per grades indicated on plans, clear utility lines and have minimum depth of cover below finished grade of 12 inches of cover.
- C. Avoid imposing strains that will overstress or buckle pipe when lowering pipe into trench.
- D. Hand shovel pipe bedding under pipe haunches and along sides of pipe barrel and compact to eliminate voids and ensure side support.
- E. Store PVC pipe under cover out of direct sunlight. Protect pipe from excessive heat or harmful chemicals. Prevent damage by crushing or piercing.
- F. Allow PVC pipe to cool to ground temperature before backfilling when assembled out of trench to prevent pullout due to thermal contraction

3.03 PVC RESTRAINED MECHANISM

- A. Do not apply lubricant to spline or pipe or coupling spline grooves.
- B. Do not use excessive force while inserting the spline through coupling.
- C. Insert spline until it is fully seated around circumference of pipe.
- D. Field Cutting of Pipe Ends:
 - 1. Perform by workers certified by manufacturer.
 - 2. Use a PVC pipe cutter and provide square ends.
 - 3. Use manufacturer approved power routing and grooving tool to field fabricate required pipe groove.

END OF SECTION 33 25 06

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**ROOM LOCATIONS FOR
VIBRATION AND NOISE TESTING**
NOT TO SCALE

OWNER CONSTRUCTION PARAMETERS

1. REFER ALSO TO GENERAL MECHANICAL NOTES ON SHEET MP4.1
2. THE GRIFFIN ANIMAL BUILDING IS AN ACTIVE 24/7 ANIMAL VIVARIUM BUILDING. THE CONTRACTOR SHALL COMMUNICATE AND SEEK APPROVAL IN ADVANCE FROM BOTH THE PROJECT MANAGER AND THE ASSOCIATE DIRECTOR-ANIMAL FACILITY, DALE WEISS, FOR NOISE AND VIBRATION PRODUCING ACTIVITIES THAT COULD POTENTIALLY STRESS THE ANIMALS. CONTRACTOR SHALL PROVIDE SUFFICIENT NOTICE (48 HOURS MINIMUM) OF UPCOMING POTENTIAL CONSTRUCTION ACTIVITIES THAT COULD STRESS THE ANIMALS. BOTTOM-LINE, USE GOOD JUDGMENT AND COMMON SENSE.
3. OWNER OR OWNERS 3RD PARTY INDEPENDENT CONSULTANT/CONTRACTOR SHALL PROVIDE SELECTIVE VIBRATION AND NOISE MONITORING (DURING NORMAL WORKING HOURS) FOR SELECTIVE DEMOLITION AND RENOVATION ACTIVITIES THAT COULD POTENTIALLY CREATE UNDESIRABLE EFFECTS.
 - A. STRUCTURAL VIBRATION THRESHOLD LIMITS SHALL NOT EXCEED 50 MICRO METERS PER SECOND WHICH EQUATES TO APPROXIMATELY 2,000 MIPS (MICRO INCHES PER SECOND) AS SET FORTH BY THE DESIGN GUIDELINES BY THE NATIONAL INSTITUTES OF HEALTH (NIH).
 - B. NOISE LEVELS FOR ANY CONSTRUCTION ACTIVITY SHALL NOT EXCEED 80 DECIBELS, AS MEASURED IN THE BUILDING AT LOCATIONS CLOUDED ON PLAN 01, THIS SHEET. CONSULTANT SHALL MEASURE NOISE IN THE FREQUENCY RANGE OF 400 HZ TO 100 KHZ.
4. USE OF IMPACT EQUIPMENT (HAMMER DRILLS AND JACK HAMMERS FOR EXAMPLE) IS NOT ALLOWED FOR WORK ACTIVITY INSIDE OR BENEATH THE ANIMAL BUILDING. CONTRACTOR SHALL TAKE PROACTIVE MEASURES TO ATTENUATE EQUIPMENT AND/OR CONSTRUCTION ACTIVITIES THAT COULD BE EXCEPTIONALLY LOUD AND PRODUCE UNACCEPTABLE VIBRATIONS.
 - A. USE OF IMPACT EQUIPMENT OUTSIDE THE BUILDING (I.E. AREAWAY CONSTRUCTION) IS PERMISSIBLE PROVIDED ABOVE VIBRATION/NOISE THRESHOLDS ARE NOT EXCEEDED. HOWEVER USE OF ANY IMPACT EQUIPMENT NECESSARY TO INSTALL FASTENERS AND OTHER ATTACHMENTS TO THE BUILDING'S EXTERIOR WALL WITHIN THE PROXIMITY OF ANIMAL HOLDING ROOMS IS NOT PERMISSIBLE. CONTRACTOR SHALL COORDINATE WITH ASSOCIATE DIRECTOR-ANIMAL FACILITY AND PROJECT MANGER TO DETERMINE ACCEPTABLE LOCATIONS PRIOR TO IMPLEMENTATION OF WORK.
 - B. CONTRACTOR SHALL NOT BEAT ON EXISTING AND/OR NEW PIPES WITH A HAMMER OR OTHER OBJECTS INSIDE OR BENEATH THE BUILDING. THESE SOUNDS AND VIBRATIONS WILL TRAVEL THROUGHOUT THE BUILDING.
6. ALL CONTRACTORS/CONSULTANTS COMING FROM DIRTY/CONTAMINATED AREAS THAT REQUIRE ACCESS/ENTRY INTO CLEAN ROOM AREAS SHALL WEAR SLIP ON SHOE BOOTIES (PROVIDED BY OWNER) PRIOR TO ENTERING CLEAN AREA TO AVOID CROSS CONTAMINATION. CONTRACTORS SHALL WEAR NEW SLIP ON SHOE BOOTIES (REUSING BOOTIES IS NOT ACCEPTABLE) EACH TIME REQUIRING RE-ENTRY FROM DIRTY SIDE TO CLEAN SIDE.
7. ALL CONTRACTORS/CONSULTANTS ARE REQUIRED TO REQUEST THE ROOM ENTRY ORDER LIST FROM THE M.D. ANDERSON PROPERTY MANAGER OR ANIMAL FACILITY DIRECTOR WHEN IT IS NECESSARY TO TO ENTER MULTIPLE ANIMAL ROOMS ON THE SAME DAY. THE ROOM ENTRY LIST IS THE ALLOWABLE ENTRY ORDER FOR ANIMAL ROOMS AND PREVENTS CROSS CONTAMINATION AMONG THE ANIMALS. PERSONNEL ENTERING INTO ANIMAL ROOMS SHALL DO SO ACCORDING TO THE ENTRY LIST. IF THEY NEED TO RE-ENTER A ROOM THAT IS LOWER ON THE ENTRY LIST, EITHER DIFFERENT PERSONNEL WILL NEED TO DO THE ENTRY OR THEY WILL NEED TO SHOWER TO PREVENT CONTAMINATION.

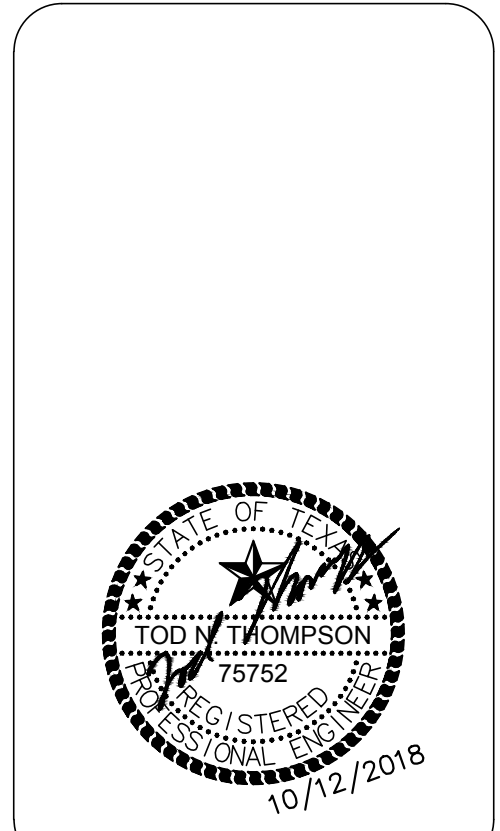
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Engineers, Inc.

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PROJECT
**GRIFFIN ANIMAL BUILDING
CRAWLSPACE IMPROVEMENTS**
M.D. ANDERSON CANCER CENTER - SMITHVILLE, TEXAS
MDACC PROJECT NO. 15-0005

DATE
OCTOBER 12, 2018



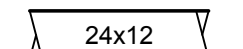
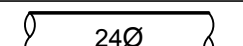
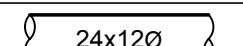
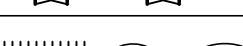
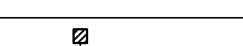
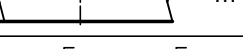
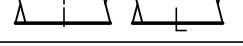
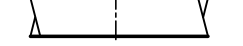
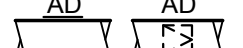
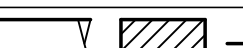
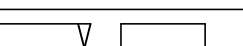
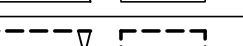
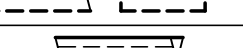
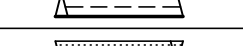
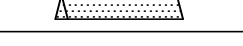
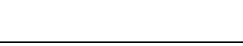
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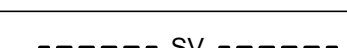
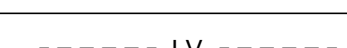
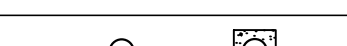
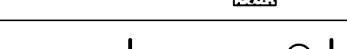
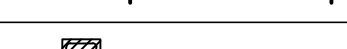
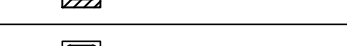
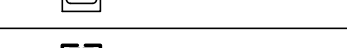
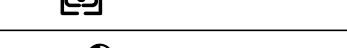
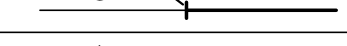
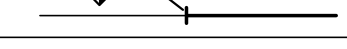
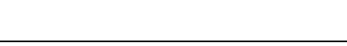
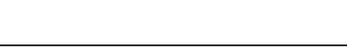
100% CONSTRUCTION DOCUMENTS

OWNER
CONSTRUCTION
PARAMETERS

SHEET NUMBER
MPE1.1

P:\M&A GRIFIN BUILDING CRAWLSPACE - 1311_00.DWG, Last saved by: jerry on Fri, Oct 12, 2018, Last Plotted by: Jerry McGovern on Fri, October 12, 2018, Layout: MPE1.2
ATTACHED REFS: X-TBLK-24X36-1311_00

MECHANICAL SYMBOLS LEGEND		
SYMBOL	DESCRIPTION	ABBREV.
	SUPPLY, OUTSIDE AIR DUCT / DEVICE	SA, OA
	RETURN, RELIEF AIR DUCT / RETURN AIR DEVICE	RA, RELA
	EXHAUST AIR DUCT / DEVICE	EA OR EXH.
	RECTANGULAR DUCT DIMENSION	
	ROUND DUCT DIMENSION	
	FLAT OVAL DIMENSION	
	TURNING VANES, ACOUSTICAL TURNING VANES WHERE INDICATED	TV, ATV
	NEW FLEX DUCT, EXISTING FLEX DUCT	
	CONTROL DAMPER WITH ACTUATOR	CD
	MANUAL BALANCING DAMPER WITH QUADRANT, SLIDING GUILLOTINE DAMPER	BD, GD
	MANUAL BALANCING DAMPER WITH REMOTE OPERATOR	BD WRDO
	DUCT ACCESS DOOR	AD
	AIR FLOW DIRECTION	
	THERMOSTAT OR TEMPERATURE SENSOR	TSTAT
	NEW DUCT, EQUIPMENT, PIPING, ETC. (HEAVY LINE WEIGHT)	
	EXISTING DUCT, EQUIPMENT, PIPING, ETC. TO REMAIN (LIGHT LINE WEIGHT)	
	EXISTING DUCT, EQUIPMENT, PIPING, ETC. TO BE REMOVED (MEDIUM LINE WEIGHT / BROKEN LINES)	
	INTERNAL DUCT LINER (INTERIOR BROKEN LINES)	
	CLEAN/COAT/DISINFECT EXISTING TO REMAIN INTERNALLY LINED DUCT	
	POINT OF CONNECTION, NEW TO EXISTING	
	POINT OF DEMOLITION, DEMO TO EXISTING	
	EXISTING TO REMAIN	ETR
	EXISTING, EXISTING RELOCATED	EX, ER
	ABOVE FINISHED FLOOR, ABOVE FINISHED GRADE	AFF, AFG
	BOTTOM OF DUCT	BOD
	BOTTOM OF PIPE	BOP
ALL SYMBOLS MAY NOT APPEAR ON PLANS		

PLUMBING SYMBOLS LEGEND		
SYMBOL	DESCRIPTION	ABBREV.
	SANITARY (BROKEN LINE INDICATES PIPING BELOW FLOOR)	SAN
		
		
		
		
	FLOOR CLEANOUT, EXTERIOR CLEANOUT W/ CONCRETE PAD	FCO
	CLEANOUT, WALL CLEANOUT	CO, WCO
	NEW FIXTURE, PIPING, ETC.	
	EXISTING FIXTURE, PIPING, ETC. TO REMAIN	
	EXISTING FIXTURE, PIPING, ETC. TO BE REMOVED	
	POINT OF CONNECTION, NEW TO EXISTING	
	POINT OF DEMOLITION, DEMO TO EXISTING	
	EXISTING, EXISTING TO REMAIN	EX, ETR
	ABOVE FINISHED FLOOR, ABOVE FINISHED GRADE	AFF, AFG
	AUTHORITY HAVING JURISDICTION	AHJ
	BELOW FINISHED FLOOR, BELOW FINISHED GRADE	BFF, BFG
	CLEANOUT, CLEANOUT TO GRADE	CO, COTG
	DRAINAGE FIXTURE UNITS, WATER FIXTURE UNITS	DFU, WFU
	FINISHED FLOOR ELEVATION	FFE
	INVERT ELEVATION (BOTTOM INSIDE OF PIPE WHERE WATER FLOWS)	IE, INV
	TOP OF FINISHED GRADE	TOFG
	VENT THROUGH ROOF	VTR
	FLOW LINE ELEVATION	FL
ALL SYMBOLS MAY NOT APPEAR ON PLANS		

GENERAL MECHANICAL NOTES:

REFER ALSO TO GENERAL DEMOLITION NOTES ON THIS SHEET.

- ALL SYSTEMS:
 - READ THE SPECIFICATIONS.
 - EXISTING SYSTEMS: LOCATIONS OF EXISTING MECHANICAL SYSTEMS WERE TAKEN FROM A COMBINATION OF VISUAL SURVEY AND THE ORIGINAL DRAWINGS. CONTRACTOR TO FIELD VERIFY EXISTING SYSTEMS. WHERE REQUIRED, MODIFY SCOPE AND LIMITS OF CONSTRUCTION AND DEMOLITION TO ACCOMMODATE INTENDED FINISHED CONDITIONS. TYPICAL THROUGHOUT PROJECT. CONTACT ENGINEER/ARCHITECT FOR CLARIFICATIONS AS NEEDED.
 - FIELD VERIFICATION: FIELD VERIFY EXACT LOCATION OF EXISTING DUCTWORK, PIPING, AND CONDUIT. RAISE/LOWER/OFFSET OR RE-ROUTE EXISTING PIPING, DUCT, AND CONDUIT (COORDINATE WITH DIVISIONS 22 AND 26) AS NEEDED TO AVOID CONFLICTS WITH OTHER SYSTEMS AND TO ACCOMMODATE FINISHED CONSTRUCTION.
- COORDINATION:
 - ROUTING: CLOSELY COORDINATE ROUTING OF EXISTING DIVISION 23 PIPING AND DUCTWORK WITH STRUCTURAL, ELECTRICAL, FIRE, AND OTHER TRADES. OFFSET PROPERLY (PER SPECIFICATIONS AND SMACNA) AS REQUIRED TO AVOID CONFLICTS WHERE NOT OTHERWISE RESOLVABLE.
 - TIGHT CONDITIONS: JOB CONDITIONS OCCUR WHICH RESULT IN INORDINATELY LIMITED SPACE FOR SYSTEM INSTALLATION WHICH ALSO PERMITS SERVICE/MAINTENANCE. UTMOST ATTENTION SHALL BE REQUIRED FOR ALL ELEMENTS OF CONSTRUCTION, BUT ESPECIALLY PLANNING, COORDINATION AND TRADES WORKMANSHIP.
- CONTROLS:
 - ELECTRICAL CIRCUITS: WHERE A SPECIFIC ELECTRICAL CIRCUIT IS DESIGNATED ON DRAWINGS FOR "HVAC CONTROLS," THAT CIRCUIT IS TO BE USED FOR THE DDC CONTROLLER(S) FOR THE RESPECTIVE EQUIPMENT/AREA.
 - DEDICATED CIRCUITS: USE ONLY DEDICATED ELECTRICAL BRANCH CIRCUITS FOR CONTROLS SYSTEM, OBTAINED FROM PANEL BOARDS SERVING "HVAC CONTROLS," WHERE NOT PROVIDED BY ELECTRICAL TRADES, PROVIDE UNDER THE CONTROLS TRADE 120 VAC POWER TO HVAC CONTROLS, AS REQUIRED FOR FIELD PARTICULARS. PROVIDE CONTROL TRANSFORMERS AS REQUIRED FOR 120V CIRCUITS SERVING LOW VOLTAGE CONTROLS ACTUATORS/EQUIPMENT. LOCATE ALL CONTROL TRANSFORMERS, UPSs, AND CONTROLLERS IN MECHANICAL ROOM 1.146.
- DAMPERS:
 - BALANCING: PROVIDE BALANCING DAMPERS AT ALL CONNECTIONS OF SUPPLY DUCT TAPS TO TRUNKBRANCH DUCTS. NOTE THAT ALL SUCH DAMPERS MAY NOT BE SPECIFICALLY SHOWN.
- DUCTWORK:
 - INSULATION: VENTILATION SUPPLY AND EXHAUST SYSTEMS IN CRAWL SPACES ARE UNINSULATED.
 - LOCATIONS: IN GENERAL, PLACE DUCTWORK HIGH/NEAR TO STRUCTURE ABOVE AS REQUIRED TO ALLOW GENEROUS CLEARANCE BETWEEN UNDERSIDE OF DUCT AND BOTTOM OF CRAWL SPACE.
 - METAL GAUGES: MINIMUM SHEET METAL GAUGE SHALL BE 26 GA. USE HEAVIER GAUGES AS REQUIRED TO CONFORM TO SMACNA STANDARDS.
- EQUIPMENT:
 - DUCT CONNECTIONS/TRANSITIONS: TRANSITION TO CONNECTION SIZES OF FANS, ETC. AS REQUIRED. COORDINATE EXACT LOCATION OF EQUIPMENT AND ASSOCIATED OPENINGS WITH STRUCTURAL AND ARCHITECTURAL.
- PHASING:
 - DISRUPTION OF SERVICES: COORDINATE WITH GENERAL CONTRACTOR/CONSTRUCTION MANAGER FOR SCHEDULING ANYALL DOWNTIMES OR DISRUPTIONS OF SERVICES. ALL DISRUPTIONS MUST BE KEPT TO A MINIMUM DURATION. CONTRACTOR SHALL USE MULTIPLE SHIFTS FOR ALL TRADES WHERE REQUIRED TO ACCOMPLISH OWNER'S LIMITATION OF DOWNTIME/DISRUPTIONS.

GENERAL MECHANICAL DEMOLITION NOTES:

REFER ALSO TO GENERAL MECHANICAL NOTES ON THIS SHEET.

- READ THE SPECIFICATIONS.
- LOCATIONS OF MECHANICAL SYSTEMS WERE TAKEN FROM A COMBINATION OF VISUAL SURVEY AND THE ORIGINAL DRAWINGS. CONTRACTOR TO FIELD VERIFY EXISTING SYSTEMS. WHERE REQUIRED, MODIFY LIMITS OF DEMOLITION AND CONSTRUCTION TO ACCOMMODATE INTENDED FINISHED CONDITIONS. (INTENT IS TO REMOVE ALL ITEMS IN AREA OF RENOVATION THAT WILL NOT BE REUSED, EXCEPT AS SHOWN OTHERWISE. ABANDONING IN PLACE IS NOT ACCEPTABLE UNLESS SPECIFICALLY NOTED.) TYPICAL THROUGHOUT PROJECT. CONTACT ENGINEER/ARCHITECT FOR CLARIFICATIONS AS NEEDED.
- NOT ALL EXISTING DUCTWORK/PIPING/SYSTEMS ARE SHOWN. VERIFY ON-SITE ALL SYSTEMS AND CONDITIONS AFFECTED BY NEW CONSTRUCTION. FOR SIZES OF EXISTING DUCTS AND PIPES TO BE REMOVED AND ALL FLOW QUANTITIES, REFER TO ORIGINAL BASE BUILDING MECHANICAL PLANS (OBTAIN FROM OWNER DURING CONSTRUCTION), OR DETERMINE FROM FIELD INVESTIGATIONS.
- CAP EXISTING PIPES TO REMAIN AT POINTS WHERE BRANCH TAPS ARE REMOVED.
- MARK (E.G., WITH PAINT) ALL SYSTEMS TO BE DEMOLISHED TO RESPECTIVE POINT OF DEMOLITION AND REVIEW LIMITS OF DEMOLITION WHERE UNCERTAINTY MAY EXIST WITH OWNER AND ENGINEER PRIOR TO START OF WORK.
- REMOVE ALL EXISTING DEBRIS/ABANDONED MATERIAL FROM CRAWLSPACE.

MECHANICAL CONTROL NOTES:

- CRAWLSPACE SUPPLY AND EXHAUST FANS SHALL BE CONTROLLED BY A TEMPERATURE SENSOR IN NEW AREAWAY. FANS SHALL RUN CONTINUOUSLY AT TEMPERATURES >42°F AND SHALL BE DE-ENERGIZED AT TEMPERATURES ≤ 42°F.
- PROVIDE FAN STATUS AND FAN START/STOP FOR EACH FAN, TEMPERATURE SENSOR SETPOINT, TEMPERATURE SENSOR READING POINT, AND HUMIDITY SENSOR READING POINT AT BAS. PROVIDE NEW CONTROLLER TO RECEIVE POINTS IN MECHANICAL ROOM 1.146.

GENERAL CONSTRUCTION AND PHASING NOTES:

REFER ALSO TO GENERAL MECHANICAL NOTES ON THIS SHEET.

- READ THE SPECIFICATIONS.
 - THE GRIFFIN BUILDING IS A VIVARUM AND REQUIRES 24 HOURS/365 DAYS PER YEAR OPERATION.
 - OPERATIONS WITHIN THE GRIFFIN BUILDING ARE VERY SENSITIVE TO NOISE AND VIBRATION. THE CONTRACTOR SHALL PROVIDE MEANS OF MEASURING AND RECORDING VIBRATION AND NOISE IN ORDER TO MAINTAIN ACCEPTABLE LEVELS OF NOISE AND VIBRATIONS AS REQUIRED BY MD ANDERSON. REFER TO SHEET MPE1.1.
 - THE OPERATIONS WITHIN THE GRIFFIN BUILDING ARE SENSITIVE TO DISRUPTION. THE CONTRACTOR SHALL DEVELOP A PHASING PLAN FOR EACH PORTION OF THE PROJECT. THE PHASING PLAN SHALL BE SUBMITTED TO THE OWNER AND ENGINEER FOR REVIEW AND APPROVAL PRIOR TO BEGINNING WORK.
 - PROVIDE ISOLATION AND CONSTRUCTION VALVES AS REQUIRED TO MINIMIZE DOWN TIME OF EXISTING SYSTEMS AND IMPACT TO BUILDING OPERATIONS.
 - WORK SHOULD BE ACCOMPLISHED DURING NORMAL WORKING HOURS. MD ANDERSON PERSONNEL ARE READILY AVAILABLE DURING THESE HOURS TO RESPOND TO EMERGENCIES OR PROVIDE ASSISTANCE.
 - THE CONTRACTOR SHALL PROVIDE A MINIMUM OF 72 HOURS NOTICE PRIOR TO SHUTDOWN OR IMPACT TO AN EXISTING SYSTEM.
 - ELECTRICAL WORK TO BE DONE WHILE PANELS ARE ENERGIZED. REFER TO ELECTRICAL DRAWING. PROVIDE REQUIRED PERSONAL PROTECTIVE GEAR AS REQUIRED BY NEC, OSHA AND MD ANDERSON.
 - THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL PERSONAL PROTECTIVE EQUIPMENT, TOOLS, EQUIPMENT, AND TRAINING REQUIRED BY OSHA AND MD ANDERSON FOR WORK WHICH INCLUDES BUT IS NOT LIMITED TO WORK ON ENERGIZED EQUIPMENT.
- REFER TO REPORT IN EXHIBIT A OF SPECIFICATIONS, "GRIFFIN FACILITY CRAWLSPACE SOIL AND WATER SAMPLING" BY BAER ENGINEERING. INCORPORATE THE INFORMATION THERE-IN INTO THE JOBSITE SAFETY PROTOCOL FOR ALL WORK IN THE CRAWLSPACE.

REFER TO REPORT IN EXHIBIT A OF SPECIFICATIONS, "GRIFFIN FACILITY CRAWLSPACE SOIL AND WATER SAMPLING" BY BAER ENGINEERING. INCORPORATE THE INFORMATION THERE-IN INTO THE JOBSITE SAFETY PROTOCOL FOR ALL WORK IN THE CRAWLSPACE.

- THE PHASING PLAN SHALL, AT A MINIMUM, INCORPORATE THE FOLLOWING SEQUENCE OF CONSTRUCTION:
 - IMPLEMENT NOISE AND VIBRATION MEASUREMENT PROVISIONS AND CONDUCT PRE-CONSTRUCTION BASELINE TESTING IN ACCORDANCE WITH SHEET MPE1.1.
 - REMOVE EXISTING SIDEWALK AND PROVIDE CONSTRUCTION ACCESS PATH TO CRAWLSPACE AT LOCATION OF AREAWAY. CONSTRUCTION ACCESS TO BE LARGER THAN THE OPENING REQUIRED FOR AREAWAY IF/AS REQUIRED TO ALLOW FULL ACCESS AND PROVIDE FOR TEMPORARY DEHUMIDIFICATION AND EXHAUST SYSTEMS. PROVIDE TEMPORARY CANOPY OVER CONSTRUCTION ACCESS AND TEMPORARY RAISED BARRIER AT PERIMETER TO MINIMIZE WATER INTRUSION INTO OPENING DURING RAIN EVENTS.
 - PROVIDE TEMPORARY DEHUMIDIFICATION UNIT EQUAL TO POLYGON R-5000 DESICCANT DEHUMIDIFIER, BALANCE TO DELIVER 3000 CFM. PROVIDE WITH 200 FT OF FLEXIBLE DUCT (RATED FOR EXTERIOR ENVIRONMENT). PROVIDE TEMPORARY 125 KVA DIESEL GENERATOR HOUSED IN A SOUND ATTENUATING ENCLOSURE TO POWER UNIT. UNIT TO BE SET ON EAST SIDE OF BUILDING NEAR CRAWLSPACE CONSTRUCTION ACCESS POINT. SET UNIT/GENERATOR ON SKID TO ELEVATE OFF OF GRADE. PROVIDE TEMPORARY EXHAUST PROVISIONS (PROPELLER FAN @ 3400 CFM) AT CONSTRUCTION ACCESS POINT. FOR BIDDING PURPOSES PRESUME A TWO (2) MONTH DURATION FOR TEMPORARY SYSTEMS.

PROVIDE TEMPORARY MEASURES TO MINIMIZE LEAKAGE IN EXISTING SANITARY PIPING (HEAVY DUTY TAPE ANTICIPATED).

MONITOR DAILY EXISTING PLUMBING SYSTEMS AS CRAWL SPACE IS VENTILATED AND DRYING ACTIVITIES ARE UNDERWAY. REPAIR PLUMBING LEAKS AS NEEDED.

- CONCURRENT WITH THE CRAWLSPACE DRYING ACTIVITIES, CONSTRUCT ALL EXTERIOR WORK (EXCEPTING THE NEW AREAWAY) INDICATED IN THE CIVIL AND ARCHITECTURAL DRAWINGS.
- ONCE CRAWLSPACE HAS DRIED SUFFICIENTLY (AS DETERMINED BY OWNER'S PROJECT MANAGER AND ENGINEER), ALL CRAWLSPACE WORK INDICATED HERE-IN IS TO BE CONSTRUCTED AS FOLLOWS:
 - PRIOR TO STARTING THE CRAWLSPACE WORK, REMOVE ALL EXISTING DEBRIS AND ABANDONED MATERIALS THROUGHOUT CRAWLSPACE.
 - APPLY SLAB INSULATION PER SHEET W200. (IF ALTERNATE #1 IS ACCEPTED.)
 - CONSTRUCT ALL MECHANICAL AND PLUMBING WORK AS INDICATED HEREIN. TERMINATE DUCTWORK WHERE THE AREAWAY WILL BE CONSTRUCTED FOR FUTURE CONNECTION TO SUPPLY FAN.
 - SHUTDOWN OF EQUIPMENT, FIXTURES, ETC. SERVED BY DRAIN PIPING BEING REPLACED SHALL BE COORDINATED WITH OWNER'S PROJECT MANAGER AT LEAST 72 HOURS IN ADVANCE.
- ONCE CRAWLSPACE WORK IS COMPLETED, CONSTRUCT AREAWAY, COMPLETE THE VENTILATION SUPPLY DUCT SYSTEM AND INSTALL ASSOCIATED SUPPLY AND EXHAUST FANS.
- SAFE, UNOBSTRUCTED ACCESS MUST BE MAINTAINED TO ROOMS M1.136 AND M1.146 FOR OWNER PERSONNEL THROUGHOUT ALL PHASES OF PROJECT.

GENERAL PLUMBING NOTES:

REFER ALSO TO GENERAL DEMOLITION NOTES ON THIS SHEET.

- READ THE SPECIFICATIONS.
- CONTRACTOR SHALL FIELD VERIFY ALL CONDITIONS AND LOCATIONS OF ABOVE GROUND EXISTING EQUIPMENT AND PIPING TO DETERMINE EXACT SIZE AND LOCATION PRIOR TO BID.
- SANITARY WASTE, LAB WASTE, ETC. PIPING 3" AND LESS SHALL BE SLOPED IN THE DIRECTION OF FLOW AT NOT LESS THAN 1/4" PER FOOT. SLOPE PIPING 4" AND LARGER AT NOT LESS THAN 1/8" PER FOOT. PITCH VENT PIPING UPWARD, AWAY FROM FIXTURES.
- COORDINATE WITH G.C./CONSTRUCTION MANAGER FOR SCHEDULING ANYALL DOWNTIMES OR DISRUPTIONS OF SERVICES. ALL DISRUPTIONS MUST BE KEPT TO A MINIMUM DURATION. CONTRACTOR SHALL USE MULTIPLE SHIFTS FOR ALL TRADES WHERE REQUIRED TO ACCOMPLISH OWNER'S LIMITATION OF DOWNTIME/DISRUPTIONS.
- REFER TO SHEET MPE2.1 FOR UNIT PRICING REQUIREMENTS.

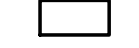
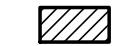
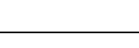
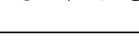
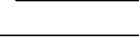
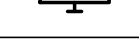
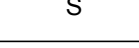
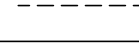
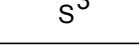
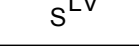
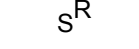
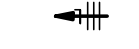
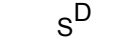
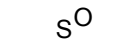
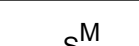
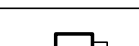
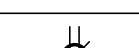
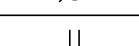
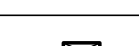
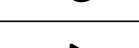
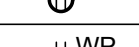
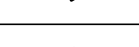
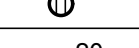
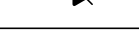
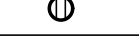
GENERAL PLUMBING DEMOLITION NOTES:

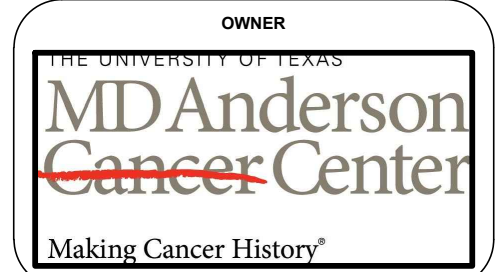
REFER ALSO TO GENERAL PLUMBING NOTES ON THIS SHEET.

- READ THE SPECIFICATIONS.
- LOCATIONS OF PLUMBING SYSTEMS ARE TAKEN FROM A COMBINATION OF VISUAL SURVEY AND ORIGINAL DRAWINGS. CONTRACTOR TO FIELD VERIFY EXISTING SYSTEMS. WHERE REQUIRED, MODIFY LIMITS AND SCOPE OF DEMOLITION AND/OR REPLACE EXISTING PIPING TO ACCOMMODATE INTENDED FINISHED CONSTRUCTION. CAP LINES AS REQUIRED. INTENT IS TO REMOVE ALL PIPING THAT WILL NOT BE IN USE. ABANDONING IN PLACE IS NOT ACCEPTABLE UNLESS SPECIFICALLY INDICATED. TYPICAL THROUGHOUT PROJECT. CONTACT ENGINEER/ARCHITECT FOR CLARIFICATIONS AS NEEDED.
- PRIOR TO OR AS SOON AS POSSIBLE DURING THE COURSE OF DEMOLITION AND/OR CONSTRUCTION, VERIFY ROUTING, SIZES, AND FLOW ELEVATIONS OF EXISTING PIPING SYSTEMS. WHERE PIPING IS BELOW GRADE OR OTHERWISE CONCEALED, CAREFULLY PERFORM SPOT EXCAVATION OR DEMOLITION TO EXPOSE PIPING TO BE VERIFIED.
- MARK (E.G., WITH PAINT) ALL SYSTEMS TO BE DEMOLISHED TO RESPECTIVE POINT OF DEMOLITION AND REVIEW LIMITS OF DEMOLITION WHERE UNCERTAINTY MAY EXIST WITH OWNER AND ENGINEER PRIOR TO START OF WORK.

GENERAL POWER NOTES:

- READ THE SPECIFICATIONS.
- ALL ITEMS SHOWN WITH THIN LINES AND/OR "ETR" DESIGNATION ARE EXISTING TO REMAIN. ALL ITEMS SHOWN WITH THIN LINES AND "ER" DESIGNATION ARE EXISTING RELOCATED/REINSTALLED.
- VERIFY EXACT LOCATIONS, ROUGH-IN REQUIREMENTS, AND FUSE SIZES (WHERE APPLICABLE) FOR ALL DIVISION 22/23 AND OWNER EQUIPMENT PRIOR TO ANY INSTALLATIONS.
- THE ELECTRICAL INSTALLATION SHALL MEET THE STANDARDS PRESCRIBED BY THE LATEST ADOPTED EDITION OF THE NATIONAL ELECTRICAL CODE AND ALL LOCAL AMENDMENTS, ALL APPLICABLE NATIONAL FIRE PROTECTION ASSOCIATION (NFFPA) CODES, AND LOCAL AND STATE BUILDING CODES.
- CONSTRUCTION SHALL BE IN ACCORDANCE WITH STANDARDS AND REQUIREMENTS OF UTILITIES AND AUTHORITIES HAVING JURISDICTION.
- UNLESS OTHERWISE NOTED, CONDUIT SHALL BE CONCEALED AND INSTALLED SQUARE TO BUILDING LINES.
- ALL JUNCTION BOX COVERS SHALL BE PERMANENTLY MARKED TO IDENTIFY PANEL DESIGNATION, EMERGENCY BRANCH, VOLTAGE, AND CIRCUIT NUMBERS. LABEL BLACK FOR NORMAL POWER SYSTEMS.
- PROVIDE ENGRAVED PLASTIC LABELS ON ALL DISCONNECTS, STARTERS, ENCLOSED CIRCUIT BREAKERS, ETC. TO IDENTIFY EQUIPMENT SERVED. PROVIDE LABELS WITH 3/8" HIGH WHITE LETTERS ON BLACK BACKGROUND FOR NORMAL POWER.
- ALL COMBINATION STARTER/DISCONNECT SWITCHES SHOWN ARE 30A/3P DISCONNECT WITH SIZE #0 STARTER, UNLESS NOTED OTHERWISE.
- PROVIDE SUBMITTAL DATA FOR STARTER/DISCONNECT SWITCHES FOR REVIEW AND ACCEPTANCE PRIOR TO PURCHASE AND INSTALLATION.
- SEAL ALL PENETRATIONS INTO THE BUILDING AS REQUIRED TO PROVIDE A WATERTIGHT INSTALLATION.
- REFER TO PHASING REQUIREMENTS, THIS SHEET.

ELECTRICAL SYMBOLS LEGEND			
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	2' x 4' LIGHTING FIXTURE		NEW DEVICE, EQUIPMENT, ETC. (HEAVY LINE WEIGHT)
	LIGHTING FIXTURE WITH BATTERY PACK		EXISTING DEVICE, EQUIPMENT, ETC. TO REMAIN (LIGHT LINE WEIGHT)
	RECESSED DOWNLIGHT		EXISTING DEVICE, EQUIPMENT, ETC. TO BE REMOVED (MEDIUM LINE WEIGHT / BROKEN LINES)
	RECESSED DOWNLIGHT WITH BATTERY PACK		BRANCH CIRCUIT IN CEILING OR WALL
	WALL FIXTURE		BRANCH CIRCUIT BELOW FLOOR/UNDERGROUND
	SINGLE POLE SWITCH, 46" HEIGHT		SWITCHING
	3-WAY SWITCH, 46" A.F.F.		HOMERUN W/ GROUND, NEUTRAL, HOT
	LOW VOLTAGE SWITCH		HOMERUN W/ GROUND, 2 HOTS
	RED SWITCH AND PLATE, EMERGENCY CIRCUIT, 46" A.F.F.		HOMERUN W/ GROUND, 3 HOTS
	DIMMER SWITCH, 46" A.F.F.		EQUIPMENT CONNECTION
	WALL SWITCH TYPE OCCUPANCY SENSOR, 46" A.F.F.		PANELBOARD
	OCCUPANCY SENSOR (CEILING MOUNTED, WALL MOUNTED)		JUNCTION BOX
	DUPLEX RECEPTACLE 20A/120V/1φ, 18" A.F.F.		MANUAL MOTOR RATED SWITCH 20A/120V/1φ, U.N.O.
	RECEPTACLE (RATING NOTED), 208V		DISCONNECT SWITCH
	DUPLEX RECEPTACLE MOUNTED 8" ABOVE COUNTER		COMB. STARTER/DISC. (SIZE AS NOTED)
	TWO DUPLEX RECEPTACLE, 20A/120V		MOTOR CONTROLLER, 3PH.
	TAMPER RESISTANT DUPLEX RECEPTACLE		MOTOR BY OTHERS, CONTRACTOR CONNECTS
	DUPLEX RECEPTACLE W/ GROUND FAULT INTERRUPTER		TELEPHONE OUTLET
	WEATHERPROOF GF DUPLEX RECEPT.		TELEPHONE OUTLET MOUNTED 8" ABOVE COUNTER
	DEDICATED DUPLEX RECEPTACLE, 20A/120V (AMP RATING NOTED)		DATA OUTLET
	ABOVE FINISHED FLOOR		TELE/DATA OUTLET
	ABOVE FINISHED GRADE		EXISTING TO REMAIN
	BELOW FINISHED GRADE		EXISTING RELOCATED/REINSTALLED
ALL SYMBOLS MAY NOT APPEAR ON PLANS			



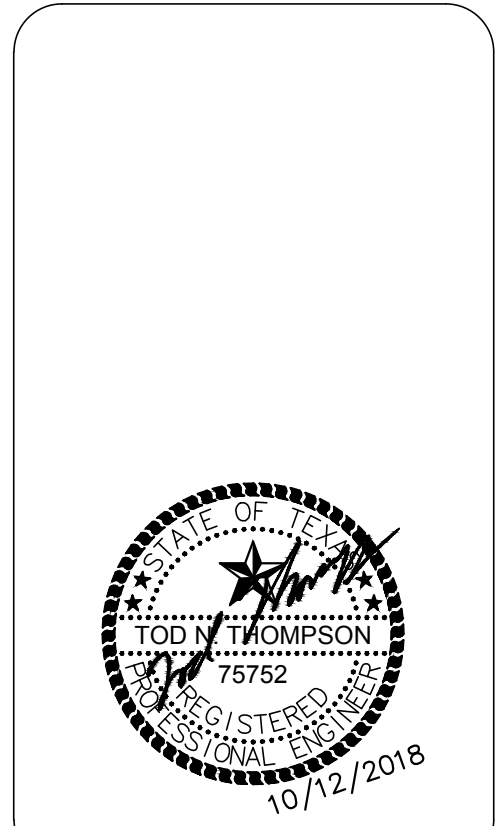
OWNER

PROJECT

GRIFFIN ANIMAL BUILDING CRAWLSPACE IMPROVEMENTS

M.D. ANDERSON CANCER CENTER - SMITHVILLE, TEXAS
MDACC PROJECT NO. 15-0005

DATE
OCTOBER 12, 2018



SCALE: NONE
DRAWN BY: JM
CHECKED BY: TT

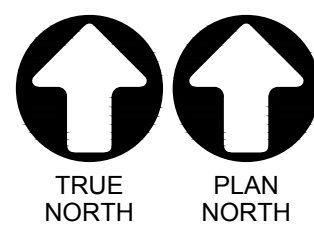
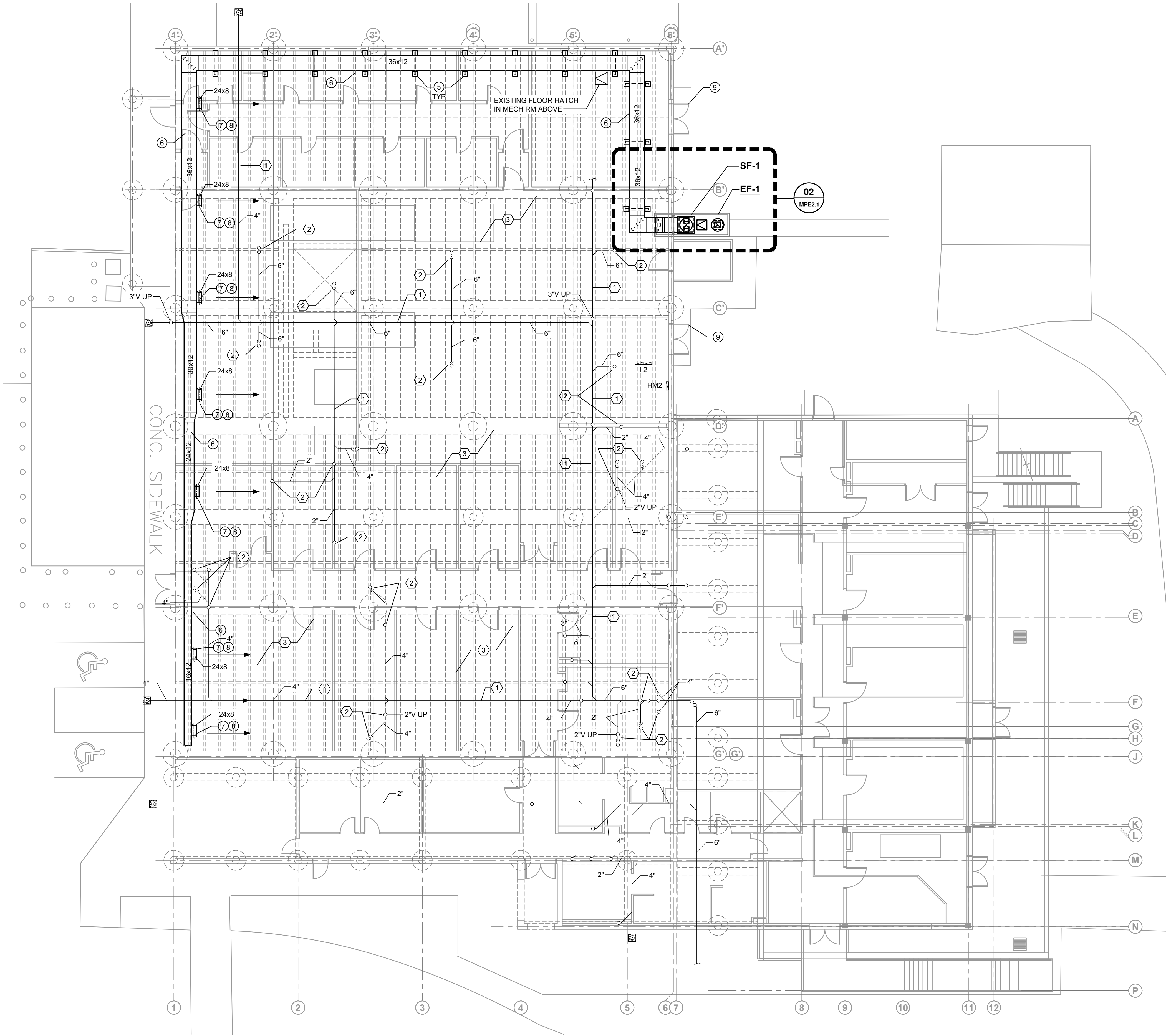
100% CONSTRUCTION DOCUMENTS

SYMBOL LEGEND AND GENERAL NOTES MECH-ELEC-PLBG

SHEET NUMBER

MPE1.2

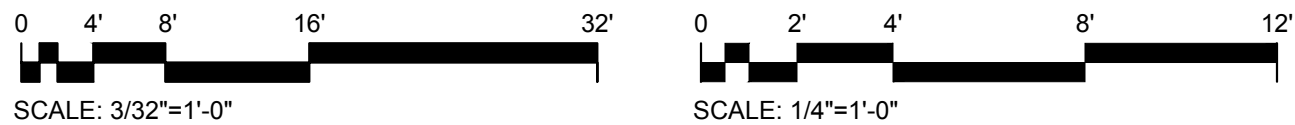
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ATTACHED REFS: X-LEVEL: 1-1311_00 - X-BLANK: 2-2036-1311_00 - X-CRAWLSPACE: 1311_00 - X-BASEMENT: 1-1311_00



01

GRIFIN BUILDING CRAWLSPACE PLAN - MECHANICAL, PLUMBING AND ELECTRICAL

SCALE: 3/32" = 1'-0"



MECHANICAL NOTES:

GENERAL: REFER ALSO TO GENERAL MECHANICAL NOTES AND GENERAL MECHANICAL DEMOLITION NOTES ON SHEET MPE1.2.

1. NEW CONCRETE AREA WAY. SEE ARCHITECTURAL / CIVIL DRAWINGS.
2. NEW 24" X 24" ACCESS HATCH.
3. MOUNT EQUIPMENT ON NEW 12" HIGH CURB. SEAL CURB TO TOP OF CONCRETE AREAWAY WEATHER AND WATER TIGHT. REFER TO ARCHITECTURAL.
4. PROVIDE FLEXIBLE CANVAS CONNECTION IN VERTICAL DUCT. MAINTAIN MINIMUM OF 2" SEPARATION BETWEEN DUCT AND SURFACE OF AREAWAY TOP AND SIDES.
5. PORTABLE DUCT SUPPORT SYSTEM EQUAL TO PHP-D. SPACE EQUALLY AT 10'-0" CENTERS. NOT ALL ARE SHOWN FOR DRAWING CLARITY.
6. ROUTE NEW GALVANIZED STEEL DUCTWORK BELOW FLOOR IN THIS VICINITY.
7. PROVIDE VOLUME DAMPER IN THROAT OF TAP. SIZE INDICATED. PROVIDE 14" GALVANIZED HARDWARE CLOTH IN A REMOVABLE FRAME OVER END OF TAP. FRAME SHALL BE 3/4" ANGLE IRON. TYPICAL.
8. BALANCE TO 450 CFM.
9. MAINTAIN SAFE, UNOBSTRUCTED ACCESS INTO MECHANICAL ROOMS 1.136 AND 1.146 FOR MDA PERSONNEL AT ALL TIMES.
10. LOCATE TEMPORARY DE-HUMIDIFIER/GENERATOR IN THIS VICINITY. COORDINATE EXACT LOCATION WITH MDA PROJECT MANAGER.

PLUMBING NOTES:

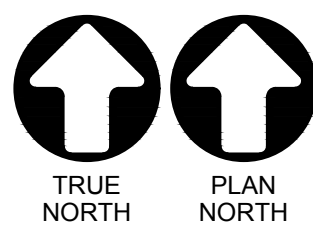
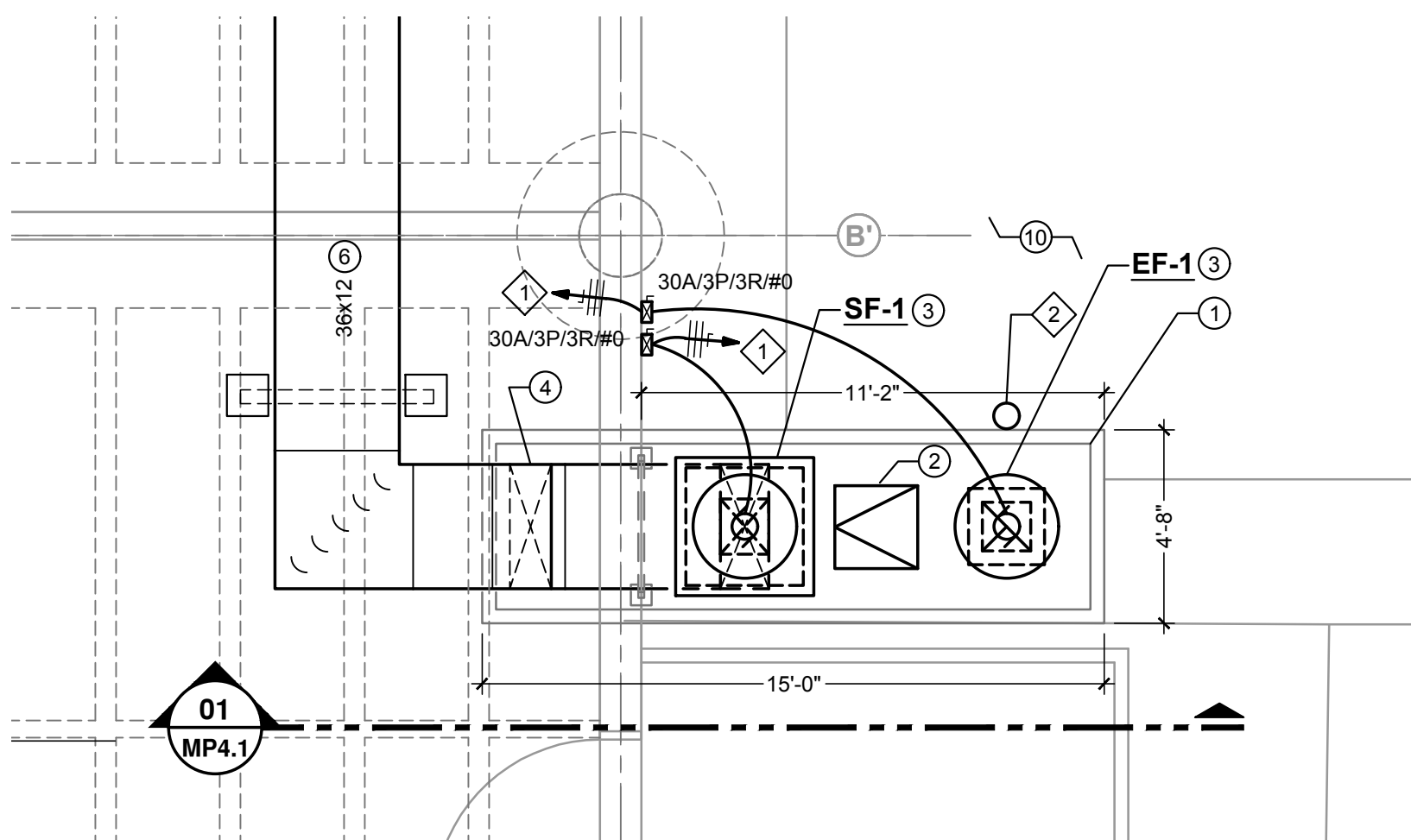
GENERAL: REFER ALSO TO GENERAL PLUMBING NOTES AND GENERAL PLUMBING DEMOLITION NOTES ON SHEET MPE1.2.

1. EXISTING MAIN DRAIN PIPING LOCATED BELOW GRADE TO REMAIN.
2. REMOVE AND REPLACE EXISTING VERTICAL PORTION (AND ASSOCIATED OFFSETS) OF DRAINAGE PIPING, ASSOCIATED NO HUB FITTINGS, COUPLINGS, P-TRAP(S), AND BRANCH PIPING FROM INITIAL SANITARY JOINT BELOW FIRST FLOOR SLAB TO CONNECTION TO UNDERGROUND MAIN. PROVIDE EXPANSION JOINT COUPLING EQUAL TO FERNCO MODEL NO. XJ AT JOINT CLOSEST TO FIXTURE TAILPIECE OR NEAR FLOOR PENETRATION.
3. SANITARY PIPING UNIT PRICING
 - a. FOR SANITARY PIPING SERVING FLOOR DRAINS, TRENCH DRAINS, AND SIMILAR SPECIALTIES, PROVIDE UNIT PRICING TO FIX AND REPAIR APPROX. 4 LF OF VERTICAL PIPING (AND ASSOCIATED OFFSETS, P-TRAPS, ETC.) WITH COUPLINGS FROM BELOW GRADE BRANCH CONNECTION TO INITIAL SANITARY JOINT BELOW FIRST FLOOR SLAB. PROVIDE EXPANSION JOINT COUPLING EQUAL TO FERNCO MODEL NO. XJ AT JOINT CLOSEST TO FIXTURE TAILPIECE OR NEAR FLOOR PENETRATION.
 - b. PROVIDE UNIT PRICE FOR SANITARY PIPING SERVING OTHER FIXTURES THAT DO NOT HAVE A P-TRAP IN CRAWLSPACE FROM INITIAL SANITARY JOINT BELOW FIRST FLOOR SLAB TO BELOW GRADE CONNECTION. EXPANSION JOINT COUPLING EQUAL TO FERNCO MODEL NO. XJ AT JOINT CLOSEST TO FIXTURE TAILPIECE OR NEAR FLOOR PENETRATION.
 - c. PROVIDE UNIT PRICE TO REPLACE PIPING/FITTINGS AS THEY PASS THROUGH THE FLOOR SLAB DOWN TO INITIAL SANITARY JOINT, INCLUDING APPROPRIATE SEALING OF PENETRATION. ASSUME EXISTING TO REMAIN SLEEVES AT PENETRATIONS.
 - d. FOR 'a', 'b', and 'c', PROVIDE UNIT PRICE FOR 2", 3", 4", AND 6" SIZES.

ELECTRICAL NOTES:

GENERAL: REFER ALSO TO GENERAL POWER NOTES ON SHEET MPE1.2.

1. ROUTE 3#12G, 3/4"C. TO EXISTING PANEL 'HM2' IN MECH. ROOM 1.146 ABOVE, PROVIDE 15A/3P CIRCUIT BREAKER IN AVAILABLE SPACE AND CONNECT AS REQUIRED.
2. PROVIDE EDWARDS 52R-N5-40WH STROBE LIGHT CONDUIT MOUNTED AT 36" AFG. PROVIDE UNISTRUT SUPPORT FOR CONDUIT. CONNECT TO NEAREST PANEL 'L2' RECEPTACLE CIRCUIT WITH 2#12G, 3/4"C. PROVIDE WEATHERPROOF SWITCH IN AREAWAY NEAR ACCESS HATCH AND CONNECT AS REQUIRED FOR CONTROL.



02

ENLARGED PLAN

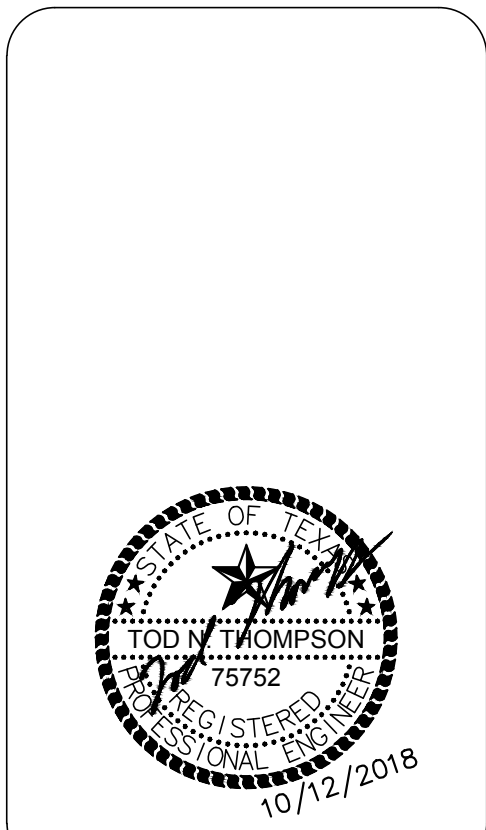
SCALE: 1/4" = 1'-0"



GRIFIN ANIMAL BUILDING CRAWLSPACE IMPROVEMENTS

M.D. ANDERSON CANCER CENTER - SMITHVILLE, TEXAS
MDACC PROJECT NO. 15-0005

DATE
OCTOBER 12, 2018



SCALE: AS SHOWN
DRAWN BY: JM
CHECKED BY: TT

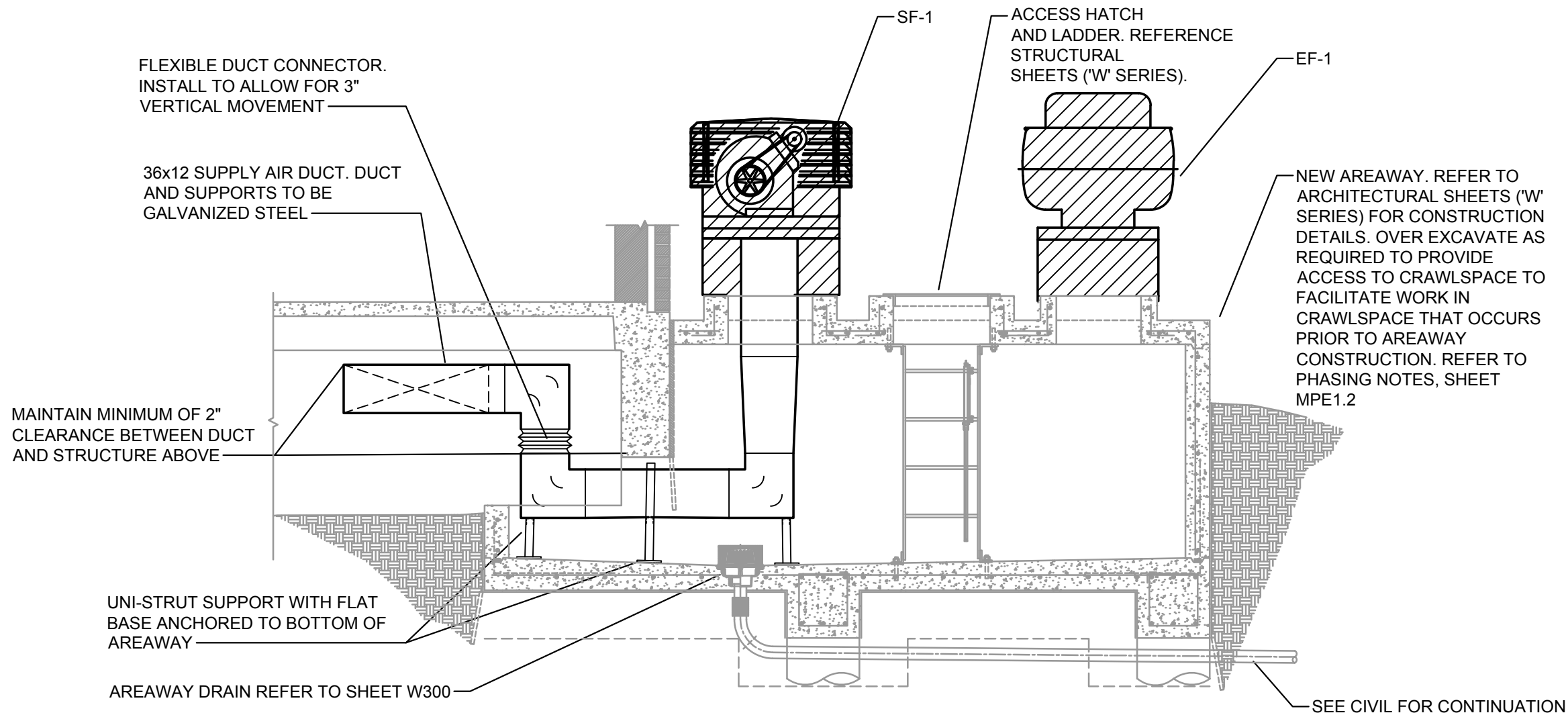
100% CONSTRUCTION DOCUMENTS

GRIFIN BLDG.
CRAWLSPACE
PLAN - MECH.
PLBG. & ELEC.

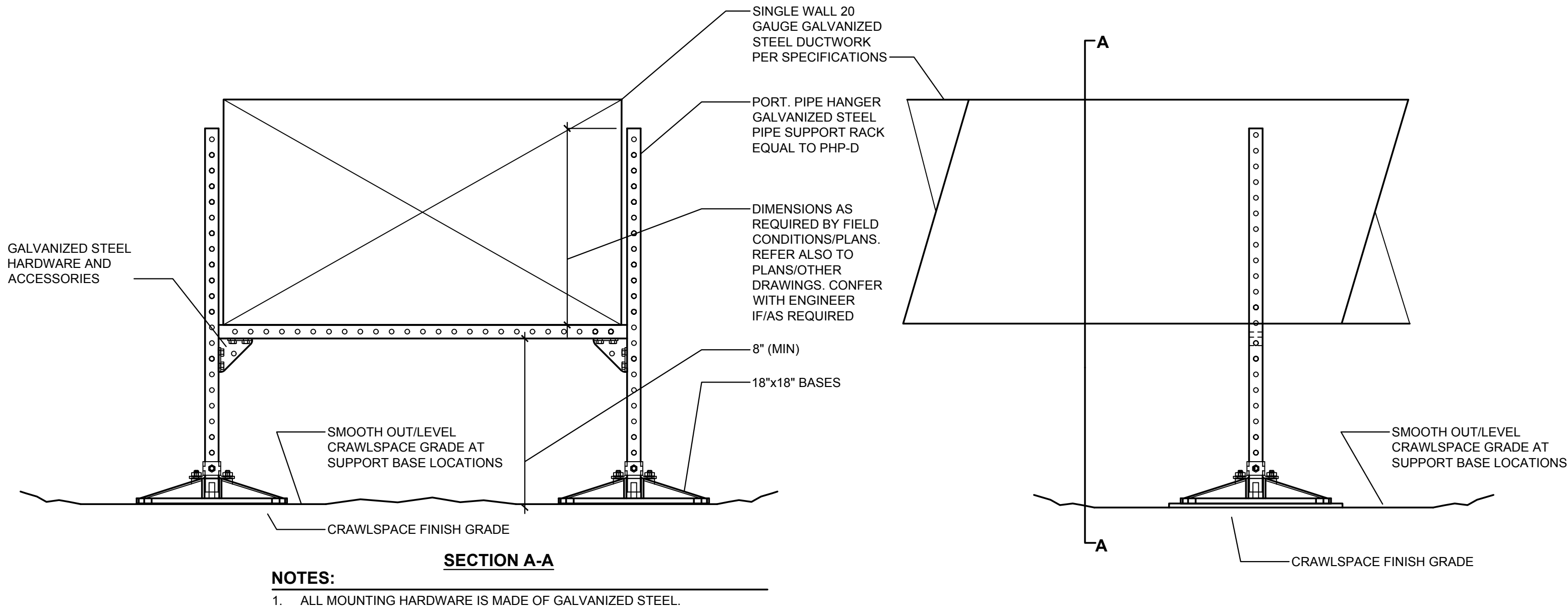
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MPE2.1

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01 SECTION THROUGH AREAWAY FANS
SCALE: 3/8" = 1'-0"



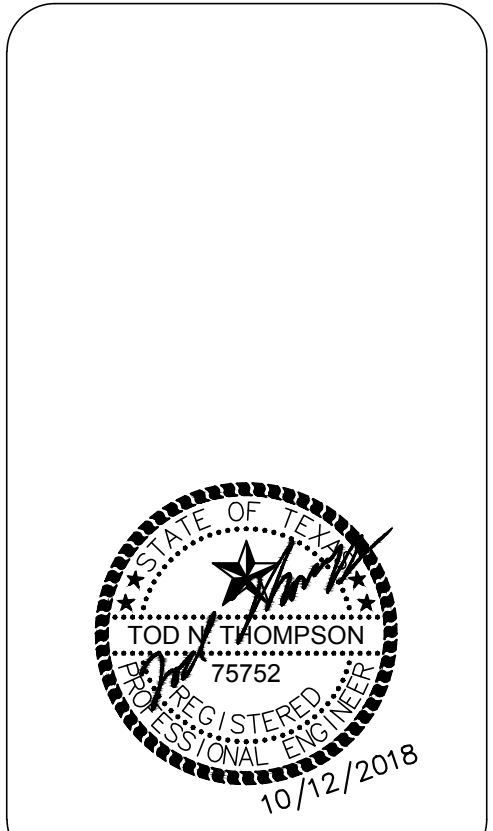
02 RECTANGULAR DUCTWORK AND SUPPORT DETAIL
SCALE: NONE

FAN SCHEDULE															
MARK	AIR FLOW (CFM)	E.S.P. (IN.W.G.)	MAX. SONES	ELECTRICAL DATA			TYPE	DRIVE	MANUF.	MODEL NO.	ACCESS. (1)				
				H.P.	B.H.P.	V / PH									
SF-1	3150	0.75	15.4	1-1/2	1.08	460 / 3	SUPPLY	BELT	GREENHECK	RSFP-120-15	B				
EF-1	3400	0.50	15.6	1	0.75	460 / 3	UPBLAST	BELT	GREENHECK	CUBE-180-7	B				
NOTES:															
1. ACCESSORIES TO BE AS INDICATED PER THE FOLLOWING KEY:															
A. INSULATED ROOF CURB (PITCHED IF/AS REQUIRED. VERIFY)			B. GRAVITY BACKDRAFT DAMPER WITH EXTENDED BASE			C. MOTORIZED BACKDRAFT DAMPER WITH EXTENDED CURB			D. BIRDCUARD			E. INSULATED HOUSING		F. NEOPRENE IN SHEAR VIBRATION ISOLATORS	
G. HANGING SPRING VIBRATION ISOLATORS			H. UNHOUSED BASE SPRING VIBRATION ISOLATORS			I. HOUSED BASE SPRING VIBRATION ISOLATORS			J. WEATHERHOOD			K. HOUSING DRAIN		L. SOLID STATE SPEED CONTROLLER (LOCATED AT FAN)	
M. NEMA 3R DISCONNECT SWITCH			N. NEMA 1 DISCONNECT SWITCH			O. FLANGED CONNECTIONS			P. EPOXY COATING			Q. HINGED ACCESS DOORS		R. SIDE ACCESS DOORS	
S. EXTENDED BASE (PER NFPA 96 FOR KITCHEN HOOD SVC.)			T. BELT GUARD			U. MANUAL STARTER			V. EXTENDED LUBRICATION LINES			W. WALL MOUNT COLLAR		X. OSHA MOTOR SIDE GUARD	
Y. DAMPER GUARD			Z. GREASE DRAIN /TRAP			AA. TIE DOWN BRACKETS			BB. WALL HOUSING GUARD			CC. LONG FILTER BOX (W/ FILTER)		DD. 2 SPEED MOTOR	
2. PROVIDE ALL SINGLE PHASE MOTORS WITH CAPACITOR START (OR EQUAL PERFORMANCE).															



PROJECT
**GRIFIN ANIMAL BUILDING
CRAWLSPACE IMPROVEMENTS**
M.D. ANDERSON CANCER CENTER - SMITHVILLE, TEXAS
MDACC PROJECT NO. 15-0005

DATE
OCTOBER 12, 2018



SCALE: AS SHOWN
DRAWN BY: JM
CHECKED BY: TT

100% CONSTRUCTION DOCUMENTS

DETAILS AND
SCHEDULES
MECHANICAL/
PLUMBING

SHEET NUMBER
MP4.1

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GENERAL CONSTRUCTION NOTES

- ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH THE SPECIFICATIONS OF THE PROJECT MANUAL. THE SPECIFICATIONS ARE BASED ON APPLICABLE TxDOT, CITY OF HOUSTON, AND CITY OF AUSTIN STANDARD SPECIFICATIONS. WHERE CONFLICTS EXIST, THE CONTRACTOR SHALL NOTIFY THE ENGINEER. THE MOST STRINGENT SHALL GOVERN.
- THE INFORMATION SHOWN ON THESE DRAWINGS INDICATING TYPE AND LOCATION OF UNDERGROUND, SURFACE, AND AERIAL UTILITIES IS NOT GUARANTEED TO BE EXACT OR COMPLETE. THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING THE EXACT TYPE AND LOCATION OF ALL UTILITIES AFFECTED BY CONSTRUCTION FOR THIS PROJECT IN ORDER TO AVOID DAMAGE TO THOSE UTILITIES. IF DAMAGE OCCURS, THE CONTRACTOR ASSUMES RESPONSIBILITY FOR THE IMMEDIATE REPAIR OF DAMAGED UTILITIES AND THE COST OF REPAIR.
- PRIOR TO BEGINNING CONSTRUCTION AND AFTER INSTALLATION OF THE EROSION CONTROLS, THE CONTRACTOR SHALL CONVENE A PRE-CONSTRUCTION CONFERENCE BETWEEN THE OWNER, CONSULTING ENGINEER, CONTRACTOR, AND OTHER AFFECTED PARTIES.
- CONTRACTOR SHALL NOTIFY THE APPROPRIATE UTILITIES AT LEAST 48 HOURS PRIOR TO WORK WITHIN EASEMENTS.
- THE CONTRACTOR SHALL GIVE THE OWNER A MINIMUM OF 48 HOURS NOTICE BEFORE BEGINNING EACH PHASE OF CONSTRUCTION.
- BEFORE DISCONNECTING ANY UTILITY LINE, CONTRACTOR MUST PROVIDE FIFTEEN (15) WORKING DAYS NOTICE TO THE OWNER EXCEPT IN AN EMERGENCY.
- THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE ENGINEER OF ANY UNREPORTED OBSTACLES THAT MAY IMPEDE OR PREVENT THE PROPER CONSTRUCTION OF THIS PROJECT.
- SLOPES OF ROADWAY CUTS AND EMBANKMENTS DAMAGED BY ANY OPERATION OF THE CONTRACTOR DURING THE EXECUTION OF THIS PROJECT SHALL BE REPAIRED AND RESTORED TO THE ORIGINAL PRE-CONSTRUCTION CONDITION IN ACCORDANCE WITH ALL APPLICABLE PROVISIONS OF THE STANDARD SPECIFICATIONS. BACK FILL AND FILL PLACED DURING REMEDIAL GRADING SHALL BE COMPACTED TO A DENSITY EQUAL TO OR GREATER THAN THAT OF THE ORIGINAL CONDITIONS AND TO THE SATISFACTION OF THE ENGINEER AND GOVERNING AUTHORITIES.
- WHERE REMOVAL OF BASE AND PAVEMENT IS NECESSARY FOR THIS PROJECT ALL BASE AND PAVEMENT SHALL BE REPLACED IN ACCORDANCE WITH THE CONSTRUCTION DOCUMENTS AND SPECIFICATIONS. ALL PAVEMENT CUTS SHALL BE SAWCUT PRIOR TO PLACEMENT OF H.M.A.C.
- ANY EXISTING PAVEMENT, CURBS, AND/OR SIDEWALKS DAMAGED OR REMOVED, NOT SHOWN FOR DEMOLITION, WILL BE REPAIRED BY THE CONTRACTOR AT HIS EXPENSE BEFORE ACCEPTANCE OF THE PROJECT.
- WHERE CONFLICTS BETWEEN NOTES, SPECIFICATIONS, AND PLANS EXIST, THE MOST STRINGENT SHALL GOVERN. CONFLICTS SHALL BE BROUGHT IMMEDIATELY TO THE ENGINEER'S ATTENTION. CLARIFICATION WITH THE OWNER AND/OR OWNER'S REPRESENTATIVE ABOUT CONFLICTS WITH PAY ITEMS SHALL BE MADE PRIOR TO THE ORDERING AND INSTALLATION.
- THE CONTRACTOR SHALL ADJUST OR RELOCATE EXISTING UNDERGROUND UTILITIES AS REQUIRED TO CONSTRUCT PROPOSED UTILITIES OR AS DIRECTLY BY THE ENGINEER.
- CONTRACTOR TO FIELD VERIFY ELEVATIONS AND ALIGNMENTS PRIOR TO CONSTRUCTION. TOPOGRAPHIC INFORMATION IS BASED ON SURVEY DATA PROVIDED BY THE OWNER.
- CONTRACTOR SHALL MAINTAIN ACCURATE RECORD DRAWINGS, ESPECIALLY OF EXISTING AND PROPOSED UTILITIES, AND PROVIDE THEM TO THE OWNER'S ENGINEER.
- CONTRACTOR'S MEANS AND METHODS FOR DEMOLITION AND CONSTRUCTION SHALL NOT CREATE NOISE & VIBRATIONS THAT IMPACT THE ADJACENT BUILDING. THE USE OF JACK HAMMERS, VIBRATORY COMPACTION EQUIPMENT, OR OTHER SIMILAR EQUIPMENT IS PROHIBITED.

BENCHMARK DATA

ELEVATIONS SHOWN ARE ASSUMED & ORIGINATE FROM TBM'S A & B AS SHOWN. TO CONVERT TO NAVD '88 (1991 ADJ.) ADD 0.70'.

T.B.M. A – ELEV 469.03 (ASSUMED) "X" IN NORTHEAST CORNER OF CONC. SLAB.

T.B.M. A~1 – ELEV 466.36' (ASSUMED) 1/2-INCH IRON ROD WITH CAP

T.B.M. A~2 – ELEV 466.56' (ASSUMED) 1/2-INCH IRON ROD WITH CAP

T.B.M. B – ELEV 487.03 (ASSUMED) "X" IN SOUTH CORNER CONC. SLAB. (ELEVATION DISCREPANCY OF 0.6 FT PER HARRIS GRANT SURVEY 11-2011.

T.B.M. 2 – ELEV 458.25' SQUARE CUT ON CONCRETE BASE OF LIGHT POLE LOCATED +/- 28' NORTH OF THE NORTHEAST CORNER OF THE CENTRAL UTILITY BUILDING.

SITE CLEAN UP AND SAFETY REQUIREMENTS

- REMOVAL OF EXCAVATED MATERIALS AND DAILY CLEANUP OPERATIONS SHALL BE PERFORMED TO THE SPECIFICATIONS AND TO THE SATISFACTION OF THE OWNER AND ENGINEER.
- CONTRACTOR SHALL MAINTAIN THE JOB SITE IN A SAFE, NEAT AND WORKMANLIKE MANNER AT ALL TIMES. JOB SITE SAFETY SHALL NOT BE COMPROMISED. ANY UNATTRACTIVE NUISANCE SHALL BE REMOVED OR CAMOUFLAGED BY CONTRACTOR WHEN DIRECTED BY THE OWNER OR ENGINEER.
- ALL UNATTENDED TRENCHES MUST BE ADEQUATELY PROTECTED TO PREVENT INJURY TO PEDESTRIANS AND VEHICULAR TRAFFIC. OPEN TRENCHES SHALL BE COVERED DAILY WITH A STEEL PLATE CAPABLE OF SUPPORTED TRAFFIC FOR EMERGENCY ACCESS.
- BARRICADES, FENCING, LIGHTS, AND/OR OTHER PROTECTIVE DEVICES SHALL ADEQUATELY PROTECT ALL HOLES, TRENCHES, AND OTHER HAZARDOUS AREAS AT ALL TIMES.
- ALL CONSTRUCTION AND TRENCHING OPERATIONS SHALL BE ACCOMPLISHED IN ACCORDANCE WITH ALL APPLICABLE REGULATIONS OF THE U.S. OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA). COPIES OF OSHA STANDARDS MAY BE PURCHASED FROM THE U.S. GOVERNMENT PRINTING OFFICE.
- CONTRACTOR SHALL MAINTAIN A SUPERINTENDENT AT THE PROJECT AT ALL TIMES WORK IS IN PROGRESS PER SPECIFICATION 00 25 00.
- CONTRACTOR SHALL BE RESPONSIBLE FOR REMOVAL OF EXCESS SPOILS FROM SITE DAILY AND DISPOSAL AT A PERMITTED OFFSITE FACILITY. CONTRACTOR SHALL ALSO PROVIDE ADDITIONAL MATERIAL FROM OFFSITE IF NEEDED AS PART OF THE PROJECT.
- CONTRACTOR SHALL NOT EXCEED LEGAL LOADS ON HAULING, OBSERVE SPEED LIMITS AND USE EXTREME CAUTION ON NARROW ROADWAYS.
- A WORK DAY IS MONDAY THROUGH FRIDAY 7 AM TO 4 PM EXCLUDING HOLIDAYS PER SPECIFICATION 00 25 00 1.04 H.

TRAFFIC CONTROL AND SIGNAGE

- THE CONTRACTOR SHALL MAINTAIN PASSAGE FOR CAMPUS TRAFFIC TO THE CRITICAL LOCATION AREAS AND PHASES OF THE PROJECT NOT DIRECTLY UNDER CONSTRUCTION AT ALL TIMES DURING THE CONSTRUCTION OF THIS PROJECT EXCEPT DURING PERIODS WHEN CONSTRUCTION IN THE AREA WOULD MAKE ACCESS UNSAFE. EMERGENCY ACCESS SHALL BE IMMEDIATELY PROVIDED TO DRIVEWAYS DURING CONSTRUCTION ON AN AS-NEEDED BASIS.
- WHERE PORTABLE SIGNS REQUIRE THE USE OF WEIGHTS, SANDBAGS SHALL BE USED. THE USE OF SOLID OBJECTS SUCH AS CONCRETE, ROCKS, IRON, ETC. SHALL NOT BE PERMITTED.
- ALL SIGNS SHALL REMAIN IN PLACE UNLESS OTHERWISE SHOWN ON THE PLANS. IF SIGNS REQUIRE RELOCATION, CONTRACTOR SHALL CONTACT THE ENGINEER
- CONTRACTOR MUST RESTORE ALL PAVEMENT MARKINGS DISTURBED DURING CONSTRUCTION. CONTRACTOR SHALL OBSERVE ALL APPLICABLE MATERIALS, SPECIFICATIONS, AND INSTALLATION REQUIREMENTS INCLUDING SPECIAL ATTENTION TO MAINTAINING PROPER DIMENSIONS AND ALIGNMENT.

EROSION CONTROL NOTES

- THE CONTRACTOR SHALL INSTALL EROSION/SEDIMENTATION CONTROLS AND TREE/NATURAL AREA PROTECTIVE FENCING PRIOR TO ANY SITE PREPARATION WORK (CLEARING, GRUBBING OR EXCAVATION).
 - THE PLACEMENT OF EROSION/SEDIMENTATION CONTROLS SHALL BE IN ACCORDANCE WITH THE EROSION AND SEDIMENTATION CONTROL PLAN AND SPECIFICATIONS.
 - THE PLACEMENT OF TREE/NATURAL AREA PROTECTIVE FENCING SHALL BE IN ACCORDANCE WITH THE SPECIFICATION 32 00 12.
 - THE CONTRACTOR IS REQUIRED TO INSPECT THE CONTROLS AND FENCES AT WEEKLY INTERVALS AND AFTER SIGNIFICANT RAINFALL EVENTS TO INSURE THAT THEY ARE FUNCTIONING PROPERLY. THE PERSON(S) RESPONSIBLE FOR MAINTENANCE OF CONTROLS AND FENCES SHALL IMMEDIATELY MAKE ANY NECESSARY REPAIRS TO DAMAGED AREAS. SILT ACCUMULATION AT CONTROLS MUST BE REMOVED WHEN THE DEPTH REACHES SIX (6) INCHES.
 - PRIOR TO FINAL ACCEPTANCE BY THE OWNER, DISTURBED AREAS SHALL BE RESTORED TO THE ORIGINAL GRADE AND REVEGETATED. ALL LAND CLEARING DEBRIS SHALL BE DISPOSED OF IN APPROVED SPOIL DISPOSAL SITES. CONTRACTOR TO PROVIDE DOCUMENTATION TO OWNER AND ENGINEER.
 - TEMPORARY AND PERMANENT EROSION CONTROL: ALL DISTURBED AREAS SHALL BE RESTORED AS NOTED BELOW.
 - ALL DISTURBED AREAS TO BE REVEGETATED ARE REQUIRED TO PLACE A MINIMUM OF SIX (6) INCHES OF TOPSOIL [SEE SPECIFICATION 32 29 11]. DO NOT ADD TOPSOIL WITHIN THE CRITICAL ROOT ZONE OF EXISTING TREES. THE TOPSOIL SHALL BE COMPOSED OF 3 PARTS OF NATIVE SOIL MIXED WITH 1 PART COMPOST, BY VOLUME.
 - THE SOIL SHALL BE LOCALLY AVAILABLE NATIVE SOIL THAT MEETS THE FOLLOWING SPECIFICATIONS:
 - SHALL BE FREE OF TRASH, WEEDS, DELETERIOUS MATERIALS, ROCKS, AND DEBRIS.
 - SHALL BE FREE OF INVASIVE SPECIES SEEDS SUCH AS JOHNSON GRASS.
 - 100% SHALL PASS THROUGH A 0.375-INCH (3/8") SCREEN.
 - SOIL TEXTURE CLASS TO BE LOAM, SANDY CLAY LOAM, OR SANDY LOAM IN ACCORDANCE WITH THE USDA TEXTURE TRIANGLE. SOIL KNOWN LOCALLY AS "RED DEATH" OR AUSTIN SANDY LOAM IS NOT AN ALLOWABLE SOIL. TEXTURAL COMPOSITION SHALL MEET THE FOLLOWING CRITERIA:

TEXTURE CLASS	MINIMUM	MAXIMUM
CLAY	5%	25%
SILT	10%	50%
SAND	30%	80%
- TOPSOIL SALVAGED FROM THE EXISTING SITE IS PREFERRED AND SHALL BE MIXED WITH COMPOST TO MEET THE ABOVE SPECIFICATIONS.
- SOIL COMPACTED BY VEHICLE ACCESS, PARKING AND CONSTRUCTION EQUIPMENT SHALL BE SCARIFIED BY DISC HARROW OR OTHER APPROVED METHOD PRIOR TO PLACEMENT OF TOPSOIL AND/OR SEED.
- THE VEGETATIVE STABILIZATION OF AREAS DISTURBED BY CONSTRUCTION SHALL BE AS FOLLOWS:
- HYDROMULCH PER SPECIFICATION 32 92 13 WITH NATIVE SEED MIX PER SPECIFICATION 32 90 10 ALONG THE LOOP ROAD. UTILIZE NATIVE AMERICAN SEED COMPANY SOUTHEAST RECOVERY MIX.
 - BERMUDA OR RYE GRASS SHALL NOT BE USED.
- THE CONTRACTOR SHALL UTILIZE DUST CONTROL MEASURES DURING SITE CONSTRUCTION SUCH AS IRRIGATION TRUCKS AND MULCHING.
 - CONTRACTOR SHALL IMPLEMENT THE STORM WATER POLLUTION PREVENTION PLAN PROVIDED BY THE OWNER IN ACCORDANCE WITH THE REQUIREMENTS OF TXR0500000 PER SPECIFICATION 01 57 23.

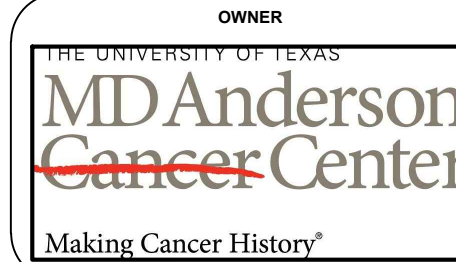
TREE AND NATURAL AREA PROTECTION NOTES

- ALL TREES AND NATURAL AREAS SHOWN ON PLAN TO BE PRESERVED SHALL BE PROTECTED DURING CONSTRUCTION WITH TEMPORARY FENCING.
- PROTECTIVE FENCES SHALL BE INSTALLED PRIOR TO THE START OF ANY SITE PREPARATION WORK (CLEARING, GRUBBING OR GRADING), AND SHALL BE MAINTAINED THROUGHOUT ALL PHASES OF THE CONSTRUCTION PROJECT.
- EROSION AND SEDIMENTATION CONTROL BARRIERS SHALL BE INSTALLED OR MAINTAINED IN A MANNER WHICH DOES NOT RESULT IN SOIL BUILD-UP WITHIN TREE DRIP LINES.
- PROTECTIVE FENCES SHALL SURROUND THE TREES OR GROUP OF TREES, AND WILL BE LOCATED AT THE OUTERMOST LIMIT OF BRANCHES (DRIP LINE), FOR NATURAL AREAS, PROTECTIVE FENCES SHALL FOLLOW THE LIMIT OF CONSTRUCTION LINE, IN ORDER TO PREVENT THE FOLLOWING:
 - SOIL COMPACTION IN THE ROOT ZONE AREA RESULTING FROM VEHICULAR TRAFFIC OR STORAGE OF EQUIPMENT OR MATERIALS;
 - ROOT ZONE DISTURBANCES DUE TO GRADE CHANGES (GREATER THAN 6 INCHES CUT OR FILL), OR TRENCHING NOT SHOWN ON PLANS;
 - WOUNDS TO EXPOSED ROOTS, TRUNK OR LIMBS BY MECHANICAL EQUIPMENT;
 - OTHER ACTIVITIES DETRIMENTAL TO TREES SUCH AS CHEMICAL STORAGE, CEMENT TRUCK CLEANING, AND FIRES.
 - EXCEPTIONS TO INSTALLING FENCES AT TREE DRIP LINES MAY BE PERMITTED IN WHERE THERE IS TO BE AN APPROVED GRADE CHANGE, IMPERMEABLE PAVING SURFACE, TREE WELL, OR OTHER SUCH SITE DEVELOPMENT, ERECT THE FENCE APPROXIMATELY 2 TO 4 FEET BEYOND THE AREA DISTURBED.
- WHERE ANY OF THE ABOVE EXCEPTIONS RESULT IN A FENCE BEING CLOSER THAN 4 FEET TO A TREE TRUNK, PROTECT THE TRUNK WITH STRAPPED-ON PLANKING TO A HEIGHT OF 8 FT (OR TO THE LIMITS OF LOWER BRANCHING) IN ADDITION TO THE REDUCED FENCING PROVIDED.
- NO TREES GREATER THAN 8 INCHES OR LARGER IN DIAMETER ARE APPROVED FOR REMOVAL IN THIS PLAN. IN THE EVENT OF THE UNANTICIPATED REMOVAL OF A TREE 8 INCHES IN DIAMETER OR LARGER AT THE DIRECTION OF THE ENGINEER OR OWNER, TREE SHALL BE REMOVED IN A MANNER WHICH DOES NOT IMPACT TREES TO BE PRESERVED.
- ANY ROOTS EXPOSED BY CONSTRUCTION ACTIVITY SHALL BE PRUNED FLUSH WITH THE SOIL. BACKFILL ROOT AREAS WITH GOOD QUALITY TOP SOIL AS SOON AS POSSIBLE. IF EXPOSED ROOT AREAS ARE NOT BACKFILLED WITHIN 2 DAYS, COVER THEM WITH ORGANIC MATERIAL IN A MANNER WHICH REDUCES SOIL TEMPERATURE AND MINIMIZES WATER LOSS DUE TO EVAPORATION.
- ANY TRENCHING REQUIRED FOR THE INSTALLATION OF LANDSCAPE IRRIGATION SHALL BE PLACED AS FAR FROM EXISTING TREE TRUNKS AS POSSIBLE.
- NO LANDSCAPE TOPSOIL DRESSING GREATER THAN 4 INCHES SHALL BE PERMITTED WITHIN THE DRIP LINE OF TREES. NO SOIL IS PERMITTED ON THE ROOT FLARE OF ANY TREE.
- PRUNING TO PROVIDE CLEARANCE FOR STRUCTURES, VEHICULAR TRAFFIC AND EQUIPMENT SHALL TAKE PLACE BEFORE DAMAGE OCCURS (RIPPING OF BRANCHES, ETC.). COORDINATE WITH OWNER AND ENGINEER.
- ALL FINISHED PRUNING SHALL BE DONE ACCORDING TO RECOGNIZED, APPROVED STANDARDS OF THE INDUSTRY (REFERENCE THE NATIONAL ARBORIST ASSOCIATION PRUNING STANDARDS FOR SHADE TREES).

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PROJECT

GRIFFIN ANIMAL BUILDING
CRAWLSPACE IMPROVEMENTS

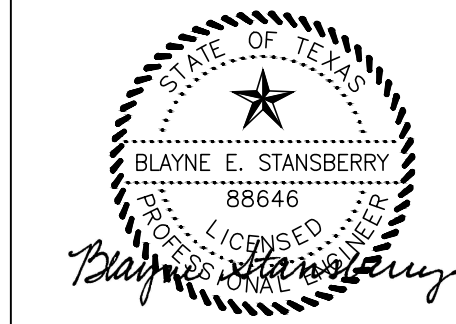
M.D. ANDERSON CANCER CENTER - SMITHVILLE, TEXAS
MDACC PROJECT NO. 15-0005

DATE
OCTOBER 12, 2018

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100% CONSTRUCTION
DOCUMENTS

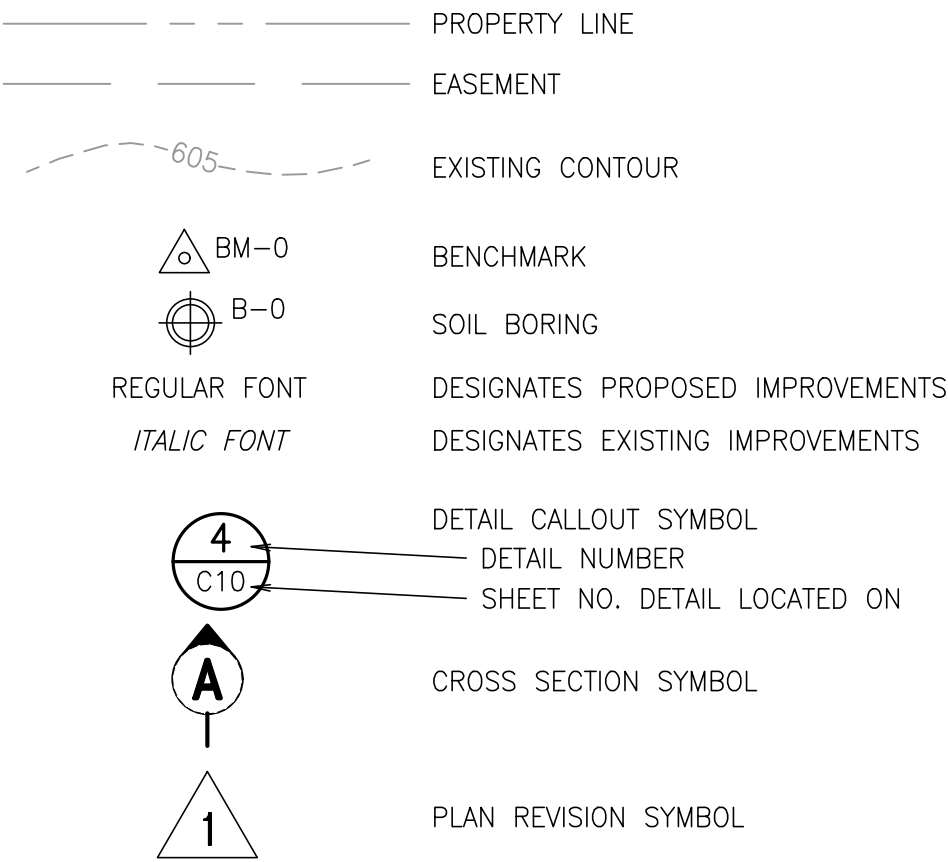
CONSTRUCTION
NOTES

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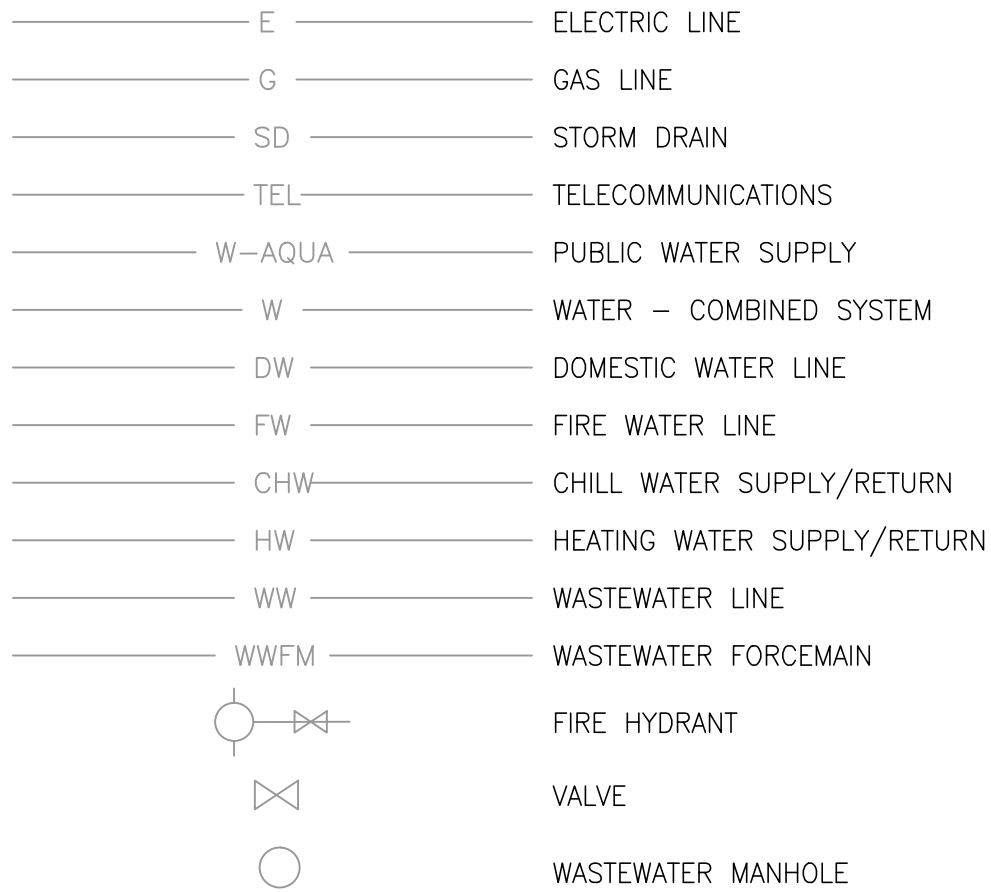
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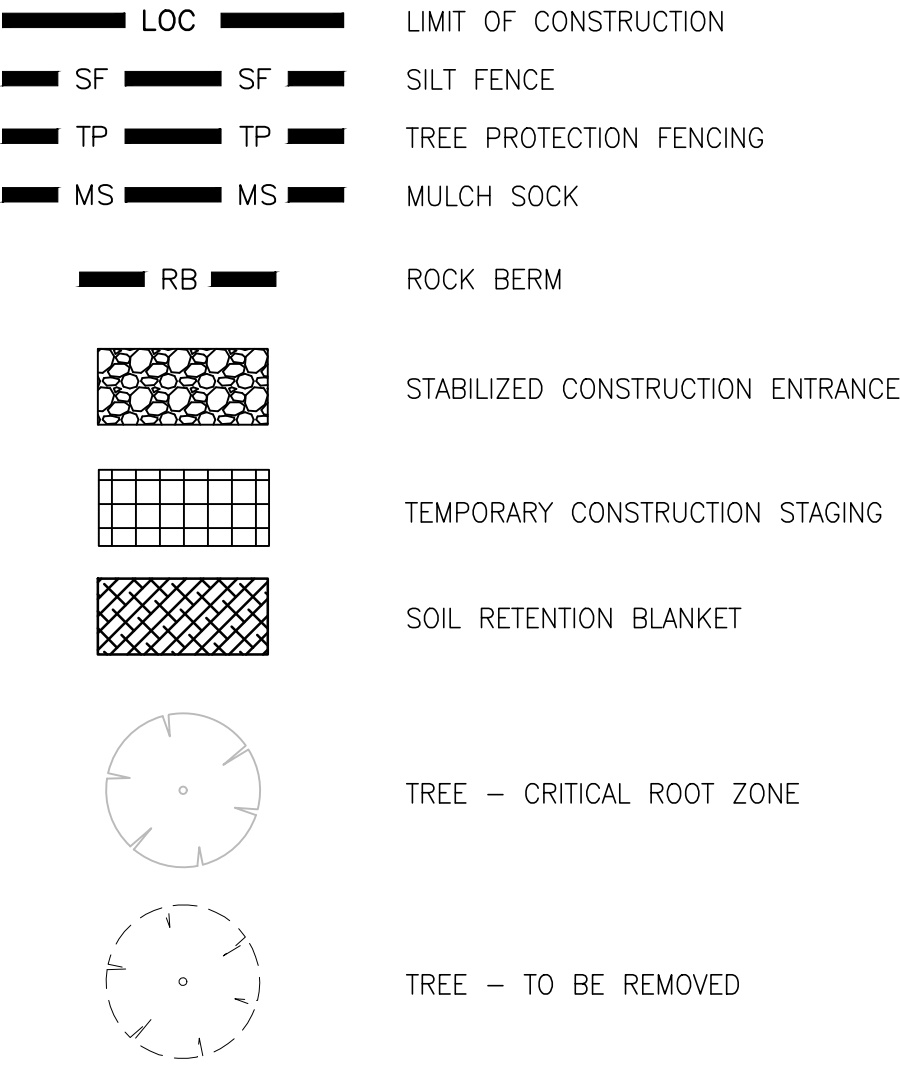
GENERAL LEGEND



EXISTING UTILITY LINES



EROSION CONTROL LEGEND

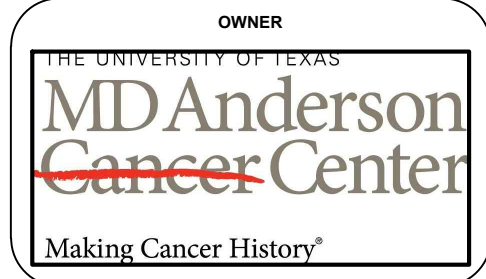


ABBREVIATIONS

A.D.	ALGEBRAIC DIFFERENCE	TYP	TYPICAL
AC	AIR CONDITIONER	U/S	UPSTREAM
APPROX	APPROXIMATE	UCM	UTILITY CRITERIA MANUAL
B/W	BOTTOM OF WALL	V	VERTICAL
BH	BIO HAZARD WASTE	V	VELOCITY
BL	BUILDING LINE	VC	VERTICAL CURVE
BLDG	BUILDING	VERT	VERTICAL
BLK	BLOCK	VLV	VALVE
BM	BENCHMARK	W, WTR	WATER
BOC	BACK OF CURB	WL	WATER LINE
CFB	COMPOST FILTER BERM	WQP	WATER QUALITY POND
CFS	CUBIC FEET PER SECOND	WSEL	WATER SURFACE ELEVATION
CI	CAST IRON	WW	WASTEWATER
CL	CENTERLINE	WWF	WELDED WIRE FABRIC
CMP	CORRUGATED METAL PIPE	WWM	WELDED WIRE MESH
CO	CLEANOUT	YR	YEAR
COA	CITY OF AUSTIN		
CONC	CONCRETE		
D/S	DOWNSTREAM		
DCM	DRAINAGE CRITERIA MANUAL		
DET, DETL	DETAIL		
DI	DUCTILE IRON		
DIA, Ø	DIAMETER		
Dn	NORMAL DEPTH OF FLOW		
DRNG	DRAINAGE		
EA	EACH		
ECM	ENVIRONMENTAL CRITERIA MANUAL		
EJ	EXPANSION JOINT		
EL, ELEV	ELEVATION		
EOP	EDGE OF PAVEMENT		
EQUIV	EQUIVALENT		
ESC	EROSION AND SEDIMENTATION CONTROL		
ESMT	EASEMENT		
EXTG	EXISTING		
EXP. JT.	EXPANSION JOINT		
F-F	FACE TO FACE		
FF, FFE	FINISHED FLOOR ELEVATION		
FG	FINISHED GRADE		
FH	FIRE HYDRANT		
FL	FLOW LINE		
FOC	FACE OF CURB		
FP	FLOODPLAIN		
FPS	FEET PER SECOND		
FT	FEET		
GPM	GALLON PER MINUTE		
GV	GATE VALVE		
H	HORIZONTAL		
HDPE	HIGH DENSITY POLYETHYLENE		
HDWL	HEADWALL		
HGL	HYDRAULIC GRADE LINE		
HL	HEAD LOSS		
HMAC	HOT MIX ASPHALTIC CONCRETE		
HORIZ	HORIZONTAL		
HP	HIGH POINT		
HW	HEADWATER		
IP	INLET PROTECTION		
JT	JOINT		
L, LT	LEFT		
LDC	LAND DEVELOPMENT CODE		
LF	LINEAR FOOT		
LN	LINE		
LOC	LIMIT OF CONSTRUCTION		
LOG	LIP OF GUTTER		
LP	LOW POINT		
LW	LAB WASTE		
MAX	MAXIMUM		
MH	MANHOLE		
MIN	MINIMUM		
MSL	MEAN SEA LEVEL		
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION		
NG	NATURAL GROUND		
NTS	NOT TO SCALE		
O/S	OFFSET		
OC	ON CENTER		
OCEW	ON CENTER EACH WAY		
OE	OVERHEAD ELECTRIC		
OHU	OVERHEAD UTILITY		
PC	POINT OF CURVATURE		
PCC	POINT OF COMPOUND CURVATURE		
PI	POINT OF INFLECTION		
PKNG	PARKING		
PRC	POINT OF REVERSE CURVATURE		
PT	POINT OF TANGENCY		
PUE	PUBLIC UTILITY EASEMENT		
PVC	POINT OF VERTICAL CURVE		
PVC	POLYVINYL CHLORIDE		
PVI	POINT OF VERTICAL INFLECTION		
PVT	POINT OF VERTICAL TANGENCY		
Q	FLOW RATE		
R, RT	RIGHT		
RB	ROCK BERM		
ROP	REINFORCED CONCRETE PIPE		
REINF	REINFORCED		
ROW	RIGHT OF WAY		
S.S.	SIDE SLOPE		
SCE	STABILIZED CONSTRUCTION ENTRANCE		
SCH	SCHEDULE		
SD	STORM DRAIN		
SF	SILT FENCE		
SF	SQUARE FOOT		
SF	FRICTION SLOPE		
SRB	SOIL RETENTION BLANKET		
SS	STORM SEWER OR SANITARY SEWER		
STA	STATION		
SWLK	SIDEWALK		
SWPPP	STORM WATER POLLUTION PREVENTION PLAN		
T/W	TOP OF WALL		
TBM	TEMPORARY BENCHMARK		
TC	TOP OF CURB		
TCEQ	TEXAS COMMISSION ON ENVIRONMENTAL QUALITY		
TEMP	TEMPORARY		
TP	TREE PROTECTION		
TRM	TURF REINFORCEMENT MAT		
TSV	TAPPING SLEEVE & VALVE		
TW	TAILWATER		
Tw	TOP WIDTH OF FLOW		

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PROJECT

**GRIFFIN ANIMAL BUILDING
CRAWLSPACE IMPROVEMENTS**

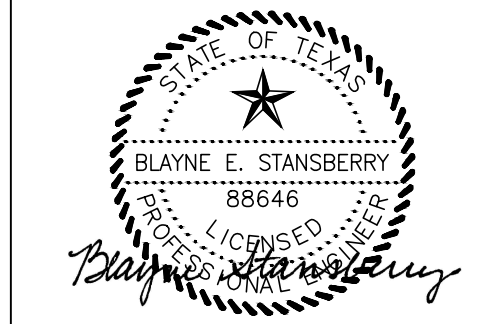
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MDACC PROJECT NO. 15-0005**

DATE
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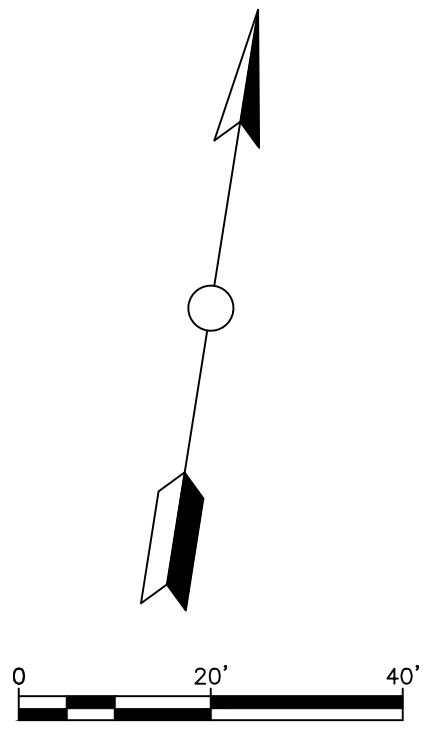
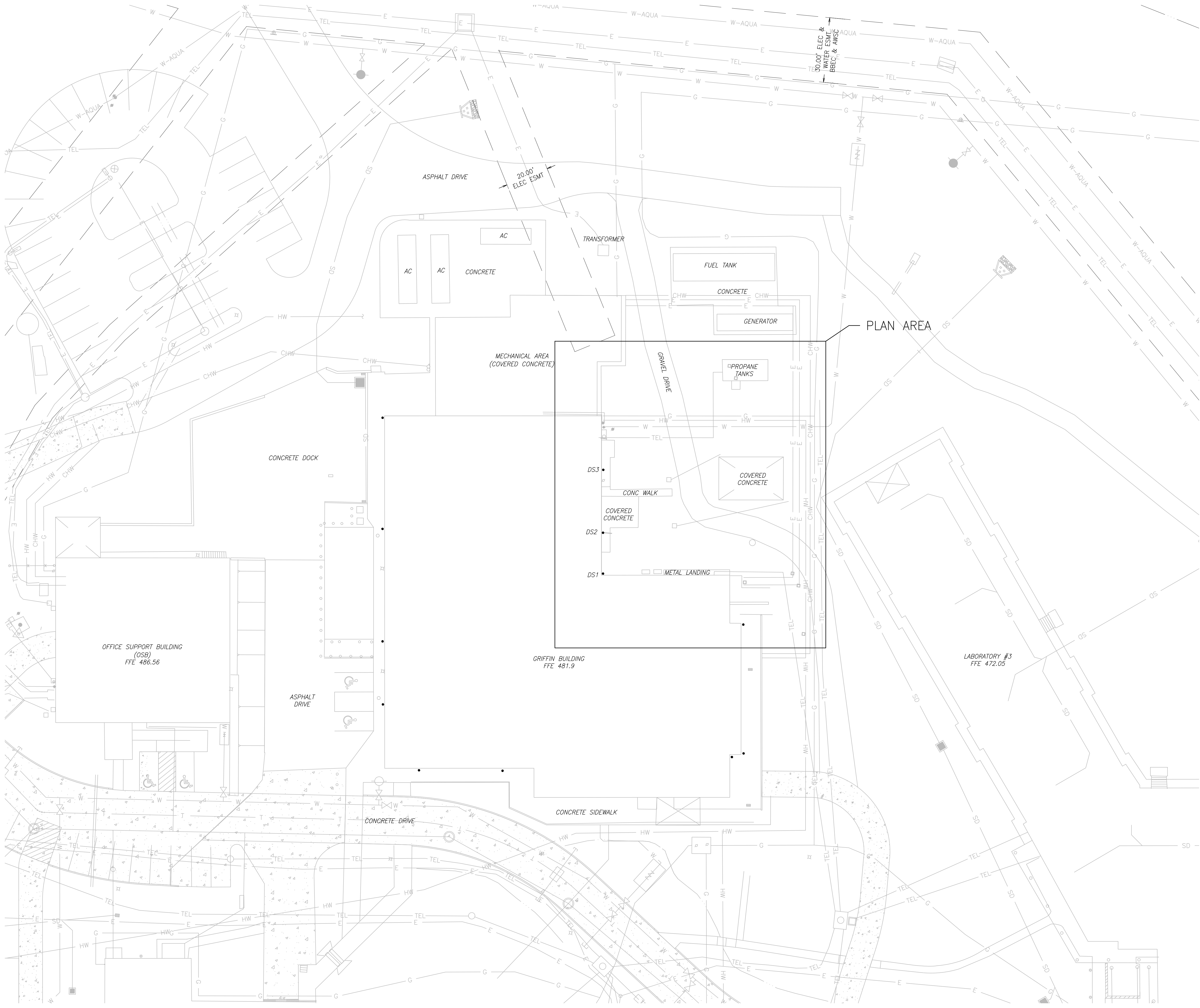
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DOCUMENTS

LEGENDS &
ABBREVIATIONS

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PROJECT

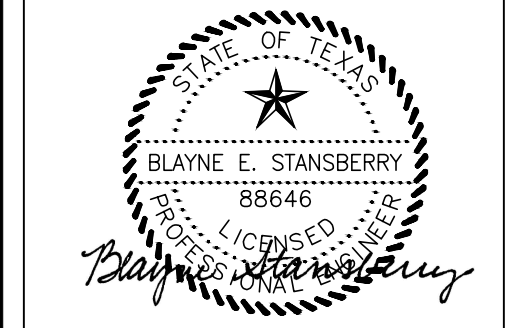
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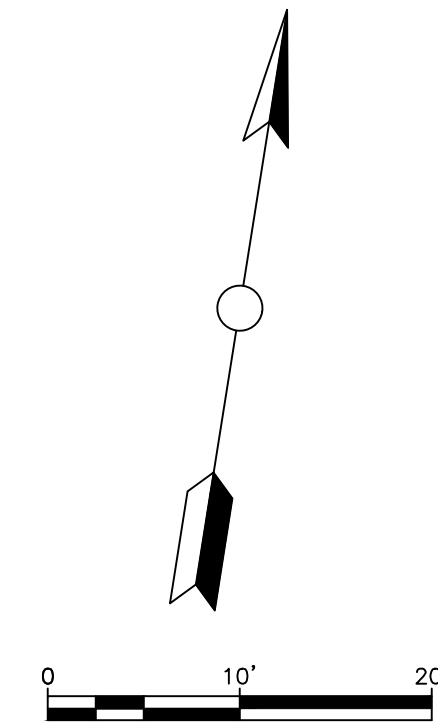
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OVERALL SITE
LAYOUT

SHEET NUMBER
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1. EXISTING CONCRETE SHALL BE SAWCUT PRIOR TO REMOVAL TO PROVIDE STRAIGHT EDGE FOR TRANSITION. CUTS SHALL BE MADE AT JOINTS WHERE FEASIBLE.
2. AREAS DISTURBED BY CONSTRUCTION SHALL BE REVEGETATED WITH ZOYSIA SOD.
3. CONTRACTOR'S MEANS AND METHODS FOR DEMOLITION AND CONSTRUCTION SHALL NOT CREATE NOISE & VIBRATIONS THAT IMPACT THE ADJACENT BUILDING. THE USE OF JACK HAMMERS, VIBRATORY COMPACTION EQUIPMENT, OR OTHER SIMILAR EQUIPMENT IS PROHIBITED.



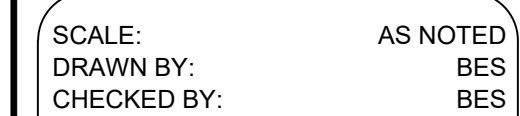
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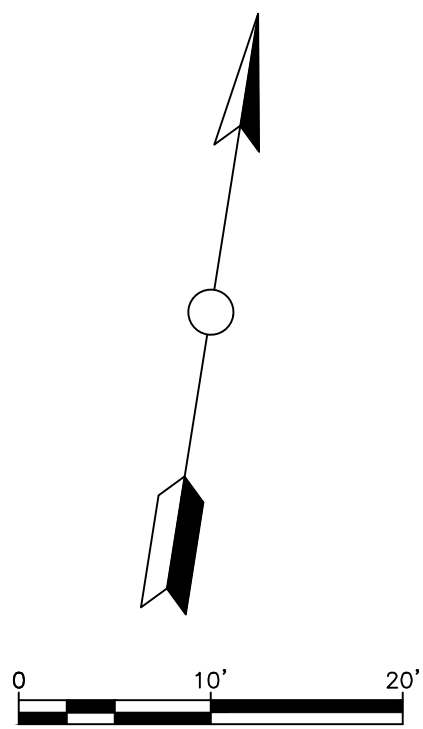
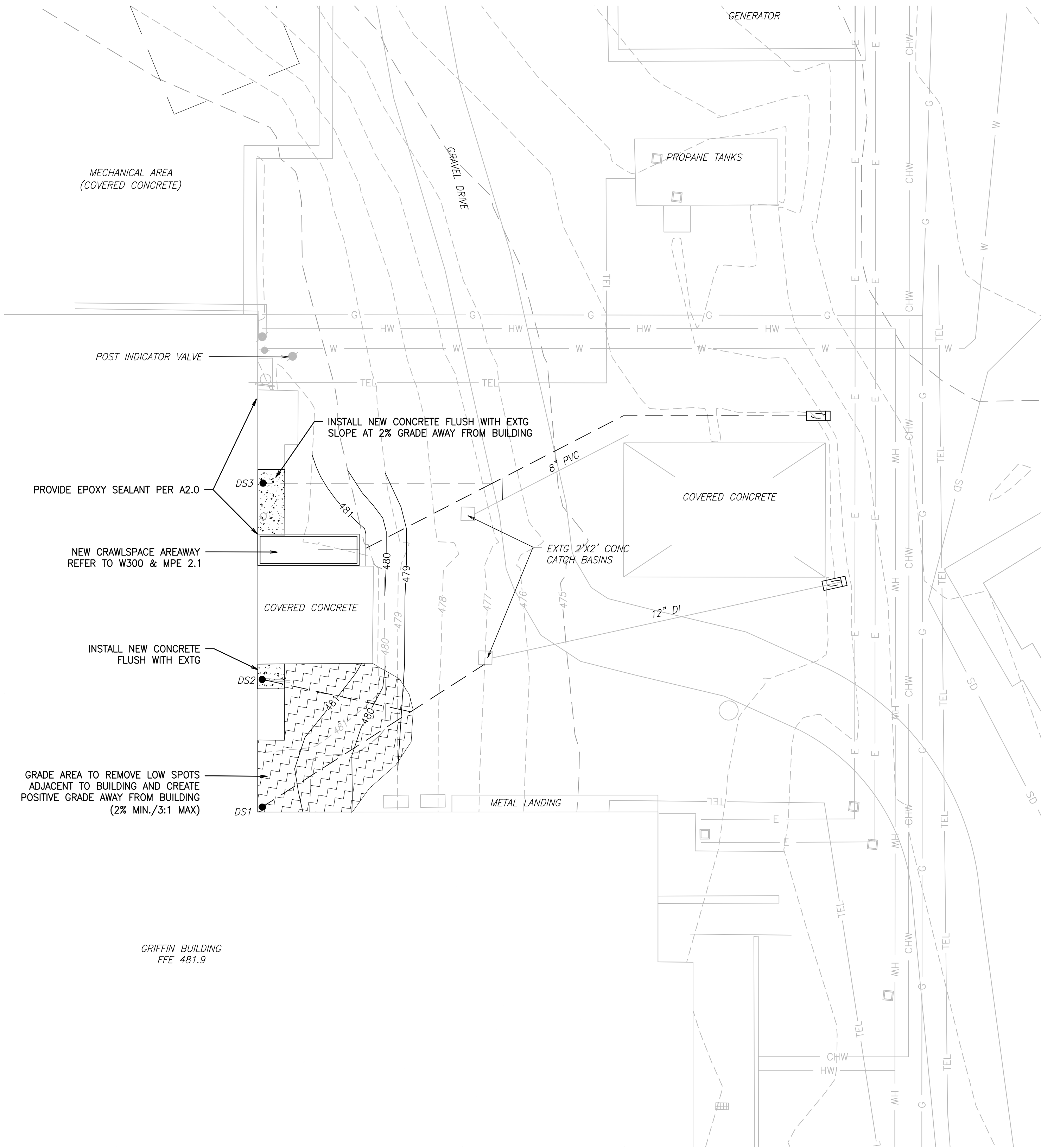
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EROSION CONTROL & DEMOLITION PLAN

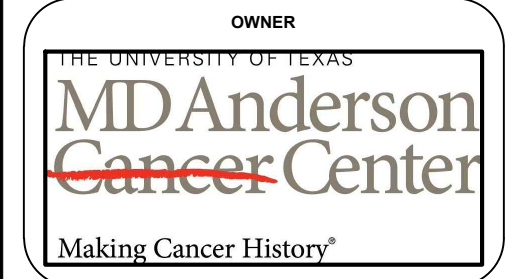
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PROJECT

Griffin Animal Building Crawlspace Improvements

M.D. Anderson Cancer Center - Smithville, Texas
MDACC Project No. 15-0005

DATE
OCTOBER 12, 2018

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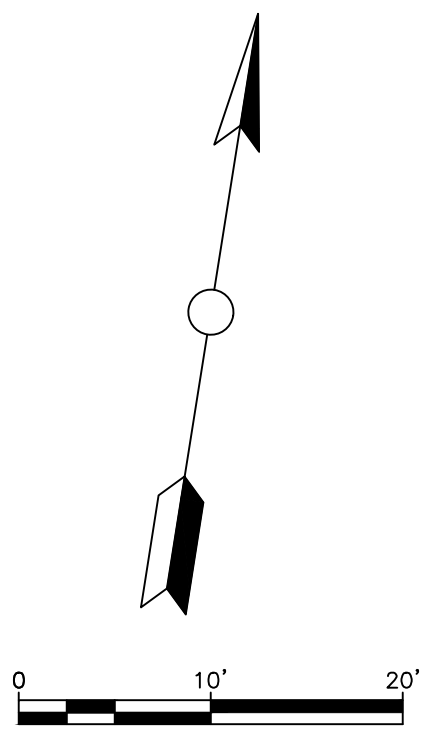
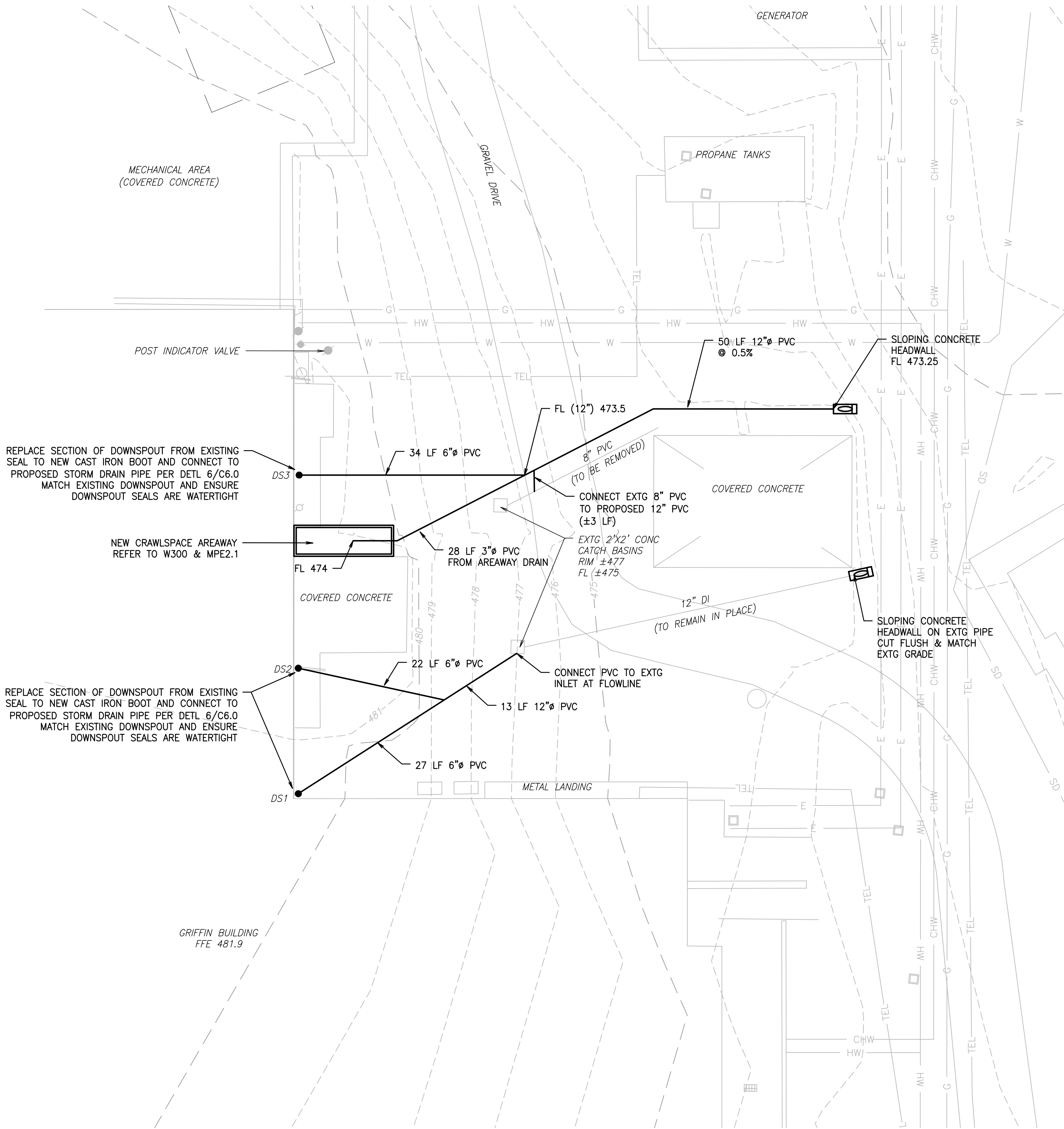
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DOCUMENTS

SITE GRADING
PLAN

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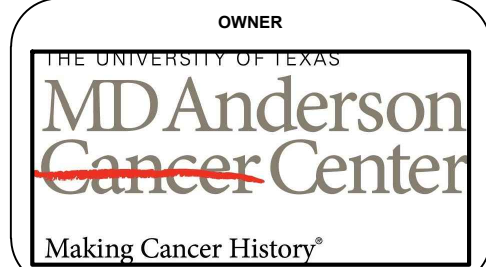
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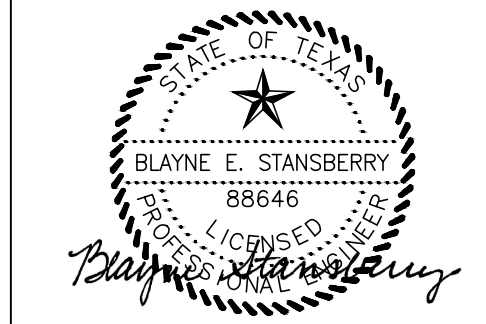
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PROJECT
**GRIFFIN ANIMAL BUILDING
CRAWLSPACE IMPROVEMENTS**
M.D. ANDERSON CANCER CENTER - SMITHVILLE, TEXAS
MDACC PROJECT NO. 15-0005

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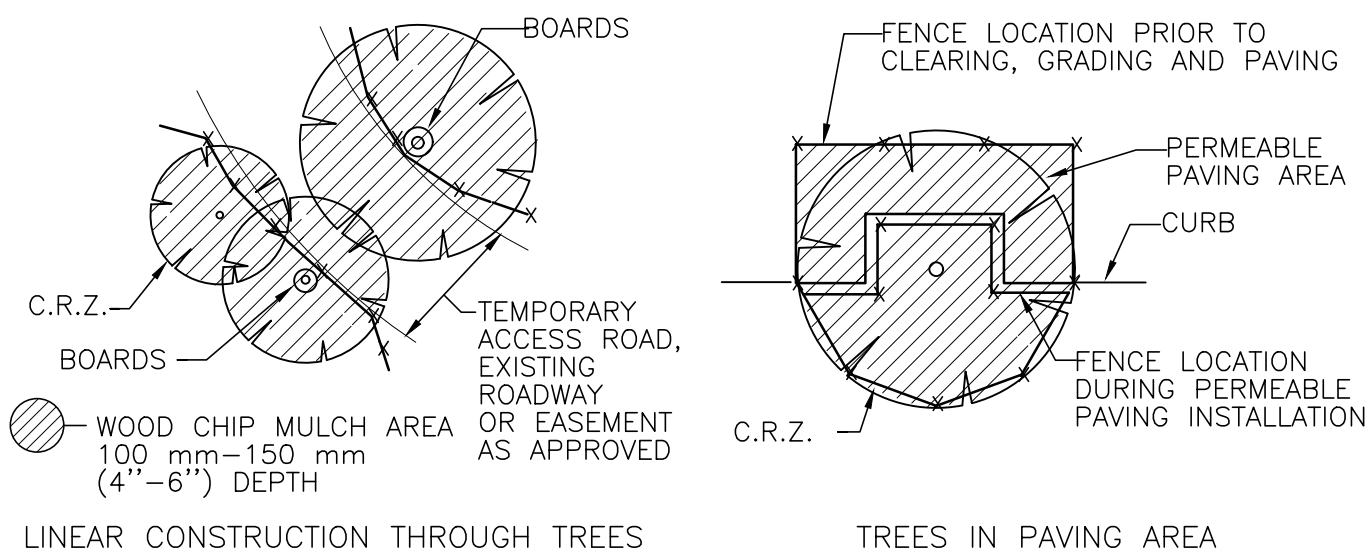
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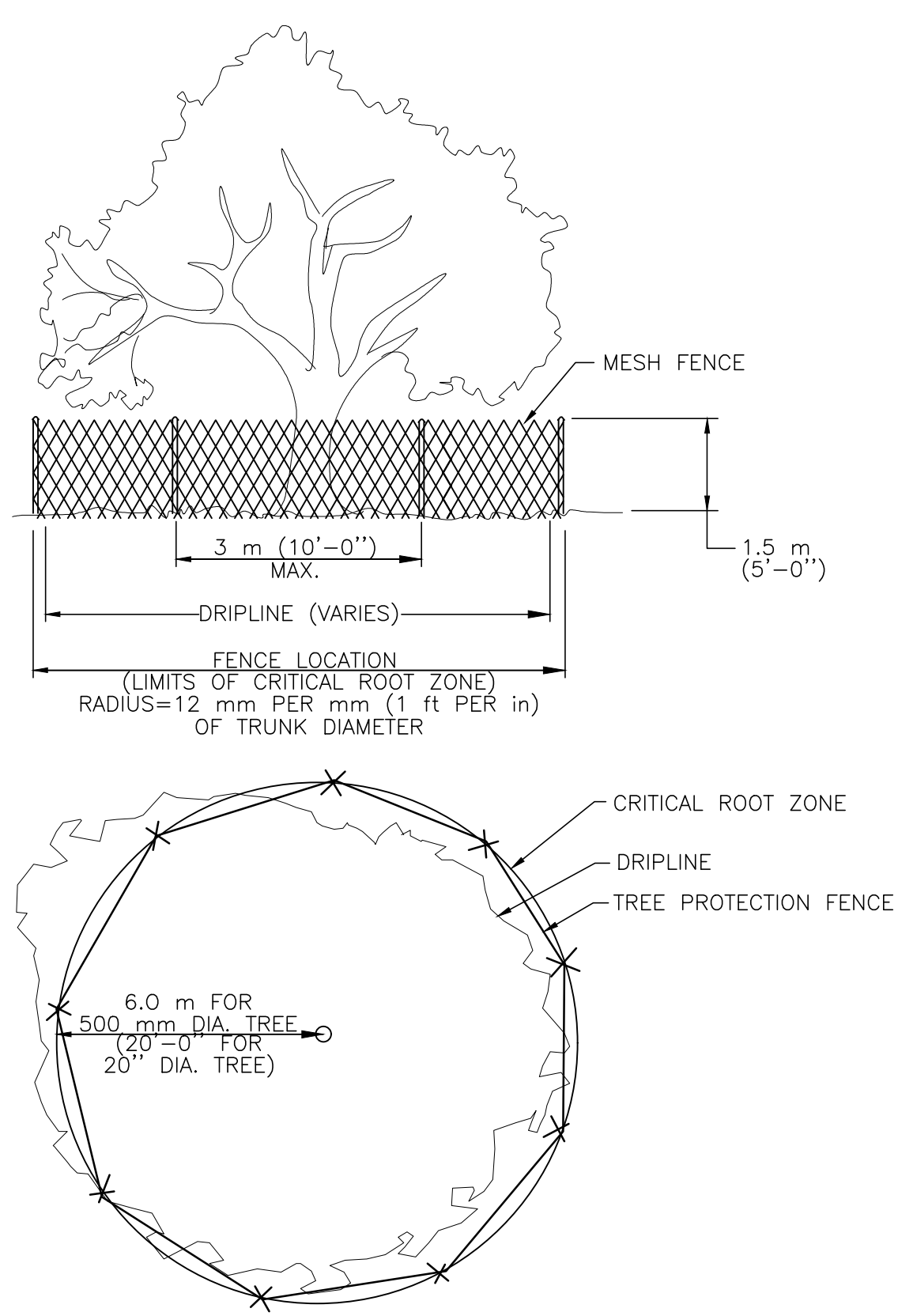
**STORM DRAIN
PLAN**

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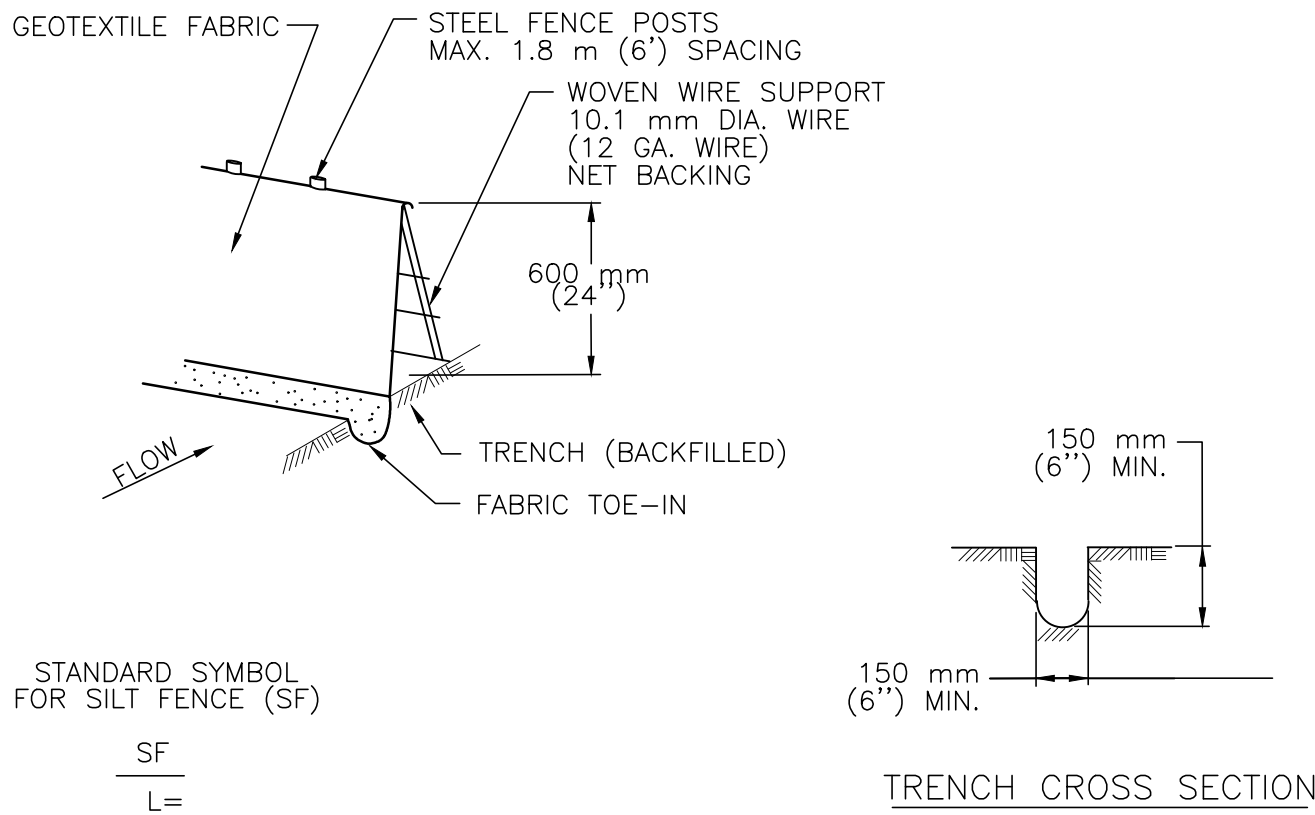
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1 TREE PROTECTION FENCE LOCATIONS
COA 610S-1

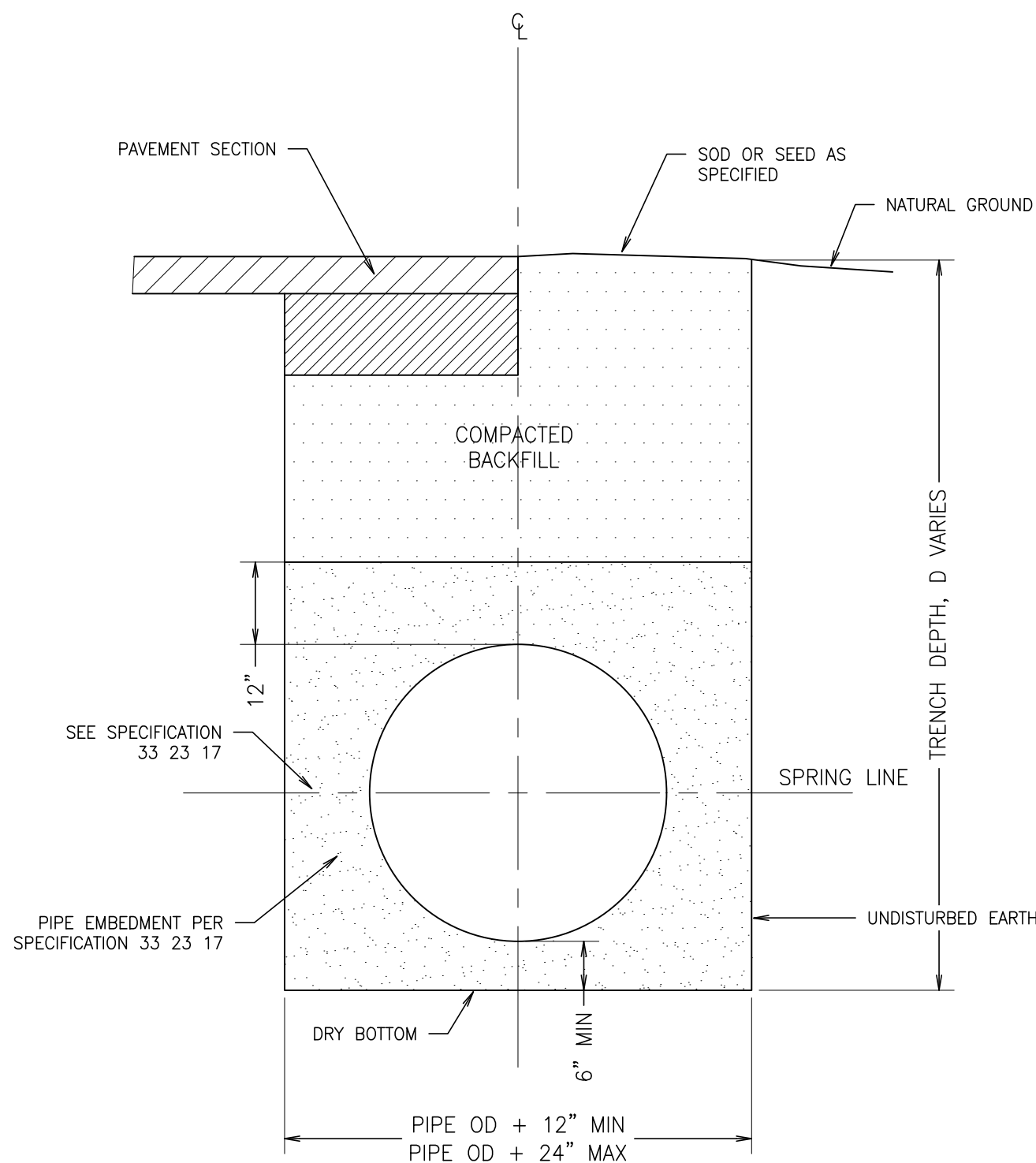


2 TREE PROTECTION FENCE

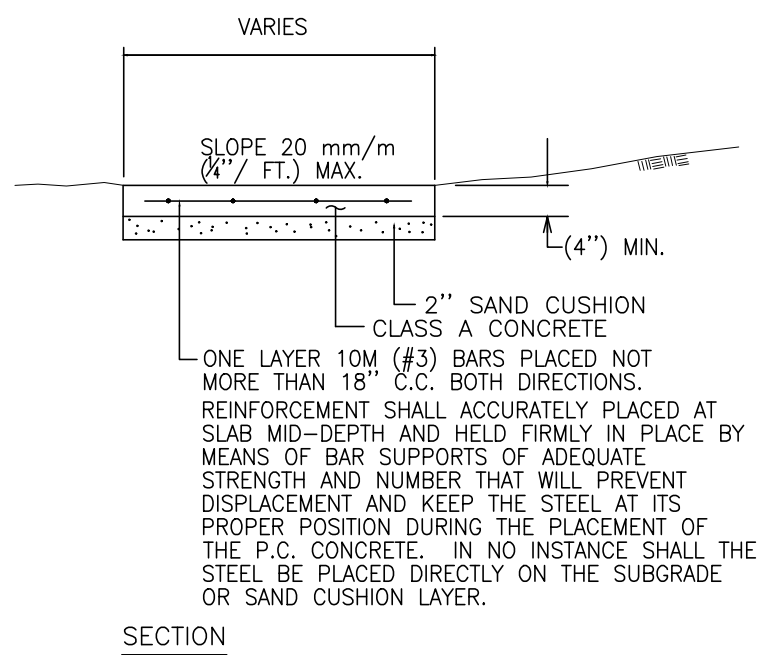
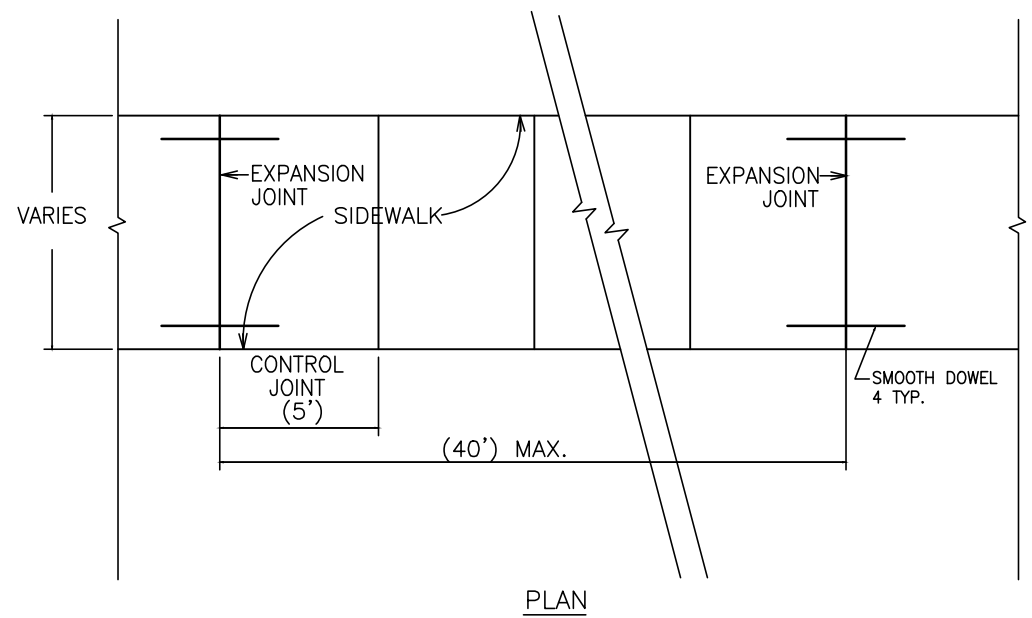


- NOTES:
1. STEEL POSTS WHICH SUPPORT THE SILT FENCE SHALL BE INSTALLED ON A SLIGHT ANGLE TOWARD THE ANTICIPATED RUNOFF SOURCE. POST MUST BE EMBEDDED A MINIMUM OF 300 mm (1").
 2. THE TOE OF THE SILT FENCE SHALL BE TRENCHED IN WITH A SPADE OR MECHANICAL TRENCHER, SO THAT THE DOWNSLOPE FACE OF THE TRENCH IS FLAT AND PERPENDICULAR TO THE LINE OF FLOW.
 3. THE TRENCH MUST BE A MINIMUM OF 150 mm (6 inches) DEEP AND 150 mm (6 inches) WIDE TO ALLOW FOR THE SILT FENCE FABRIC TO BE LAID IN THE GROUND AND BACKFILLED WITH COMPACTED MATERIAL.
 4. SILT FENCE SHOULD BE SECURELY FASTENED TO EACH STEEL SUPPORT POST OR TO WOVEN WIRE, WHICH IS IN TURN ATTACHED TO THE STEEL FENCE POST.
 5. INSPECTION SHALL BE MADE WEEKLY OR AFTER EACH RAINFALL EVENT AND REPAIR OR REPLACEMENT SHALL BE MADE PROMPTLY AS NEEDED.
 6. SILT FENCE SHALL BE REMOVED WHEN THE SITE IS COMPLETELY STABILIZED SO AS NOT TO BLOCK OR IMPEDE STORM FLOW OR DRAINAGE.
 7. ACCUMULATED SILT SHALL BE REMOVED WHEN IT REACHES A DEPTH OF 150 mm (6 inches). THE SILT SHALL BE DISPOSED OF ON AN APPROVED SITE AND IN SUCH A MANNER THAT WILL NOT CONTRIBUTE TO ADDITIONAL SILTATION.

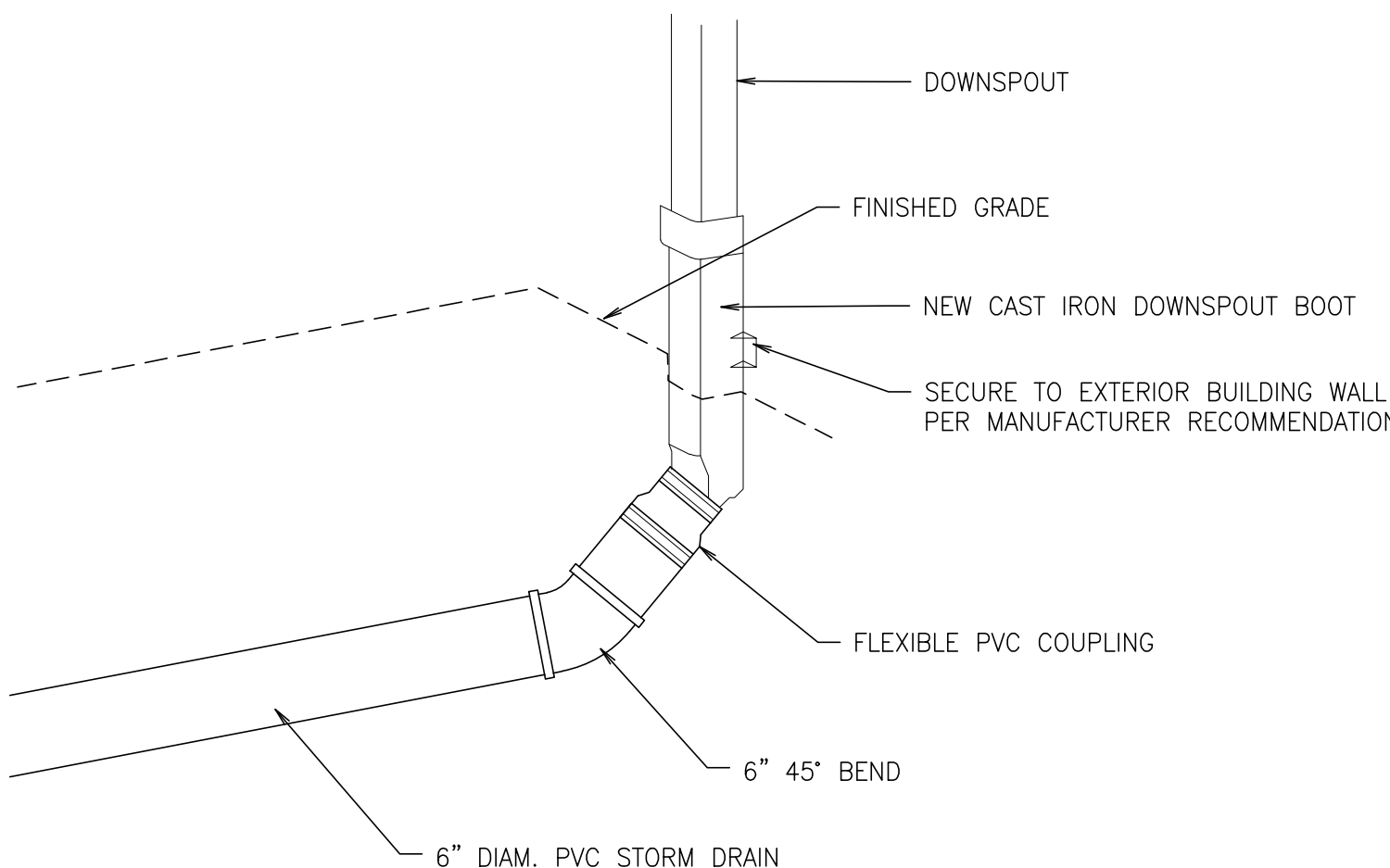
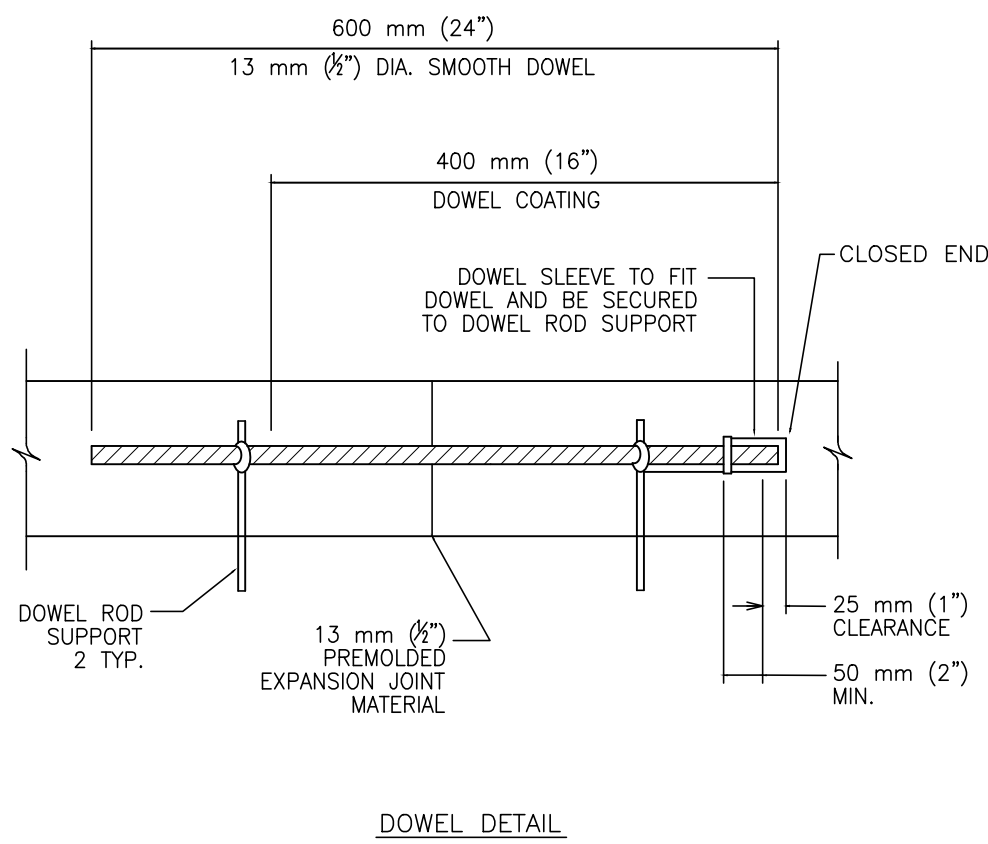
3 SILT FENCE
COA 642S-1



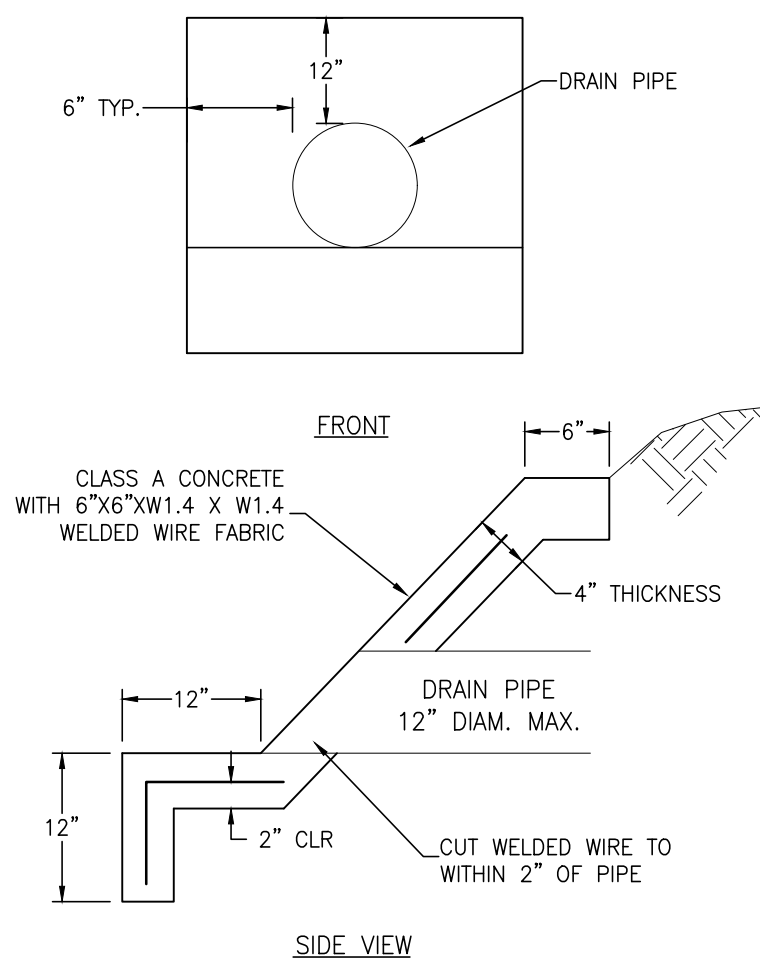
4 UTILITY LINE BEDDING/BACKFILL
REF SPEC 33 23 17 (COH 02317-04)



5 SIDEWALK
NTS



6 DOWNSPOUT STORM DRAIN CONNECTION
NTS



7 SMALL HEADWALL
NTS

GENERAL NOTES

SCOPE OF PROJECT

1. SCOPE OF WORK IS DEFINED BY THESE DRAWINGS, INCLUDES ALL LABOR, MATERIALS AND EQUIPMENT TO ACCOMPLISH THE WORK. THE SCOPE GENERALLY INCLUDES:

1. INSTALLATION OF CONCRETE AREAWAY WITH UNDERREAMED PIERS AND ASSOCIATED EXHAUST EQUIPMENT AND ACCESS EQUIPMENT.
2. GUTTER AND DOWNSPOUT ALTERATIONS INCLUDING SIDEWALK DRAINAGE TRENCHES.
3. REMOVAL AND REPLACEMENT OF SEALANT JOINTS BETWEEN EXTERIOR WALL AND ADJACENT SIDEWALK.

CODE COMPLIANCE

1. DRAWINGS HAVE BEEN DESIGNED IN ACCORDANCE WITH THE FOLLOWING CODES:

- 2015 INTERNATIONAL BUILDING CODE,
- 2015 INTERNATIONAL EXISTING BUILDING CODE,
- 2015 INTERNATIONAL ENERGY CONSERVATION CODE,
- 2015 INTERNATIONAL MECHANICAL CODE,
- 2015 INTERNATIONAL PLUMBING CODE,
- 2015 INTERNATIONAL FUEL GAS CODE,
- 2015 NFPA 101, LIFE SAFETY CODE,
- 2015 NFPA 1 FIRE CODE.

2. THE CONTRACTOR SHALL COMPLETE THE WORK IN A SAFE & WORKMANLIKE MANNER IN ACCORDANCE WITH LOCAL CODES, ORDINANCES, AND LAWS AS ADOPTED BY THE CITY OF SMITHVILLE, TEXAS.

COORDINATION

1. THE CONTRACTOR SHALL COORDINATE WORK BETWEEN ALL TRADES AND BRING ANY CONFLICTS TO THE ARCHITECT'S ATTENTION PRIOR TO THE WORK BEING PERFORMED. CONTRACTOR IS RESPONSIBLE FOR ALL COSTS FOR CORRECTIONS ASSOCIATED WITH THE CONTRACTOR'S FAILURE TO PROPERLY COORDINATE THE WORK.

2. THE DETAILS OR NOTES DESIGNATED AS "TYPICAL" APPLY TO THE DRAWINGS IN ALL AREAS WHERE CONDITIONS ARE SIMILAR TO THOSE DESCRIBED AS TYPICAL.

3. ANY SUBSTITUTIONS CAUSING OR REQUIRING CHANGES TO THE DESIGN SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO COORDINATE.

4. ANY REQUIRED CHANGES TO THE DRAWINGS DUE TO THE ACCEPTANCE OF ALTERNATES AND/OR SUBSTITUTES ARE THE RESPONSIBILITY OF THE CONTRACTOR AND SHALL BE SUBMITTED TO THE ARCHITECT FOR APPROVAL.

5. IF CONDITIONS EXIST THAT ARE NOT ADEQUATELY DETAILED, INFORM THE ARCHITECT, AND ADDITIONAL DETAILS OR INTERPRETATION WILL BE PROVIDED. DO NOT PROCEED WITHOUT VERIFICATION FROM THE ARCHITECT.

FAMILIARITY WITH CONDITIONS

1. THE CONTRACTOR SHALL THOROUGHLY EXAMINE AND BECOME FAMILIAR WITH THE REQUIREMENTS OF THE CONTRACT DRAWINGS.

2. THE CONTRACTOR MUST VISIT THE SITE OF THE PROPOSED WORK AND BECOME FULLY ACQUAINTED WITH THE EXISTING CONDITIONS RELATING TO THE CONSTRUCTION, LABOR, FACILITIES INVOLVED, DIFFICULTIES, RESTRICTIONS, AND THE LOGICAL EXTENSIONS OF THE SCOPE ATTENDING THE PERFORMANCE OF THE CONTRACT.

3. THE CONTRACTOR SHALL IN NO WAY BE RELIEVED OF ANY OBLIGATION UNDER THE CONTRACT BECAUSE OF THE CONTRACTOR'S FAILURE TO VISIT THE SITE AND BECOME FULLY INFORMED OF ANY AND ALL CONDITIONS AND REQUIREMENTS THAT MAY IN ANY MANNER AFFECT THE WORK TO BE PERFORMED.

DOCUMENTATION OF PRE-CONSTRUCTION PHOTOGRAPHS

1. THE CONTRACTOR SHALL PHOTOGRAPH AND/OR VIDEO DOCUMENT AND TAKE WRITTEN NOTES OF EXISTING CONDITIONS PRIOR TO COMMENCEMENT OF THE WORK ON THE SITE. COPIES OF ALL DOCUMENTATION SHALL BE SUBMITTED TO THE OWNER AND/OR ARCHITECT PRIOR TO COMMENCING WORK.

EXISTING CONDITIONS

1. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING DIMENSIONS AND CONDITIONS. DIMENSIONS SHOWN ON THE DRAWINGS ARE APPROXIMATE, AND FIELD MEASUREMENTS AND VERIFICATION WILL BE REQUIRED TO COMPLETE THE WORK. CONTRACTOR SHALL OBTAIN ALL FIELD MEASUREMENTS AS NECESSARY TO COORDINATE WITH, AND MATCH NEW CONSTRUCTION TO EXISTING CONDITIONS.

2. SOME INFORMATION SHOWN IN THE DRAWINGS, IN REGARDS TO EXISTING FEATURES, IS NECESSARILY CONJECTURAL DUE TO HIDDEN CONDITIONS AT THE TIME OF PREPARATION. IF CONDITIONS EXIST THAT DIFFER FROM THE DRAWINGS, OR ARE NOT ADEQUATELY DETAILED, INFORM THE ARCHITECT AND ADDITIONAL DETAILS OR INTERPRETATION WILL BE PROVIDED. DO NOT PROCEED WITHOUT VERIFICATION FROM THE ARCHITECT.

SAFETY

1. CONTRACTOR IS SOLELY RESPONSIBLE FOR THEIR MEANS AND METHODS OF CONSTRUCTION, AND SHALL PERFORM ALL WORK IN A SAFE AND CONSCIENTIOUS MANNER TO PREVENT INJURIES.

2. CONTRACTOR IS SOLELY RESPONSIBLE FOR JOBSITE SAFETY, AND SHALL ENSURE THEIR COMPLIANCE WITH OSHA STANDARDS FOR JOB SAFETY AND WORKER PROTECTION. SAFETY MEASURES INCLUDE, BUT ARE NOT LIMITED TO ADEQUATE FALL PROTECTION, ERECTION BRACING, BARRICADES, FENCING, SIGNS, FIRST-AID STATIONS, ETC.

3. CONTRACTOR SHALL PROVIDE ALL SHORING, BRACING, AND SHEETING REQUIRED FOR SAFETY AND PROPER EXECUTION OF THE WORK.

4. THE CONTRACTOR SHALL PROVIDE WARNING SIGNS, BARRIERS OR BARRICADES, AS REQUIRED AND OTHERWISE NECESSARY TO SEPARATE THE WORK AREAS FROM THE PUBLIC, TO PREVENT PEDESTRIANS AND TRAFFIC FROM ENTERING THE WORK AREAS, AND TO PROVIDE A SAFE AND ORDERLY FLOW OF PEDESTRIAN AND VEHICLE TRAFFIC THROUGH REQUIRED ENTRANCES AND EXITS DURING THE REPAIR WORK.

5. THE OWNER AND ARCHITECT SHALL NOT HAVE CONTROL OVER OR CHARGE OF, AND SHALL NOT BE RESPONSIBLE FOR CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES OR PROCEDURES, OR FOR SAFETY PRECAUTIONS AND SAFETY PROGRAMS IN CONNECTION WITH THE PROJECT.

FIRE PROTECTION

1. THE CONTRACTOR SHALL BE RESPONSIBLE FOR FIRE PROTECTION AND FIRE WATCH DURING ALL CONSTRUCTION OPERATIONS.

2. NO SMOKING SHALL BE PERMITTED ONSITE. CONTRACTOR SHALL PROVIDE AND MAINTAIN TEMPORARY FIRE EXTINGUISHERS UNTIL SUBSTANTIAL COMPLETION.

PROTECTION OF BUILDING AND SITE

1. CONTRACTOR SHALL PROTECT ALL EXISTING BUILDING SURFACES FOR THE DURATION OF THE PROJECT. ANY DAMAGE TO THE EXISTING STRUCTURE OR BUILDING CONTENTS THAT HAS BEEN DETERMINED TO BE CAUSED BY THE CONTRACTOR, OR CONSTRUCTION PRACTICES THAT OCCUR FOLLOWING THE NOTICE TO PROCEED, SHALL BE CORRECTED TO PRE-CONSTRUCTION CONDITION AT NO EXPENSE TO THE OWNER.

2. CONTRACTOR SHALL PROTECT ALL EXISTING TREES, LANDSCAPING, SITE LIGHTING, SIDEWALKS, AND SITE FEATURES FROM DAMAGE FOR THE DURATION OF THE PROJECT. IF DAMAGED DURING THE COURSE OF WORK, THE CONTRACTOR SHALL REPAIR THE DAMAGED AREAS TO PRE-CONSTRUCTION CONDITION PRIOR TO THE COMPLETION OF THE PROJECT AT NO EXPENSE TO THE OWNER.

3. DO NOT PLACE LOADS ON THE STRUCTURE OR STORE DEMOLISHED MATERIALS ON THE STRUCTURE IN A MANNER THAT WILL ENDANGER IT.

4. CONTRACTOR SHALL KEEP THE BUILDINGS SECURE AT ALL TIMES.

5. ALL CONSTRUCTION MATERIALS KEPT IN ELEVATED AREAS, SUCH AS AND ROOFS, SHALL REMAIN SECURED TO ENSURE THE MATERIALS DO NOT BECOME AIRBORNE AND CAUSE INJURY OR DAMAGE TO THE BUILDING OR ITS OCCUPANTS.

6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE HANDLING, STORAGE, HAULING AND REMOVAL OF THE MATERIALS REMOVED.

7. CONTRACTOR SHALL MAINTAIN THE WATER-TIGHTNESS OF THE BUILDING DURING THE CONSTRUCTION PERIOD. ANY DAMAGES RESULTING FROM WATER INFILTRATION WILL BE THE RESPONSIBILITY OF THE CONTRACTOR TO REPAIR AT NO EXTRA COST TO THE OWNER.

BUILDING MAINTENANCE

1. CONTRACTOR SHALL PERFORM SITE CLEAN UP ON A DAILY BASIS, AND MAINTAIN THE SITE IN A CLEAN AND ORDERLY MANNER.

2. CONTRACTOR SHALL ADEQUATELY SECURE ALL WORK AT THE END OF EACH WORK DAY.

3. AREAS THAT ARE NOT DIRECTLY UNDER CONSTRUCTION THAT ARE USED AS PATHWAYS TO TRANSPORT MATERIALS, OR TO REMOVE TRASH, ARE TO BE KEPT CLEAN AT ALL TIMES. THIS MAINTENANCE INCLUDES, BUT IS NOT LIMITED TO DUSTING, SWEEPING, MOPPING, AND PICKING UP TRASH AS REQUIRED TO KEEP THE AREAS FREE OF WASTE MATERIALS, DEBRIS, AND RUBBISH.

SHOP DRAWINGS AND SUBMITTALS

1. SHOP DRAWINGS SHALL BE PREPARED FOR ALL STRUCTURAL ITEMS AND SUBMITTED FOR REVIEW BY THE ENGINEER. CONTRACT DRAWINGS SHALL NOT BE REPRODUCED AND USED AS SHOP DRAWINGS. ALL ITEMS DEVIATING FROM THE CONTRACT DRAWINGS OR FROM PREVIOUSLY SUBMITTED SHOP DRAWINGS SHALL BE CLOUDED.

2. MANUFACTURER'S PRODUCT DATA FOR EACH MATERIAL TO BE USED SHALL BE SUBMITTED FOR REVIEW. WORK ASSOCIATED WITH THESE ITEMS SHALL NOT COMMENCE UNTIL THE SUBMITTALS HAVE BEEN REVIEWED AND RETURNED.

3. CONTRACTOR TO DEVELOP SUBMITTAL LOG FOR THE ARCHITECT'S REVIEW & APPROVAL PRIOR TO START OF WORK. THE SUBMITTAL LOG SHOULD INCLUDE THE FOLLOWING ITEMS AT A MINIMUM. REFER TO RELEVANT NOTE SECTIONS FOR COMPLETE SUBMITTAL REQUIREMENTS

- A. PRE-CONSTRUCTION DOCUMENTATION, INCLUDING PHOTOGRAPHS, VIDEOS, FIELD NOTES, ETC.
- B. CORRUGATED FIBER CARTON FORMS & ASSOCIATED ACCESSORIES PRODUCT DATA
- C. RETAINER PANEL PRODUCT DATA
- D. REINFORCING STEEL SHOP DRAWINGS
- E. CONCRETE MIXTURE DESIGNS FOR EACH ELEMENT TYPE
- F. CONCRETE CURING PROTOCOL
- G. SLAB-ON-GRADE EXPANSION JOINT SEALANTS PRODUCT DATA
- H. SLAB-ON-GRADE VAPOR BARRIER PRODUCT DATA.
- I. EXTERIOR SHEATHING PRODUCT DATA
- J. SLAB-ON-GRADE PROPOSED JOINT SPACING LAYOUT.
- K. PROJECT RECORD DOCUMENTS, INCLUDING AS-BUILT DRAWINGS, OPERATION AND MAINTENANCE MANUALS, ETC. (NOT ROD BEFORE CONST. BEGINS)
- L. REBAR CHAIRS AND PRODUCT DATA.
- M. WATERSTOP MATERIAL AND PRODUCT DATA.

BURIED UTILITIES

1. THE CONTRACTOR SHALL CONTACT THE APPROPRIATE UTILITY COMPANY/ENTITY AT LEAST 48 HOURS BEFORE ANY EXCAVATION TO REQUEST EXACT FIELD LOCATION OF UTILITIES.

2. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO RELOCATE ALL EXISTING UTILITIES WHICH CONFLICT WITH THE PROPOSED IMPROVEMENTS SHOWN ON THESE DRAWINGS.

TEMPORARY BRACING, FALSEWORK, AND FORMWORK

1. THE DESIGN, CONSTRUCTION, AND SAFETY OF ALL TEMPORARY SUPPORTS SUCH AS GUYS, FALSEWORK, FORMWORK, SHORES AND BRACING REQUIRED FOR THE EXECUTION OF THE CONTRACT ARE NOT INCLUDED IN THE DRAWINGS AND SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR. DESIGN FOR STRUCTURAL SUPPORT AT ALL LOCATIONS SHOULD BE PERFORMED BY A QUALIFIED, LICENSED PROFESSIONAL ENGINEER.

2. SUBMIT SHOP DRAWINGS SHOWING THE LOCATION, DISTRIBUTION, AND QUANTITY OF SHORING TO BE PROVIDED AT LOCATIONS TO BE SHORED AND CALCULATIONS SHOWING THAT SUPPORT OF LOADS WILL BE CONSISTENT WITH SHORING DESIGN LOADS SHOWN ON DRAWINGS.

QUALITY ASSURANCE

1. WHERE APPLICABLE, THE CONTRACTOR SHALL BE A LICENSED APPLICATOR OR INSTALLER OF ALL SPECIFIED PROPRIETARY PRODUCTS AND MATERIALS.

2. THE PRESENCE OF THE ARCHITECT OR TESTING AGENCY AT THE JOBSITE DOES NOT RELIEVE CONTRACTOR OF THE OBLIGATION TO PERFORM THE WORK IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.

3. THE OWNER AND ARCHITECT MAY PERFORM QUALITY CONTROL TESTS ON A RANDOM BASIS FROM TIME TO TIME TO EVALUATE INSTALLATION OF THE NEW CONSTRUCTION FOR CONFORMANCE TO THE DRAWINGS AND SPECIFICATIONS. THE CONTRACTOR SHALL MAKE ACCESS AVAILABLE TO INSPECT AND TEST THE SPECIFIED AREA AND MAKE APPROPRIATE REPAIRS (BASED ON UNIT COSTS) AFTER COMPLETION OF INSPECTION. ANY DEFECTIVE WORK WILL BE REPAIRED AT NO COST TO THE OWNER.

WARRANTY

1. ALL WORK PERFORMED SHALL BE WARRANTED BY THE GENERAL CONTRACTOR AS REQUIRED BY THE CONTRACT.

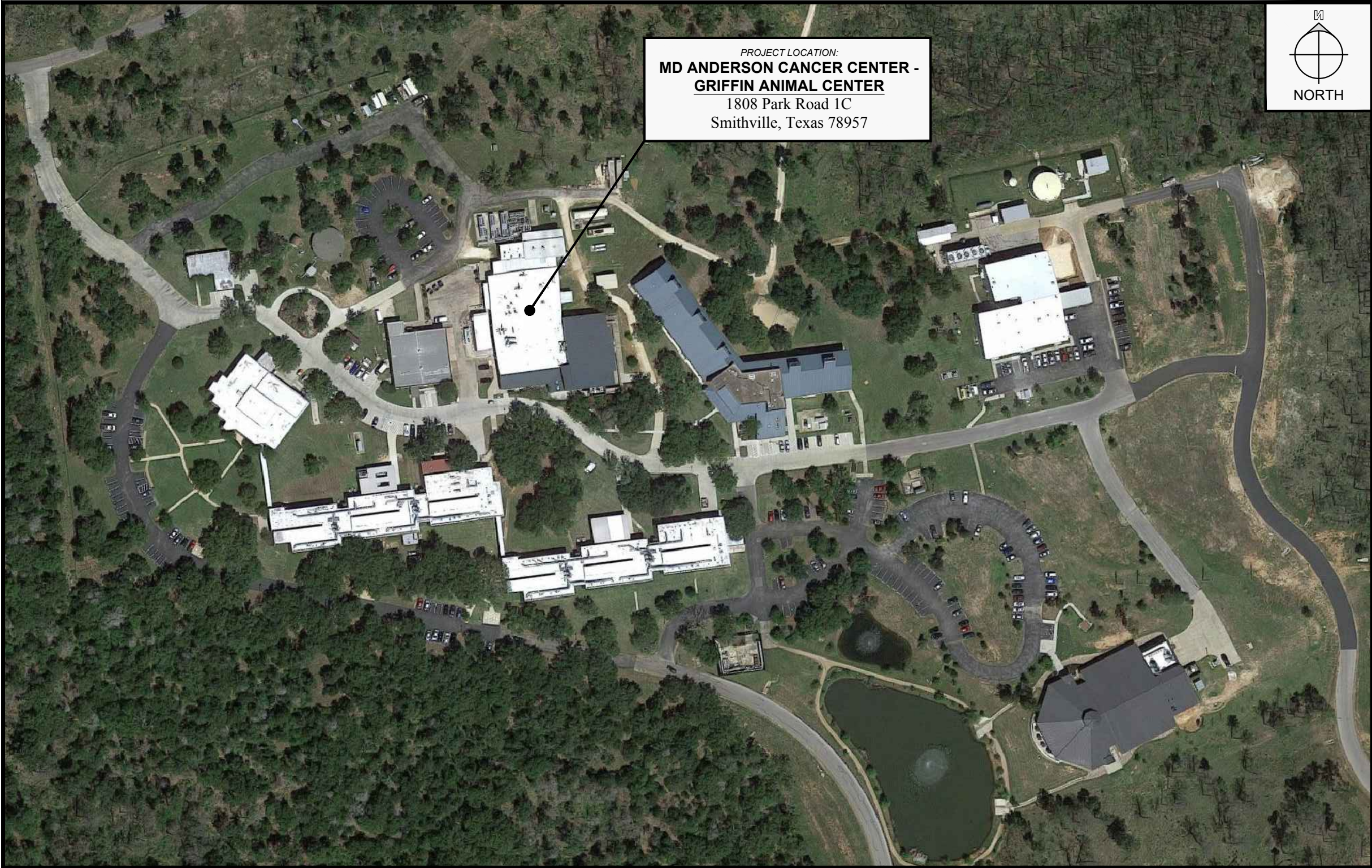
STRUCTURAL NOTES

DESIGN STANDARDS

1. THE PROJECT WAS DESIGNED IN ACCORDANCE WITH THE FOLLOWING CODES:

- A. THE INTERNATIONAL BUILDING CODE, 2015 EDITION.
- B. ASCE 7-93, MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES.
- C. ACI 318-99, BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE.

PROJECT VICINITY MAP - NOT TO SCALE



COMMON SYMBOLS LEGEND

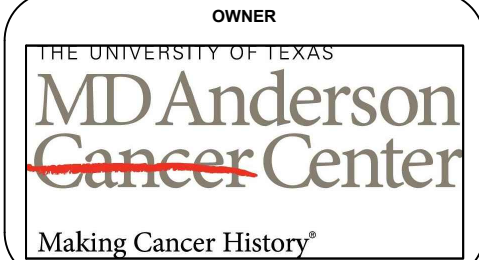
	PLAN / DETAIL NAME LABEL
	ELEVATION CALLOUT
	SECTION CALLOUT
	DETAIL / VIEW CALLOUT
	KEYED NOTE / OBSERVATION
	ELEVATION MARKER
	CHANGE IN ELEVATION
	DRAWING MATCHLINE
	GRAPHICAL PLAN SCALE
	STRUCTURAL GRIDLINE
	NORTH ARROW

COMMON ABBREVIATIONS

&	AND
A.F.F.	ABOVE FINISH FLOOR
ADD'L	ADDITIONAL(LY)
APPROX.	APPROXIMATE
ARCH.	ARCHITECT
ARCH'L	ARCHITECTURAL
A/C	AIR CONDITIONER
B.F.F.	BELOW FINISH FLOOR
B.O.	BOTTOM OF - - -
B.O.C.	" " CONCRETE
B.O.S.	" " SLAB
C	CENTERLINE
CONC.	CONCRETE
CMU	CONCRETE MASONRY UNIT
CONT.	CONTINUOUS(LY)
C.J.	CONSTRUCTION JOINT
d	PENNY (NAIL SIZE)
DL	DEAD LOAD
DIAG.	DIAGONAL
DIA.	DIAMETER
DIM(S)	DIMENSION(S)
DS	DOWNSPOUT
DBL	DOUBLE
DN	DOWN
EA.	EACH
E.F.	EACH FACE
E.W.	EACH WAY
EL. or ELEV.	ELEVATION
ELEC.	ELECTRIC(AL)
EQ.	EQUAL(LY)
EQUIP.	EQUIPMENT
EXP.	EXPANSION
EXT.	EXTERIOR
F.F.	FINISH FLOOR
FD	FLOOR DRAIN
F.V.	FIELD VERIFY
GA.	GAGE OR GAUGE
GALV.	GALVANIZED
GWB	GYPNUM WALL BOARD
H.D.	HOT-DIP (GALVANIZING)
H.S.	HOLLOW STEEL SECTION
HORIZ.	HORIZONTAL
INFO.	INFORMATION
INT.	INTERIOR
K	KIPS (1000 lbs.)
KLF	KIPS PER LINEAR FOOT
KSF	KIPS PER SQUARE FOOT
LL	LIVE LOAD
LLH	LONG LEG HORIZONTAL
LLV	LONG LEG VERTICAL
LSL	LONG SLOTTED HOLE
MFR.	MANUFACTURE(D)(R)
MAX.	MAXIMUM
MECH.	MECHANICAL(LY)
MIN.	MINIMUM
MISC.	MISCELLANEOUS
N.I.W.	NOT IN CONTRACT
N.T.S.	NOT TO SCALE
O.C.	ON CENTER
O.H. or OPP.	OPPOSITE HAND
PERP.	PERPENDICULAR
P.T.	PRESERVATIVE TREATED
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
R	RADIUS
REINF.	REINFORCE(D) (MENT) (ING)
RD	ROOF DRAIN
RTU	ROOF TOP UNIT
SCHED.	SCHEDULE(D)
SIM.	SIMILAR(LY)
SF	SQUARE FEET
S.S.	STAINLESS STEEL
TEMP.	TEMPORARY(Y) (ILY)
T.O.	TOP OF - - -
T.O.B.	" " BEAM
T.O.C.	" " CONCRETE
T.O.F.F.	" " FINISH FLOOR
T.O.S.	" " SLAB
T.O.W.	" " WALL
TS	TUBE STEEL SECTION
TYP.	TYPICAL(LY)
U.N.O.	UNLESS NOTED OTHERWISE
VERT.	VERTICAL

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GRIFFIN ANIMAL BUILDING
CRAWLSPACE IMPROVEMENTS

M.D. ANDERSON CANCER CENTER - SMITHVILLE, TEXAS
MDACC PROJECT NO. 15-0005

DATE
OCTOBER 12, 2018

WJE ENGINEERS
ARCHITECTS
MATERIALS SCIENTISTS
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SCALE: AS SHOWN
DRAWN BY: FV/TJH
CHECKED BY: EJM

100% CONSTRUCTION DOCUMENTS

GENERAL NOTES
& PROJECT INFO

SHEET NUMBER
W100

FOUNDATIONS

1. A GEOTECHNICAL REPORT, DATED OCTOBER 3, 2000 AND PREPARED BY FUGRO SOUTH, INC. PROVIDED FOR THIS PROJECT AND IS AVAILABLE FOR INFORMATION ONLY. THE OPINIONS EXPRESSED IN THIS REPORT ARE THOSE OF GEOTECHNICAL ENGINEER AND REPRESENT INTERPRETATIONS OF SUBSOIL CONDITIONS, TESTS, AND RESULTS OF ANALYSES CONDUCTED BY GEOTECHNICAL ENGINEER. OWNER IS NOT RESPONSIBLE FOR INTERPRETATIONS OR CONCLUSIONS DRAWN FROM THIS DATA. THE GEOTECHNICAL REPORT IS AVAILABLE UPON REQUEST.

2. COMPLY WITH DRILLED-PIER STANDARD: ACI 336.1 - SPECIFICATIONS FOR THE CONSTRUCTION OF DRILLED PIERS EXCEPT AS MODIFIED IN THIS SECTION.

3. THE FOUNDATION FOR THE STRUCTURE HAS BEEN DESIGNED FOR THE FOLLOWING ALLOWABLE SOIL BEARING PRESSURES.

A. UNDER REAMED DRILLED PIERS: 4,500 PSF (END BEARING)

4. DRILLED AND UNDER REAMED FOOTINGS SPACED CLOSER THAN 6 FEET (CLEAR SPACING) SHOULD BE PLACED AT LEAST 6 HOURS APART AND PREFERABLY ON ALTERNATE DAYS.

5. PENETRATION OF THE BOTTOM OF DRILLED PIERS INTO VERY STIFF STIFF, UNDISTURBED, NATURAL CLAY AT DEPTH OF 10 FEET BELOW EXISTING GRADE. THE CONTRACTOR SHALL TAKE ACCURATE MEASUREMENTS OF THE DEPTH OF PENETRATION INTO THE BEARING STRATUM. TO BE ASSURED OF CONFORMANCE WITH THE DEPTH OF REQUIRED PENETRATION, AND SUBMIT A REPORT OF DEPTHS OF PENETRATION DRILLED TO THE ENGINEER.

6.TEMPORARY STEEL CASING MAY BE REQUIRED DURING THE INSTALLATION OF DRILLED PIERS. THE CONTRACTOR SHALL PROVIDE A UNIT PRICE FOR THE USE OF STEEL CASING AS A SEPARATE ITEM IN THE CONTRACT.

7. NOTIFY AND ALLOW TESTING AND INSPECTING AGENCY TO TEST AND INSPECT BOTTOM OF EXCAVATION. IF UNSUITABLE BEARING STRATUM IS ENCOUNTERED, MAKE ADJUSTMENTS TO DRILLED PIERS AS DETERMINED BY ENGINEER. DO NOT EXCAVATE SHAFTS DEEPER THAN ELEVATIONS INDICATED UNLESS APPROVED BY ENGINEER.

8. DRILLED PIERS: PROBE WITH AUGER TO A DEPTH BELOW BEARING ELEVATION, EQUAL TO DIAMETER OF THE BEARING AREA OF DRILLED PIER. DETERMINE WHETHER VOIDS, CLAY SEAMS, OR SOLUTION CHANNELS EXIST.

9. CONSTRUCT DRILLED PIERS TO WITHIN ACI 336.1 TOLERANCES AND AS NOTED HEREIN. VERTICAL PLUMBNESS - 1 INCH IN 10 FEET OF DEPTH. CENTER OF PIERS LOCATED UNDER BEAMS - 1 INCH OF HORIZONTAL PLAN POSITION. CENTER OF SHAFT LOCATED UNDER FOOTING - 3 INCHES OF HORIZONTAL PLAN POSITION.

10. PLACE CONCRETE IN CONTINUOUS OPERATION AND WITHOUT SEGREGATION IMMEDIATELY AFTER INSPECTION AND APPROVAL OF SHAFT BY A QUALIFIED TESTING AGENCY

11. PLACE CONCRETE TO FALL VERTICALLY DOWN THE CENTER OF DRILLED PIER WITHOUT STRIKING SIDES OF SHAFT OR STEEL REINFORCEMENT.

12. TESTING AGENCY: OWNER WILL ENGAGE A QUALIFIED TESTING AGENCY TO PERFORM TESTS AND INSPECTIONS.

13. REMOVE SURPLUS SATISFACTORY SOIL AND WASTE MATERIAL, INCLUDING UNSATISFACTORY SOIL, TRASH, AND DEBRIS, AND LEGALLY DISPOSE OF IT OFF OF OWNER'S PROPERTY.

14. FOUNDATION CONDITIONS NOTED DURING CONSTRUCTION, WHICH DIFFER FROM THOSE DESCRIBED IN THE GEOTECHNICAL REPORT SHALL BE REPORTED TO THE STRUCTURAL ENGINEER OF RECORD AND GEOTECHNICAL ENGINEER BEFORE FURTHER CONSTRUCTION IS ATTEMPTED.

15. GENERAL CONTRACTOR SHALL NOTIFY THE STRUCTURAL ENGINEER OF RECORD 24 HOURS PRIOR TO EACH PLACEMENT OF CONCRETE IN THE PIERS.

16. FOUNDATION ELEMENTS , NOT INCLUDING SLAB-ON-GRADE, SHALL BE CAST SUCH THAT A VOID OF NOT LESS THAN 12 INCHES IS MAINTAINED BENEATH ALL ELEMENTS.

17. RETAINER PANELS: SUREVOID - BACKFILL RETAINER PANELS, CONCRETE RETAINER PANELS, OR APPROVED EQUAL.

EARTHWORK

1. SELECT FILL SHALL HAVE A MAXIMUM PLASITICITY INDEX (PI) OF 15, BE FREE OF ALL ORGANIC AND OTHER DELETERIOUS MATERIALS, AND HAVE NO STONES LARGER THAN 2 INCHES.

2. SCARIFY AND RE-COMPACT TOP 6 INCHES OF EXISTING SUBGRADE TO 95 PERCENT OF THE MAXIMUM DRY DENSITY DETERMINED IN ACCORDANCE WITH ASTM D 698.

3. ALL BACKFILL MATERIALS SHALL BE PLACED IN LOOSE LIFTS NOT TO EXCEED 2 INCHES IN THICKNESS AND COMPACTED TO 95 PERCENT OF THE MAXIMUM DRY DENSITY DETERMINED IN ACCORDANCE WITH ASTM D 698.

4. THE ALLOWABLE RANGE OF MOISTURE CONTENT DURING COMPACTION SHALL BE WITHIN +/- 2 PERCENT OF THE OPTIMUM MOISTURE CONTENT DETERMINED IN ACCORDANCE WITH ASTM D 698.

5. COMPACT SOIL WITH APPROVED HAND-OPERATED OR OTHER APPROVED EQUIPMENT WELL SUITED TO THE SOIL BEING COMPACTED.

6. OWNER SHALL PROVIDE SOIL TESTING AND QUALITY ASSURANCE INSPECTION DURING BACKFILL OPERATIONS.

REINFORCING STEEL

1. DETAILING OF CONCRETE REINFORCEMENT BARS AND ACCESSORIES SHALL CONFORM TO THE RECOMMENDATIONS OF ACI 315 "DETAILS AND DETAILING OF CONCRETE REINFORCEMENT" AND ACI 318-88 "DETAILING MANUAL".

2. PLACING OF REINFORCING BARS SHALL CONFORM TO THE RECOMMENDATIONS OF ACI 315R "MANUAL OF ENGINEERING AND PLACING DRAWINGS FOR REINFORCED CONCRETE STRUCTURES" AND CRSI "MANUAL OF STANDARD PRACTICE" FOR FABRICATING, PLACING, AND SUPPORTING REINFORCING.

3. MINIMUM CONCRETE COVER PROTECTION FOR REINFORCEMENT BARS SHALL BE AS FOLLOWS: (SEE ACI 318 SECTION 7.7 FOR CONDITIONS NOT NOTED)

A. DRILLED PIERS 3 INCHES
B. BEAMS 2 INCHES
C. SLAB ON GRADE 2 INCHES

4. PROVIDE BAR CHAIRS AND SPACERS AS REQUIRED TO MAINTAIN CONCRETE PROTECTION SPECIFIED. BAR SUPPORTS SHALL CONFORM TO CRSI SPECIFICATIONS AS TO SIZE, SPACING, INSTALLATION AND MATERIALS USED.

5. CONCRETE REINFORCEMENT BARS SHALL CONFORM TO ASTM A615, GRADE 60, UNLESS NOTED OTHERWISE.

6. REINFORCEMENT BARS SHALL NOT BE TACK WELDED, WELDED, HEATED OR CUT UNLESS INDICATED ON THE CONTRACT DOCUMENTS OR REVIEWED BY THE STRUCTURAL ENGINEER OF RECORD.

7. REINFORCEMENT DESIGNATED AS "CONTINUOUS" SHALL LAP 36 BAR DIAMETERS AT SPLICES UNLESS NOTED OTHERWISE. REINFORCEMENT BAR SPLICES IN RETAINING BEAMS SHALL BE LOCATED AT THE CENTERLINE OF SUPPORTS FOR BOTTOM BARS AND AT MIDSPAN FOR TOP BARS. PROVIDE STANDARD ACI HOOKS FOR TOP AND BOTTOM BARS AT DISCONTINUOUS ENDS OF ALL GRADE BEAMS.

8. STIRRUPS SHALL BE SPACED FROM FACE OF SUPPORT, EACH END OF BEAM.

9. LONGITUDINAL BEAM REINFORCEMENT SHALL BE EQUALLY SPACED ACROSS BEAM WIDTH EXCEPT AS REQUIRED TO CLEAR PIER VERTICAL BARS.

10. CLEAR DISTANCE BETWEEN PARALLEL BARS, BARS IN A SINGLE LAYER OR BETWEEN

TWO OR MORE LAYERS, SHALL NOT BE LESS THAN A NOMINAL BAR DIAMETER OR ONE INCH.

11. WHERE PARALLEL REINFORCEMENT IS PLACED IN TWO OR MORE LAYERS, BARS IN THE UPPER LAYERS SHALL BE PLACED DIRECTLY ABOVE BARS IN THE BOTTOM LAYER.

12. PROVIDE TWO NO. 4 X 4'-0" BARS AT EACH RE-ENTRANT CORNER IN SLABS. PLACED ON THE DIAGONAL WITH 2-INCHES CLEARANCE FROM CORNER AND TOP OF SLAB. THIS INCLUDES ANY RECTANGULAR HOLES MADE DUE TO STANDARD CONSTRUCTION PRACTICES.

13. STEEL TIE WIRE SHOULD BE PROVIDED AT 50% OF REBAR INTERSECTIONS.

CONCRETE

1. CONCRETE IN THE FOLLOWING AREAS SHALL HAVE NATURAL SAND FINE AGGREGATE AND NORMAL WEIGHT COARSE AGGREGATES CONFORMING TO ASTM C33, TYPE I PORTLAND CEMENT CONFORMING TO ASTM C150, AND SHALL HAVE THE FOLLOWING COMPRESSIVE STRENGTH (FC) AT 28 DAYS:

A. DRILLED PIERS 4000 PSI
B. BEAMS 4000 PSI
C. SLAB ON GRADE 4000 PSI

2. FLY ASH MAY BE USED AS A POZZOLAN TO REPLACE A PORTION OF THE PORTLAND CEMENT IN A CONCRETE MIX, SUBJECT TO THE APPROVAL OF THE STRUCTURAL ENGINEER OF RECORD. FLY ASH, WHEN USED, SHALL CONFORM TO ASTM C618, TYPE C OR F. CONCRETE MIXES USING FLY ASH SHALL BE PROPORTIONED TO ACCOUNT FOR THE PROPERTIES OF THE SPECIFIC FLY ASH USED AND TO ACCOUNT FOR THE SPECIFIC PROPERTIES OF THE FLY ASH CONCRETE THUS RESULTING. THE RATO OF THE AMOUNT OF THE FLY ASH TO THE TOTAL AMOUNT OF FLY ASH AND CEMENT IN THE MIX SHALL NOT EXCEED 25 PERCENT.

3. SLAB-ON-GRADE CONCRETE MIX SHALL BE DESIGNED FOR LOW SHRINKAGE CHARACTERISTICS.

4. EACH CONCRETE MIX SHALL BE DESIGNED IN ACCORDANCE WITH ACI 211.1 "STANDARD PRACTICE FOR SELECTING PROPORTIONS FOR NORMAL, HEAVYWEIGHT, AND MASS CONCRETE."

5. CONCRETE MIX DESIGNS MUST BE SUBMITTED A MINIMUM OF 15 DAYS PRIOR TO THE START OF THE CONCRETE WORK FOR ENGINEER'S APPROVAL. ANY ADJUSTMENTS IN APPROVED MIX DESIGNS INCLUDING CHANGES IN ADMIXTURES MUST BE SUBMITTED IN WRITING TO THE ENGINEER FOR APPROVAL PRIOR TO USE IN THE FIELD.

6. MIXING, TRANSPORTING, AND PLACING OF CONCRETE SHALL CONFORM TO ACI 301 "SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS."

7. CONSTRUCTION JOINTS BETWEEN PIERS AND PIER CAPS, FOOTINGS AND WALLS OR COLUMNS, OR WALLS, COLUMNS, BEAMS AND THE FLOOR SYSTEM THEY SUPPORT SHALL BE PREPARED BY ROUGHENING THE CONTACT SURFACE TO A FULL AMPLITUDE OF APPROXIMATELY 1/4 INCH LEAVING THE CONTACT SURFACE CLEAN AND FREE OF LAITANCE.

8. CURE CONCRETE BY MOIST CURING FOR A PERIOD OF NOT LESS THAN 72 HOURS FROM THE END OF FINISHING OPERATIONS. DURING MOIST CURING, THE SURFACE OF THE CONCRETE SHALL NOT BE ALLOWED TO DRY.

SLAB ON GRADE

1. FLOAT AND TROWEL SLAB ON GRADE TO MATCH FINISH OF EXISTING SLAB ON GRADE.

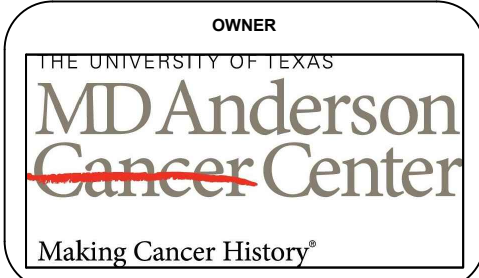
2. MOIST CURE SLAB FOR A PERIOD OF NOT LESS THAN 7 DAYS FROM THE END OF FINISHING OPERATIONS. THE SURFACE OF THE CONCRETE SHALL NOT BE ALLOWED TO DRY.

3. CONTRACTOR TO SUBMIT CONCRETE CURING PROTOCOL FOR ENGINEER'S APPROVAL PRIOR TO PLACEMENT. CONCRETE PLACEMENT WILL NOT PROCEED WITHOUT ENGINEER'S APPROVAL.

4. EXPANSIONS JOINTS SHALL BE SEALED WITH BASF MASTERSEAL SL1, OR AN APPROVED EQUAL. SUBMIT PRODUCT INFORMATION FOR ENGINEERING APPROVAL.

5. VAPOR BARRIER FOR SLAB-ON GRADE SHALL BE 15 MIL STEGO WRAP VAPOR BARRIER, IF REQUIRED.

6. CONTRACTOR TO SUBMIT PROPOSED JOINT (CONSTRUCTION/EXPANSION) LAYOUT, NOT TO EXCEED 15 FEET IN ANY DIRECTION, FOR APPROVAL.



PROJECT

DATE

OCTOBER 12, 2018

GRIFFIN ANIMAL BUILDING
CRAWLSPACE IMPROVEMENTS

M.D. ANDERSON CANCER CENTER - SMITHVILLE, TEXAS
MDACC PROJECT NO. 15-0005



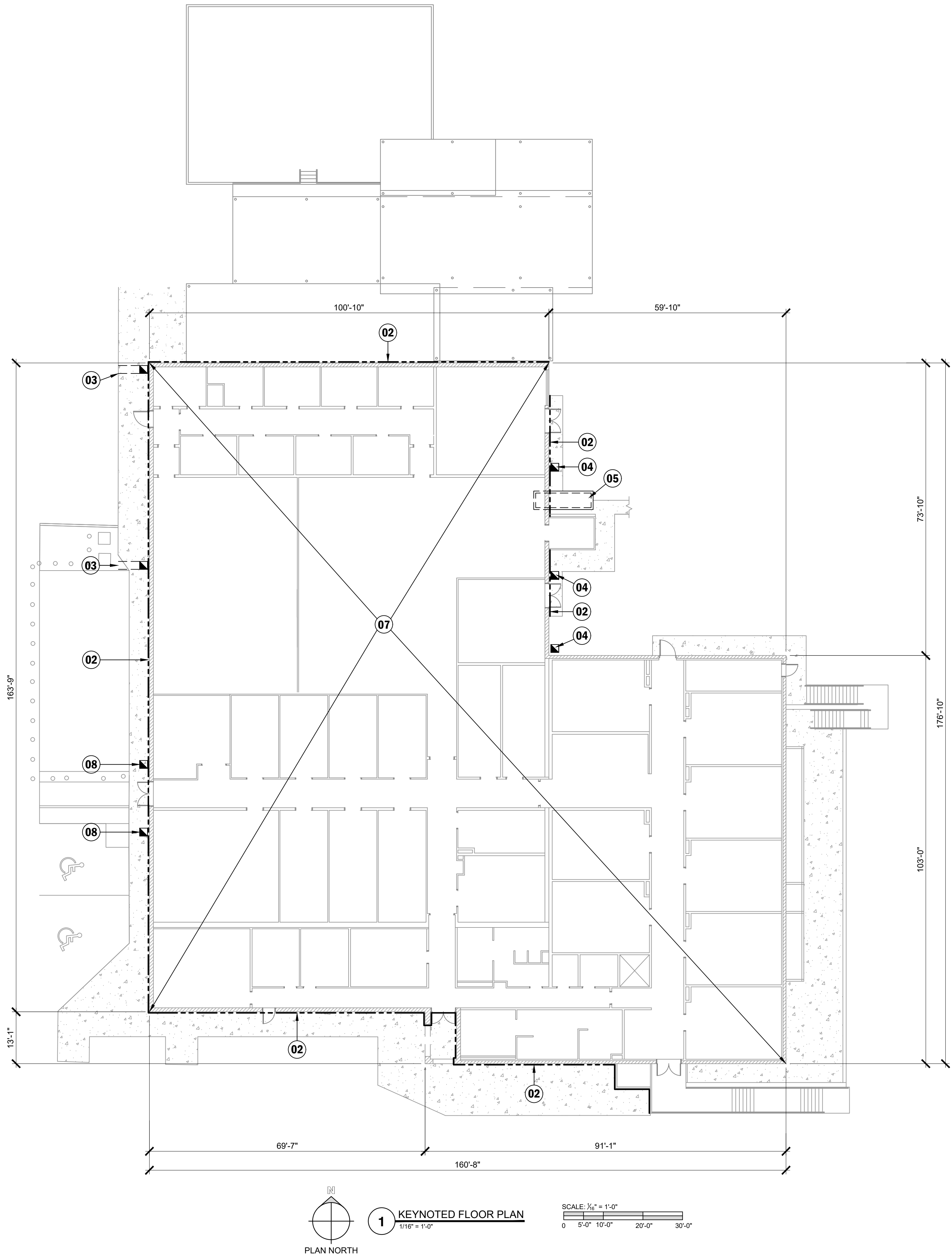
SCALE: AS SHOWN
DRAWN BY: FV/TJH
CHECKED BY: EJM

100% CONSTRUCTION DOCUMENTS

GENERAL NOTES

SHEET NUMBER

W101



SHEET NOTES

1. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING DIMENSIONS AND CONDITIONS. DIMENSIONS SHOWN ON THE DRAWINGS ARE APPROXIMATE, AND FIELD VERIFICATION WILL BE REQUIRED TO COMPLETE WORK. CONTRACTOR SHALL OBTAIN ALL FIELD MEASUREMENTS AS NECESSARY TO COORDINATE WITH, AND MATCH NEW CONSTRUCTION TO EXISTING CONDITIONS.
2. SOME INFORMATION SHOWN IN THE DRAWINGS, IN REGARDS TO EXISTING FEATURES, IS NECESSARILY CONJECTURAL DUE TO HIDDEN CONDITIONS AT THE TIME OF DRAWING PREPARATION. IF CONDITIONS EXIST THAT DIFFER FROM THE DRAWINGS, OR ARE NOT ADEQUATELY DETAILED, INFORM THE ENGINEER AND ADDITIONAL DETAILS OR INTERPRETATION WILL BE PROVIDED. DO NOT PROCEED WITHOUT VERIFICATION FROM THE ENGINEER.

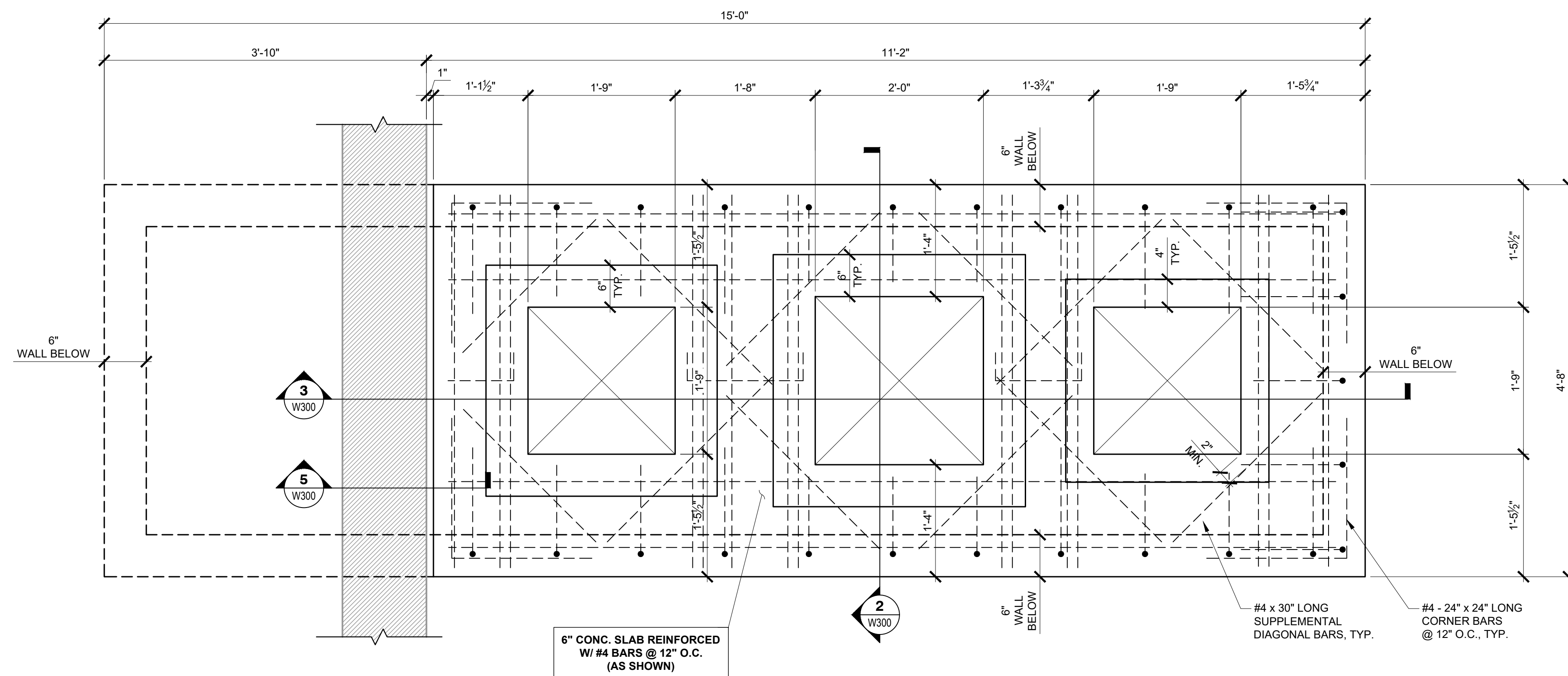
REPAIR KEYNOTES

- 01 - NOT USED
- 02 - REMOVE EXISTING SEALANT AND/OR DEBRIS AND CLEAN AND PREPARE JOINT. INSTALL NEW SELF-LEVELING SEALANT OVER BACKER ROD, REF. 2/W301 (APPROX. 471 LF)
- 03 - SAWCUT SIDEWALK AND PROVIDE METAL SIDEWALK BOX WITH STEEL COVER. REWORK BOTTOM OF DOWNSPOUT TO EXIT INTO BOX, REF. 1/W301
- 04 - NEW CAST IRON BOOT ON DOWNSPOUT, REF. CIVIL C5.0 AND 6/C6.0
- 05 - CONCRETE AREA WAY WITH SOLID COVER AND ACCESS HATCH. REFER TO W300 FOR STRUCTURAL REQUIREMENTS. REFER TO MECHANICAL FOR ADDITIONAL INFORMATION. SAWCUT SIDEWALK AS REQUIRED.
- 06 - NOT USED
- 07 - ALTERNATE #1: APPLY PRIMER, SPRAY FOAM INSULATION, AND INTUMESCENT COATING TO ALL EXPOSED SLAB AND STRUCTURE IN CRAWLSPACE. IN ACCORDANCE WITH SPECIFICATION SECTIONS 07.13.19 & 07.21.19. CONTRACTOR TO ENSURE COMPLETE MIGRATION OF WATER VAPOR FROM SLAB PRIOR TO APPLICATION OF PRIMER AND COATINGS.
- 08 - REPAIR / SEAL DAMAGED DOWNSPOUTS AT TRANSITION TO SIDEWALK PENETRATION. PROVIDE PROTECTIVE COVER ADDED OVER EXISTING DOWNSPOUT. SEE DETAIL 1/W301.

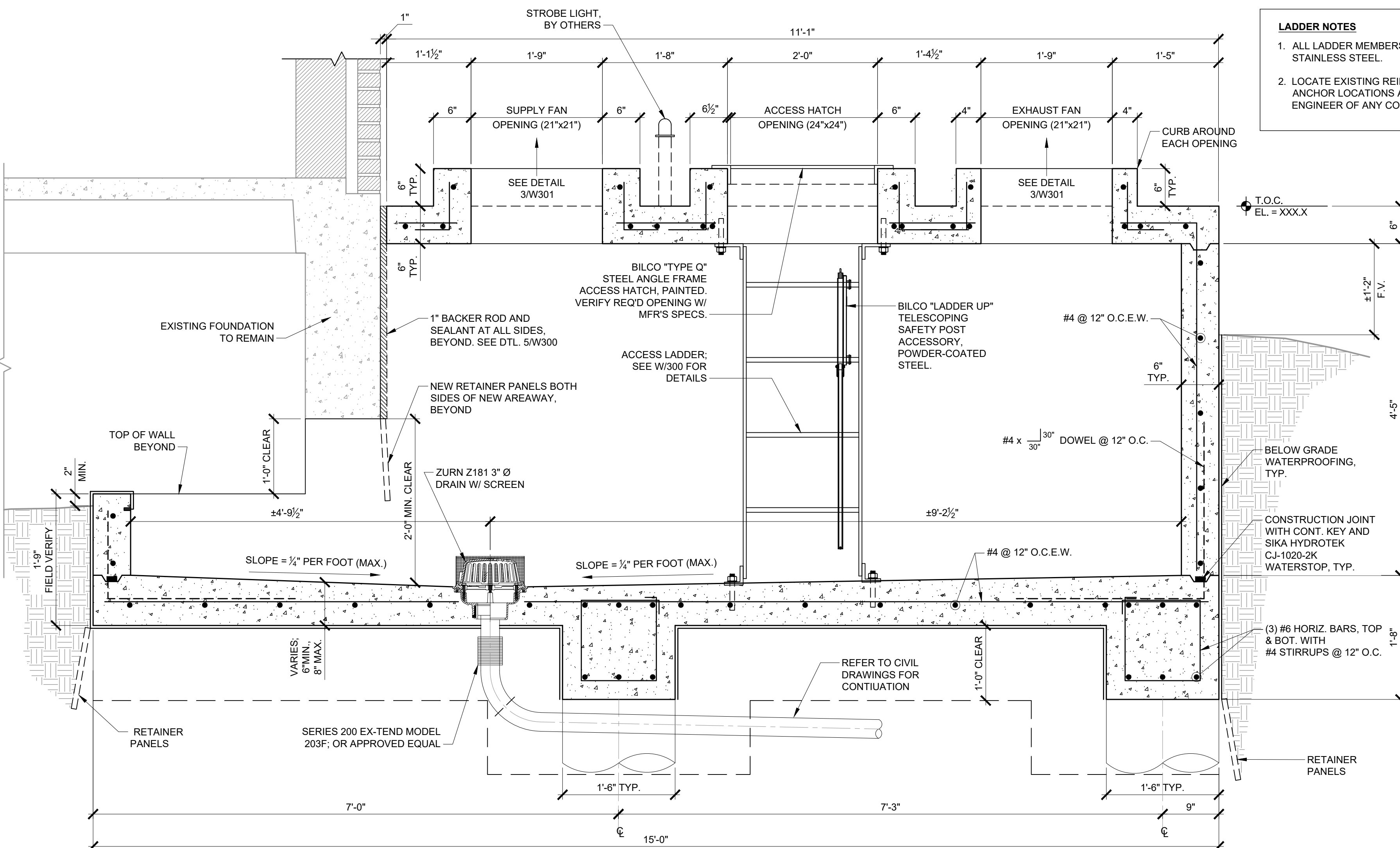
LEGEND

- EXISTING EXTERIOR WALL
- EXTENT OF SEALANT JOINT REPLACEMENT, REFER TO KEYNOTE 02
- EXISTING DOWNSPOUT TO BE REPAIRED (LOCATION SHOWN IS APPROXIMATE)
- NEW DOWNSPOUT, VERIFY LOCATION IN FIELD.
- EXISTING LATERAL PIPE UNDER SIDEWALK (LOCATION SHOWN IS APPROXIMATE)
- EXISTING FLATWORK

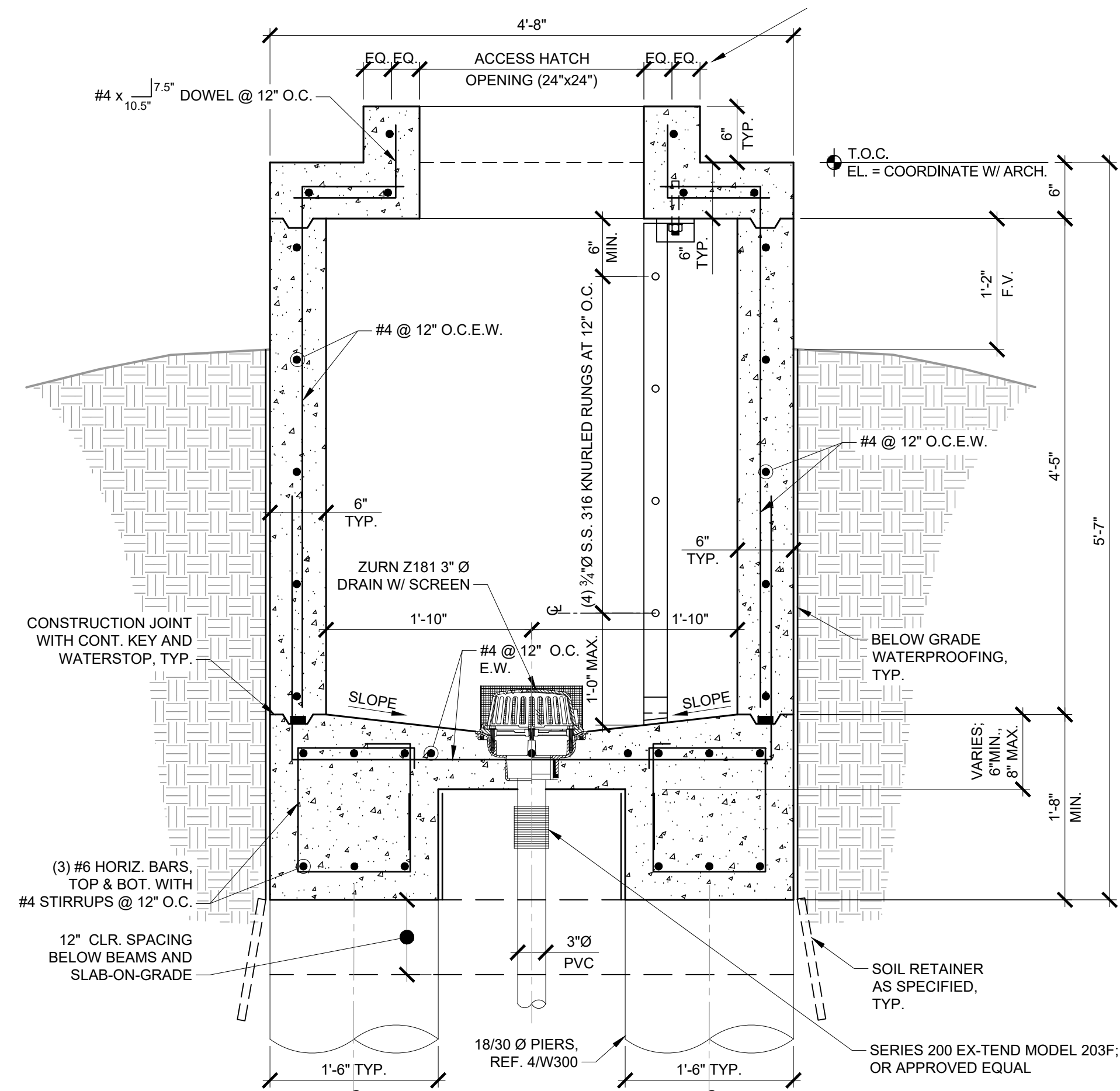
REPAIR/REPLACE ANY EXISTING FLATWORK THAT IS AFFECTED IN ORDER TO COMPLETE SCOPE OF WORK. SAWCUT 3/4" MINIMUM PRIOR TO REMOVAL AT LOCATIONS WHERE FLATWORK MUST BE REMOVED. REFER TO CIVIL DRAWINGS FOR FLATWORK REPAIR REQUIREMENTS



1 AREAWAY SECTION
1" = 1'-0"



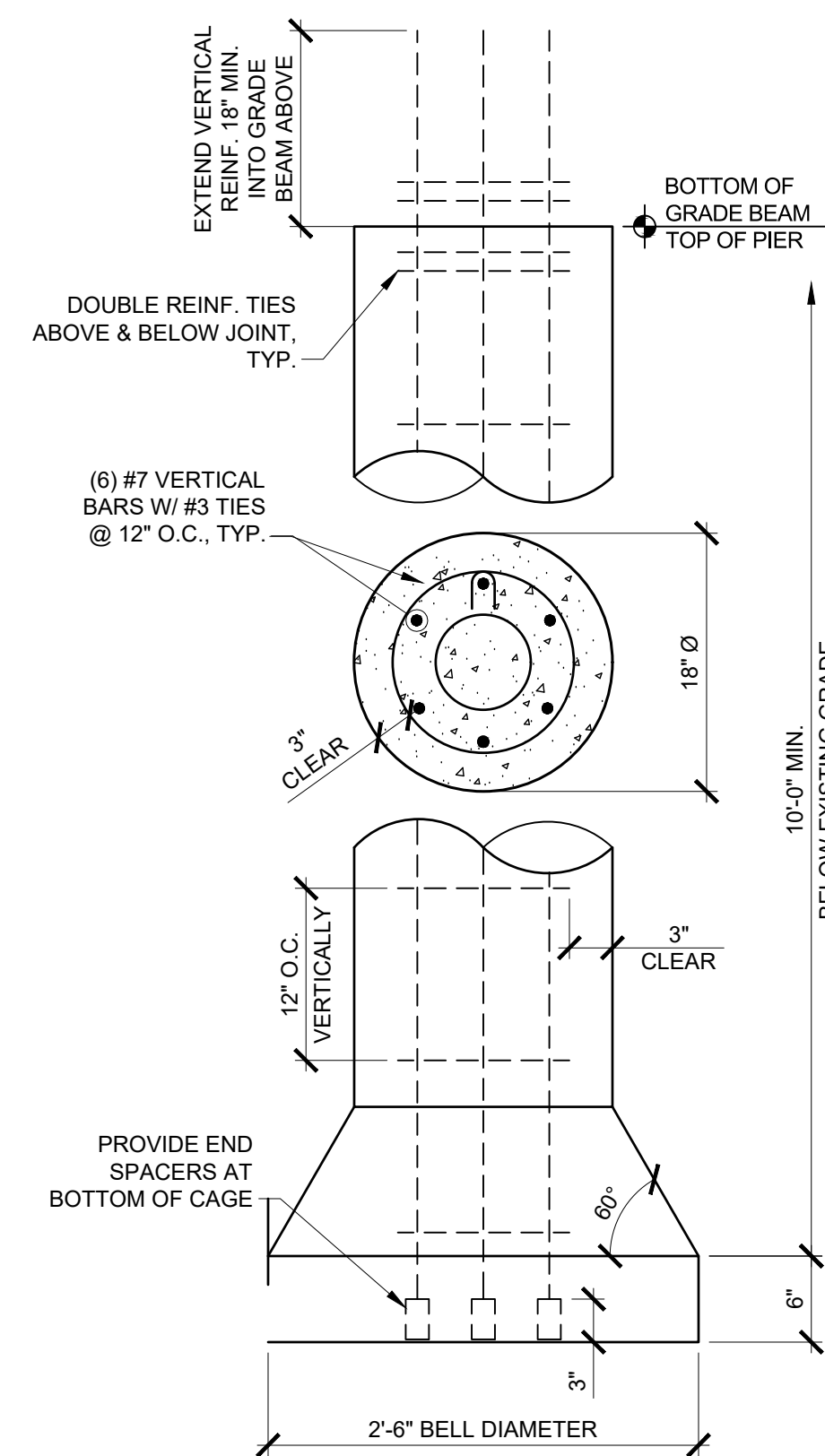
3 AREAWAY SECTION
1" = 1'-0"



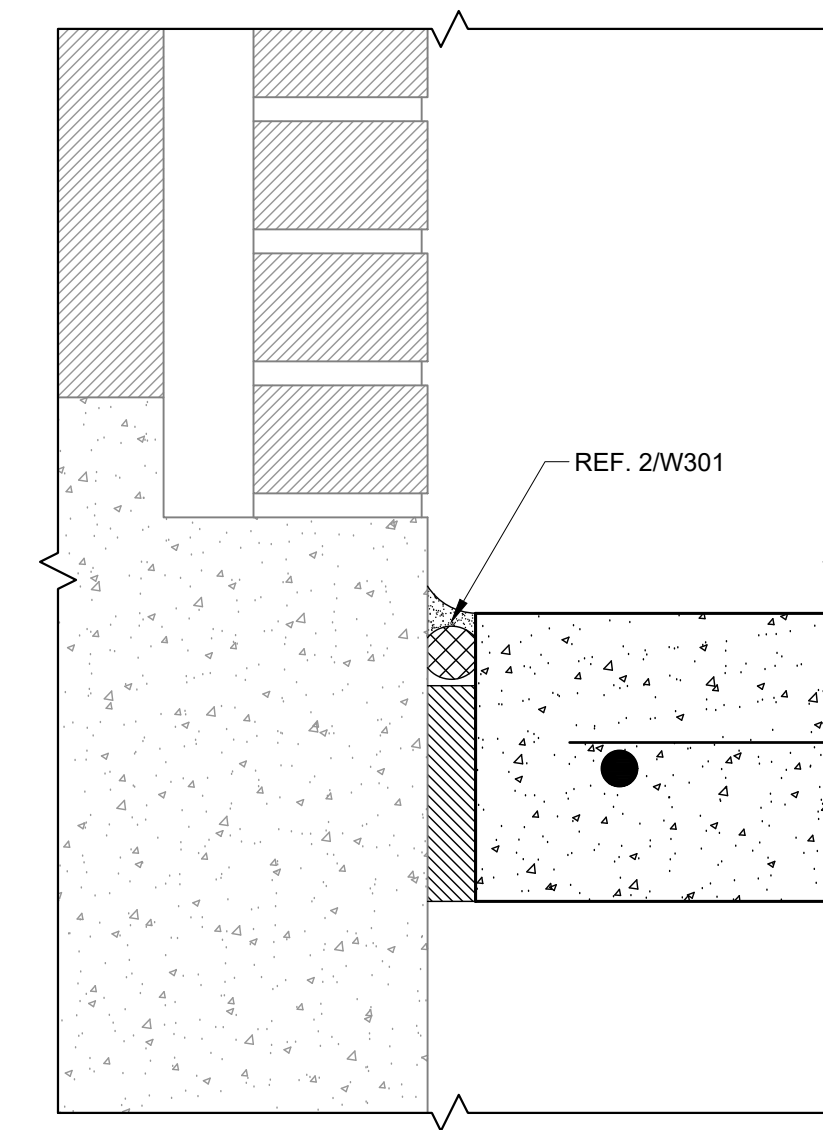
2 AREAWAY CROSS-SECTION
1" = 1'-0"

LADDER NOTES

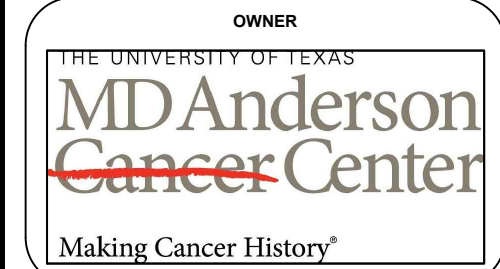
- ALL LADDER MEMBERS TO BE TYPE 316 STAINLESS STEEL.
- LOCATE EXISTING REINFORCING AND NEW ANCHOR LOCATIONS AND NOTIFY SITE ENGINEER OF ANY CONFLICTS.



4 BELLED PIER DETAIL, TYP.
1" = 1'-0"



5 EXPANSION JOINT DETAIL
3" = 1'-0"



PROJECT

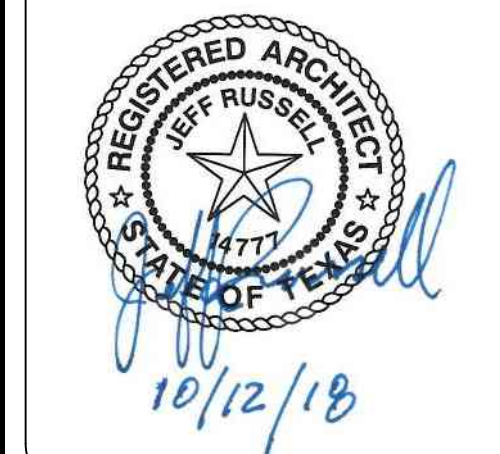
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SCALE: AS SHOWN
DRAWN BY: FV
CHECKED BY: JTR

100% CONSTRUCTION DOCUMENTS

STRUCTURAL
DETAILS

SHEET NUMBER
W301

