

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1 of 4

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------|--------------------------------|
| 2. AMENDMENT/MODIFICATION NO. 1 | 3. EFFECTIVE DATE 17-Apr-2004 | 4. REQUISITION/PURCHASE REQ. NO. | 5. PROJECT NO. (If applicable) |
| 6. ISSUED BY US Army Corps of Engineers, Kansas City District 760 Federal Building, 601 East 12th Street Kansas City, Missouri 64106-2896 | | 7. ADMINISTERED BY (If other than item 6) | |

| | |
|---------------------------------------------------------------------------------------|------------------------------------------------------------------|
| 8. NAME AND ADDRESS OF CONTRACTOR <i>(No., street, county, State and ZIP Code)</i> | (x) 9a. AMENDMENT OF SOLICITATION NO. W912DQ-04-B-0004 |
| | 9B. DATED (SEE ITEM 11) 3/18/2004 |
| | 10A. MODIFICATION OF CONTRACT/ORDER NO. |
| | 10B. DATED (SEE ITEM 13) |

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

The above number solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers is extended, is not extended.

Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:
 (a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegraph which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS, IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (x) A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A. |
| B. THE ABOVE NUMBER CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF: |
| C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF: |
| D. OTHER (Specify type of modification and authority) |

E. IMPORTANT: Contractor is not, is required to sign this document and return _____ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

**Barracks - 1st BDE, FY04, PN 36388
Fort Riley, Kansas**

The Solicitation is amended in accordance with the attached pages.

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

| | |
|-----------------------------------------------|------------------------------------------------------------|
| 15A. NAME AND TITLE OF SIGNER (Type or print) | 16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print) |
| 15B. CONTRACTOR/OFFEROR | 16B. UNITED STATES OF AMERICA |
| 15C. DATE SIGNED | 16C. DATE SIGNED |
| (Signature of person authorized to sign) | BY (Signature of Contracting Officer) |

The SOLICITATION is amended as follows:

1. SPECIFICATIONS:

a. Wage Determinations:

Wage Determination KS030021 is hereby deleted from the solicitation.

Wage Determination KS030011, dated 06/13/2003, no mods, is deleted and replaced with Wage Determination KS030011, dated 04/09/2004, 1 mod. A copy of the revised wage determination is attached.

b. Revised Sections: The following sections are deleted and replaced with revised sections of the same numbers. Copies of the revised sections are attached.

01356A
02220
07311A
13851A
15951A
16370A
16375A
16415A

c. Revised Pages: The following pages are deleted and replaced with pages of the same numbers. Copies of the revised pages are attached.

1 of 135 (SF 1442)
00810-i

d. New Section: Section 02555A PREFABRICATED UNDERGROUND HEATING/COOLING DISTRIBUTION SYSTEM is a new section and is added to the Specification. A copy of the new section is attached.

2. DRAWINGS: The following drawings are deleted and replaced with revised drawings of the same numbers. Copies of the revised sections are attached.

| a. <u>Architecture:</u> | <u>Volume 1</u> | <u>Volume 2</u> | <u>Volume 3</u> | <u>Volume 4</u> |
|-------------------------|-----------------|-----------------|-----------------|-----------------|
| | A-A-101 | | | |
| | A-A-304 | | | |
| | A-A-604 | | | |
| | B-A-601 | | | |
| | B-A-602 | | | |

| | | | | |
|-----------------------|-----------------|-----------------|-----------------|-----------------|
| b. <u>Electrical:</u> | <u>Volume 1</u> | <u>Volume 2</u> | <u>Volume 3</u> | <u>Volume 4</u> |
| | E-001 | E-001 | ED101 | |
| | E-601 | A_E-301 | ES100 | |
| | B_E-101 | A_E-302 | ES101 | |
| | B_E-102 | A_E-602 | ES102 | |
| | B_E-103 | B_E-301 | ES103 | |
| | B_E-104 | B_E-602 | ES104 | |
| | B_E-105 | E-902 | E-501 | |
| | B_E-106 | | E-901 | |
| | E-902 | | E-902 | |
| | A_E-601 | | E-904 | |
| c. <u>Mechanical:</u> | <u>Volume 1</u> | <u>Volume 2</u> | <u>Volume 3</u> | <u>Volume 4</u> |
| | FX101 | FX101 | | |
| | A_P-101 | FX102 | | |
| | B_M-104 | A_P-103 | | |
| | B_M-105 | | | |
| | B_M-106 | | | |
| | B_M-107 | | | |
| | B_M-108 | | | |
| | B_M-109 | | | |
| | B_M-301 | | | |
| | B_M-404 | | | |
| d. <u>Civil</u> | <u>Volume 1</u> | <u>Volume 2</u> | <u>Volume 3</u> | <u>Volume 4</u> |
| | | | | T-102 |
| | | | | CE100 |
| | | | | CG401 |
| | | | | CG402 |
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| | | | | CG415 |
| | | | | CG416 |
| | | | | CG417 |
| | | | | CG418 |

3. For convenience, on the revised specification pages, essential changes have been emphasized by an underline. However, all portions of the revised specifications shall apply whether or not changes have been indicated.
4. Bidders are required to acknowledge receipt of this amendment on the Bidding Form, in the space provided, or by separate letter or telegram prior to opening of bids. Failure to acknowledge all amendments may cause rejection of the bid.
5. Bids will be received until **2:00 p.m., local time, 4 May 2004**, in Room 748 Federal Building, 601 E. 12th Street, Kansas City, Missouri 64106-2896. and at that time publicly opened.

| | | | | | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------|---------------------------------------------------------------------------------------------------|--------------------|---------|-------|
| SOLICITATION, OFFER, AND AWARD <i>(Construction, Alteration, or Repair)</i> | | 1. SOLICITATION NO. | 2. TYPE OF SOLICITATION | 3. DATE ISSUED | PAGE OF | PAGES |
| | | W912DQ-04-B-0004 | <input checked="" type="checkbox"/> SEALED BID (IFB) <input type="checkbox"/> NEGOTIATED (RFP) | 3/18/2004 | 1 | 135 |
| IMPORTANT - The "offer" section on the reverse must be fully completed by offeror. | | | | | | |
| 4. | | 5. REQUISITION/PURCHASE REQUEST NO. | 6. PROJECT NO. | | | |
| | | W58XUW-2311-0552 | | | | |
| 7. ISSUED BY | | CODE | 8. ADDRESS OFFER TO | | | |
| U.S. Army Engineer District, Kansas City 760 Federal Building, 601 E. 12th Street Kansas City, Missouri 64106-2896 Tel: (816) 983-3845 Fax: (816) 426-5169 | | | See Item 7 Bid Opening Room: 748 | | | |
| 9. FOR INFORMATION CALL: | A. NAME | B. TELEPHONE NO. (Include area code) | | (NO COLLECT CALLS) | | |
| | Perry Marks | 816-983-3850 Ext. | | | | |

SOLICITATION

NOTE: In sealed bid solicitation "offer" and "offeror" mean "bid" and "Bidder".

10. THE GOVERNMENT REQUIRES PERFORMANCE OF THE WORK DESCRIBED IN THESE DOCUMENTS (Title, identifying no., date):

Barracks - 1st BDE
FY04, PN 36388

Description of Work: Construction of two 3-story barracks buildings which will house 312 persons, a Soldier Community Building, and six Company Operations Facilities. Optional work would include removal and replacement of approximately 3,700 meters of concrete roadway (Kitty Drive).

11. The Contractor shall begin performance within 10 calendar days and complete it within 630 calendar days after receiving award Notice to Proceed-C. This performance period is mandatory, negotiable. (See Sec. 00800, FAR 52.211-10)

12A. THE CONTRACTOR MUST FURNISH ANY REQUIRED PERFORMANCE AND PAYMENT BONDS? (If "YES", indicate within how many calendar days after award in Item 12B.)
 YES NO

12B. CALENDAR DAYS
10

13. ADDITIONAL SOLICITATION REQUIREMENTS:

A. Sealed offers in original and one copies to perform the work required are due at the place specified in Item 8 by 2:00 p.m. local time 5/4/2004 (date). If this is a sealed bid solicitation, offers will be publicly opened at that time. Sealed envelopes containing offers shall be marked to show the offeror's name and address, the solicitation number, and the date and time offers are due.

B. An offer guarantee is, is not required. NOT TO EXCEED 20% OF TOTAL BID AMOUNT

C. All offers are subject to the (1) work requirements, and (2) other provisions and clauses incorporated in the solicitation in full text or by reference.

D. Offers providing less than 90 calendar days for Government acceptance after the date offers are due will not be considered and will be rejected.

SECTION 00810

WAGE RATES

1. KS030004, dated 06/13/2003, no mods.
2. KS030011, dated 04/09/2004, 1 mod.
3. TEXT DELETED.
4. KS030027, date 06/13/2003, no mods.

General Decision Number: KS030011 04/09/2004 KS11

Superseded General Decision Number: KS020011

State: Kansas

Construction Type: Building

County: Riley County in Kansas.

BUILDING CONSTRUCTION PROJECTS (does not include residential construction consisting of single family homes and apartments up to and including 4 stories)

| Modification Number | Publication Date |
|---------------------|------------------|
| 0 | 06/13/2003 |
| 1 | 04/09/2004 |

* PLUM0165-001 01/01/2003

| | Rates | Fringes |
|--------------|----------|---------|
| Plumber..... | \$ 24.69 | 10.40 |

ROOF0020-013 06/01/2003

| | Rates | Fringes |
|------------|----------|---------|
| Rofer..... | \$ 23.41 | 6.64 |

* SFKS0669-002 01/01/2004

| | Rates | Fringes |
|-----------------------|----------|---------|
| Sprinkler Fitter..... | \$ 28.31 | 7.15 |

SHEE0077-003 06/01/2001

| | Rates | Fringes |
|------------------------------------------------------|----------|---------|
| Sheetmetal Worker (Including HVAC Duct Work)..... | \$ 23.58 | 7.34 |

SUKS2000-003 03/01/2000

| | Rates | Fringes |
|--------------------------------------------------------------------------------|----------|---------|
| Bricklayer..... | \$ 18.00 | |
| Carpenter (Including Drywall Hanging and Excluding Insulation, Batt).... | \$ 12.93 | 3.01 |

| | | |
|--------------------------------------------------------------------|----------|------|
| Cement Mason..... | \$ 11.00 | 0.44 |
| Laborer | | |
| Unskilled (Excluding Blown Installation)..... | \$ 8.42 | |
| Painter, Brush and Roller (Including Drywall Finishing)..... | | |
| | \$ 11.39 | |
| Power Equipment Operator | | |
| Backhoe..... | \$ 13.19 | 2.68 |
| Rollers (All Types)..... | \$ 10.53 | |

WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

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Unlisted classifications needed for work not included within the scope of the classifications listed may be added after award only as provided in the labor standards contract clauses (29CFR 5.5 (a) (1) (ii)).

In the listing above, the "SU" designation means that rates listed under the identifier do not reflect collectively bargained wage and fringe benefit rates. Other designations indicate unions whose rates have been determined to be prevailing.

WAGE DETERMINATION APPEALS PROCESS

1.) Has there been an initial decision in the matter? This can be:

- * an existing published wage determination
- * a survey underlying a wage determination
- * a Wage and Hour Division letter setting forth a position on a wage determination matter
- * a conformance (additional classification and rate) ruling

On survey related matters, initial contact, including requests for summaries of surveys, should be with the Wage and Hour Regional Office for the area in which the survey was conducted because those Regional Offices have responsibility for the Davis-Bacon survey program. If the response from this initial contact is not satisfactory, then the process described in 2.) and 3.) should be followed.

With regard to any other matter not yet ripe for the formal process described here, initial contact should be with the Branch of Construction Wage Determinations. Write to:

Branch of Construction Wage Determinations

Wage and Hour Division

U.S. Department of Labor

200 Constitution Avenue, N.W.

Washington, DC 20210

2.) If the answer to the question in 1.) is yes, then an interested party (those affected by the action) can request review and reconsideration from the Wage and Hour Administrator (See 29 CFR Part 1.8 and 29 CFR Part 7). Write to:

Wage and Hour Administrator

U.S. Department of Labor

200 Constitution Avenue, N.W.

Washington, DC 20210

The request should be accompanied by a full statement of the interested party's position and by any information (wage payment data, project description, area practice material, etc.) that the requestor considers relevant to the issue.

3.) If the decision of the Administrator is not favorable, an interested party may appeal directly to the Administrative Review Board (formerly the Wage Appeals Board). Write to:

Administrative Review Board

U.S. Department of Labor

200 Constitution Avenue, N.W.

Washington, DC 20210

4.) All decisions by the Administrative Review Board are final.

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END OF GENERAL DECISION

SECTION 01356A

STORM WATER POLLUTION PREVENTION MEASURES
08/96

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|-------------|--------------------------------------------------------------------|
| ASTM D 4439 | (1997) Standard Terminology for Geosynthetics |
| ASTM D 4491 | (1996) Water Permeability of Geotextiles by Permittivity |
| ASTM D 4533 | (1991; R 1996) Trapezoid Tearing Strength of Geotextiles |
| ASTM D 4632 | (1991; R 1996) Grab Breaking Load and Elongation of Geotextiles |
| ASTM D 4751 | (1995) Determining Apparent Opening Size of a Geotextile |
| ASTM D 4873 | (1995) Identification, Storage, and Handling of Geosynthetic Rolls |

1.2 GENERAL

The Contractor shall implement the storm water pollution prevention measures specified in this section in a manner which will meet the requirements of Section 01355A ENVIRONMENTAL PROTECTION, and National Pollution Discharge Elimination System (NPDES) requirements. Please note that the District will acquire the permit prior to issuing Notice to Proceed. Permit requirements can be downloaded from the following website:
http://www.kdhe.state.ks.us/stormwater/resources/cgp_revision_final.pdf

1.4 EROSION AND SEDIMENT CONTROLS

The controls and measures required by the Contractor are described below.

1.4.1 Stabilization Practices

The stabilization practices to be implemented shall include temporary seeding, mulching, geotextiles,. On his daily CQC Report, the Contractor shall record the dates when the major grading activities occur, (e.g., clearing and grubbing, excavation,); when construction activities temporarily or permanently cease on a portion of the site; and when stabilization practices are initiated. Except as provided in paragraphs UNSUITABLE CONDITIONS and NO ACTIVITY FOR LESS THAN 21 DAYS, stabilization practices shall be initiated as soon as practicable, but no more than 14 days, in any portion of the site where construction activities have temporarily or permanently ceased.

1.4.1.1 Unsuitable Conditions

Where the initiation of stabilization measures by the fourteenth day after

construction activity permanently ceases is precluded by unsuitable conditions caused by the weather, stabilization practices shall be initiated as soon as practicable after conditions become suitable.

1.4.1.2 No Activity for Less Than 21 Days

Where construction activity will resume on a portion of the site within 21 days from when activities ceased (e.g., the total time period that construction activity is temporarily ceased is less than 21 days), then stabilization practices do not have to be initiated on that portion of the site by the fourteenth day after construction activity temporarily ceased.

1.4.2 Structural Practices

Structural practices shall be implemented to divert flows from exposed soils, temporarily store flows, or otherwise limit runoff and the discharge of pollutants from exposed areas of the site. Structural practices shall be implemented in a timely manner during the construction process to minimize erosion and sediment runoff. Structural practices shall include the following devices.

1.4.2.1 Silt Fences

The Contractor shall provide silt fences as a temporary structural practice to minimize erosion and sediment runoff. Silt fences shall be properly installed to effectively retain sediment immediately after completing each phase of work where erosion would occur in the form of sheet and rill erosion (e.g. clearing and grubbing, excavation, embankment, and grading). Silt fences shall be installed in the locations indicated on the drawings. Final removal of silt fence barriers shall be upon approval by the Contracting Officer.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Mill Certificate or Affidavit; G, RE.

PART 2 PRODUCTS

2.1 COMPONENTS FOR SILT FENCES

2.1.1 Filter Fabric

The geotextile shall comply with the requirements of ASTM D 4439, and shall consist of polymeric filaments which are formed into a stable network such that filaments retain their relative positions. The filament shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of ester, propylene, or amide, and shall contain stabilizers and/or inhibitors added to the base plastic to make the filaments resistance to deterioration due to ultraviolet and heat exposure. Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of -18 to 49 degrees C. The filter fabric shall meet the following requirements:

FILTER FABRIC FOR SILT SCREEN FENCE

| PHYSICAL PROPERTY | TEST PROCEDURE | STRENGTH REQUIREMENT |
|--------------------------------|----------------|-------------------------|
| Grab Tensile Elongation (%) | ASTM D 4632 | 445 N min. 30 % max. |
| Trapezoid Tear | ASTM D 4533 | 245 N min. |
| Permittivity | ASTM D 4491 | 0.2 sec-1 |
| AOS (U.S. Std Sieve) | ASTM D 4751 | 20-100 |

2.1.2 Silt Fence Stakes and Posts

The Contractor may use either wooden stakes or steel posts for fence construction. Wooden stakes utilized for silt fence construction, shall have a minimum cross section of 50 mm by 50 mm when oak is used and 100 mm by 100 mm when pine is used, and shall have a minimum length of 1.5 m. Steel posts (standard "U" or "T" section) utilized for silt fence construction, shall have a minimum mass of 1.98 kg per linear meter and a minimum length of 1.5 m.

2.1.3 Mill Certificate or Affidavit

A mill certificate or affidavit shall be provided attesting that the fabric and factory seams meet chemical, physical, and manufacturing requirements specified above. The mill certificate or affidavit shall specify the actual Minimum Average Roll Values and shall identify the fabric supplied by roll identification numbers. The Contractor shall submit a mill certificate or affidavit signed by a legally authorized official from the company manufacturing the filter fabric.

2.1.4 Identification Storage and Handling

Filter fabric shall be identified, stored and handled in accordance with ASTM D 4873.

2.2 COMPONENTS FOR STRAW BALES

The straw in the bales shall be stalks from oats, wheat, rye, barley, rice, or from grasses such as byhalia, bermuda, etc., furnished in air dry condition. The bales shall have a standard cross section of 350 mm by 450 mm. All bales shall be either wire-bound or string-tied. The Contractor may use either wooden stakes or steel posts to secure the straw bales to the ground. Wooden stakes utilized for this purpose, shall have a minimum dimensions of 50 mm by 50 mm in cross section and shall have a minimum length of 1 m. Steel posts (standard "U" or "T" section) utilized for securing straw bales, shall have a minimum mass of 1.98 kg per linear meter and a minimum length of 1 m .

PART 3 EXECUTION

3.1 INSTALLATION OF SILT FENCES

Silt fences shall extend a minimum of 400 mm above the ground surface and shall not exceed 860 mm above the ground surface. Filter fabric shall be from a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are unavoidable, filter fabric shall be spliced together at a support post, with a minimum 150 mm overlap, and securely sealed. A trench shall be excavated approximately 100 mm wide and 100 mm deep on the upslope side of the location of the silt fence. The 100 mm by 100 mm trench shall be backfilled and the soil compacted over the filter fabric. Silt fences shall be removed upon approval by the Contracting Officer.

3.2 INSTALLATION OF STRAW BALES

Straw bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 100 mm. After the bales are staked and chinked (gaps filled by wedging with straw), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 100 mm against the uphill side of the barrier. Loose straw shall be scattered over the area immediately uphill from a straw bale barrier to increase barrier efficiency.

Each bale shall be securely anchored by at least two stakes driven through the bale. The first stake or steel post in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or steel pickets shall be driven a minimum 450 mm deep into the ground to securely anchor the bales.

3.3 MAINTENANCE

The Contractor shall maintain the temporary and permanent vegetation, erosion and sediment control measures, and other protective measures in good and effective operating condition by performing routine inspections to determine condition and effectiveness, by restoration of destroyed vegetative cover, and by repair of erosion and sediment control measures and other protective measures. The following procedures shall be followed to maintain the protective measures.

3.3.1 Silt Fence Maintenance

Silt fences shall be inspected in accordance with paragraph INSPECTIONS. Any required repairs shall be made promptly. Close attention shall be paid to the repair of damaged silt fence resulting from end runs and undercutting. Should the fabric on a silt fence decompose or become ineffective, and the barrier is still necessary, the fabric shall be replaced promptly. Sediment deposits shall be removed when deposits reach one-third of the height of the barrier. When a silt fence is no longer required, it shall be removed. The immediate area occupied by the fence and any sediment deposits shall be shaped to an acceptable grade. The areas disturbed by this shaping shall , paragraph be seeded in accordance with Section 02921, .

3.3.2 Straw Bale Maintenance

Straw bale barriers shall be inspected in accordance with paragraph INSPECTIONS. Close attention shall be paid to the repair of damaged bales, end runs and undercutting beneath bales. Necessary repairs to barriers or replacement of bales shall be accomplished promptly. Sediment deposits shall be removed when deposits reach one-half of the height of the barrier. Bale rows used to retain sediment shall be turned uphill at each end of each row. When a straw bale barrier is no longer required, it shall be removed. The immediate area occupied by the bales and any sediment deposits shall be shaped to an acceptable grade. The areas disturbed by this shaping shall be seeded in accordance with Section 02921 TURF.

3.3.3 Diversion Dike Maintenance

Diversion dikes shall be inspected in accordance with paragraph INSPECTIONS. Close attention shall be paid to the repair of damaged diversion dikes and necessary repairs shall be accomplished promptly. When diversion dikes are no longer required, they shall be shaped to an acceptable grade. The areas disturbed by this shaping shall be seeded in accordance with Section 02921 TURF.

3.4 INSPECTIONS

3.4.1 General

The Contractor shall inspect disturbed areas of the construction site, areas used for storage of materials that are exposed to precipitation that have not been finally stabilized, stabilization practices, structural practices, other controls, and area where vehicles exit the site at least once every seven (7) calendar days and within 24 hours of the end of any storm that produces 13 mm or more rainfall at the site. Where sites have been finally stabilized, such inspection shall be conducted at least once every month.

3.4.2 Inspections Details

Disturbed areas shall be inspected for evidence of, or the potential for, pollutants entering the drainage system. Erosion and sediment control measures identified in the Storm Water Pollution Prevention Plan shall be observed to ensure that they are operating correctly. Discharge locations or points shall be inspected to ascertain whether erosion control measures are effective in preventing significant impacts to receiving waters. Locations where vehicles exit the site shall be inspected for evidence of offsite sediment tracking.

3.4.3 Inspection Reports

For each inspection conducted, the Contractor shall prepare a report summarizing the scope of the inspection, name(s) and qualifications of personnel making the inspection, the date(s) of the inspection, major observations relating to the implementation of the Storm Water Pollution Prevention Plan, maintenance performed, and actions taken. The report shall be furnished to the Contracting Officer within 24 hours of the inspection as a part of the Contractor's daily CQC REPORT. A copy of the inspection report shall be maintained on the job site.

-- End of Section --

SECTION 02220A

DEMOLITION
05/01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1 (1996) U.S. Army Corps of Engineers Safety and Health Requirements Manual

1.2 GENERAL REQUIREMENTS

The work includes demolition, salvage of identified items and materials, and removal of resulting rubbish and debris. Rubbish and debris shall be removed from Government property daily, unless otherwise directed, to avoid accumulation at the demolition site. In the interest of occupational safety and health, the work shall be performed in accordance with EM 385-1-1, Section 23, Demolition, and other applicable Sections. In the interest of conservation, salvage shall be pursued to the maximum extent possible. A 1.8 meter high chain link fence around the site is required.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Work Plan; G, RE

The procedures proposed for the accomplishment of the work. The procedures shall provide for safe conduct of the work, including procedures and methods to provide necessary supports, lateral bracing and shoring when required, careful removal and disposition of materials specified to be salvaged, protection of property which is to remain undisturbed, coordination with other work in progress, and timely disconnection of utility services. The procedures shall include a detailed description of the methods and equipment to be used for each operation, and the sequence of operations in accordance with EM 385-1-1.

1.4 DUST CONTROL

The amount of dust resulting from demolition shall be controlled to prevent the spread of dust to occupied portions of the construction site and to avoid creation of a nuisance in the surrounding area. Use of water will not be permitted when it will result in, or create, hazardous or objectionable conditions such as ice, flooding and pollution.

1.5 PROTECTION

1.5.1 Protection of Personnel

During the demolition work the Contractor shall continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site. No area, section, or component of floors, roofs, walls, columns, pilasters, or other structural element will be allowed to be left standing without sufficient bracing, shoring, or lateral support to prevent collapse or failure while workmen remove debris or perform other work in the immediate area.

1.5.2 Protection of Structures

Structural components that are designed and constructed to stand without lateral support or shoring, and are determined to be in stable condition, shall remain standing without additional bracing, shoring, or lateral support until demolished, unless directed otherwise by the Contracting Officer. The Contractor shall ensure that no elements determined to be unstable are left unsupported and shall be responsible for placing and securing bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

1.5.3 Protection of Existing Property

Before beginning any demolition work, the Contractor shall survey the site and examine the drawings and specifications to determine the extent of the work. The Contractor shall take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the Government; any damaged items shall be repaired or replaced as approved by the Contracting Officer. The Contractor shall coordinate the work of this section with all other work and shall construct and maintain shoring, bracing, and supports as required. The Contractor shall ensure that structural elements are not overloaded and shall be responsible for increasing structural supports or adding new supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

1.5.4 Protection From the Weather

Salvageable materials and equipment shall be protected from the weather at all times.

1.5.5 Protection of Trees

Trees within the project site which might be damaged during demolition, and which are indicated to be left in place, shall be protected by a 1.8 m high fence. The fence shall be securely erected a minimum of 1.5 m from the trunk of individual trees or follow the outer perimeter of branches or clumps of trees. Any tree designated to remain that is damaged during the work under this contract shall be replaced in kind or as approved by the Contracting Officer.

1.5.6 Environmental Protection

The work shall comply with the requirements of Section 1355.

1.6 BURNING

The use of burning at the project site for the disposal of refuse and debris will not be permitted.

1.7 USE OF EXPLOSIVES

Use of explosives will not be permitted.

1.8 AVAILABILITY OF WORK AREAS

Areas in which the work is to be accomplished will be available in accordance with the following schedule:

| <u>Area</u> | <u>Date</u> |
|----------------------------|----------------------------------------------------|
| BARRACKS / SCB AREA /4 COF | <u>NTP-C - See Section 00800, Page 133 of 135.</u> |
| 2 COF / Estes Road | <u>NTP-C - See Section 00800, Page 133 of 135.</u> |
| Kitty Drive | <u>NTP-C - See Section 00800, Page 133 of 135.</u> |

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 EXISTING STRUCTURES

Existing structures indicated shall be removed. Sidewalks, curbs, gutters and street light bases shall be removed as indicated.

3.2 UTILITIES

Disconnection of utility services, with related meters and equipment, are specified in Section special clauses. Existing utilities shall be removed as indicated. When utility lines are encountered that are not indicated on the drawings, the Contracting Officer shall be notified prior to further work in that area. Gas and water service lines shall be capped 25 mm from the main.

3.3 ASBESTOS CONTAINING MATERIALS

Immediately notify the contracting officer should materials suspected to contain asbestos be encountered. Contractor is responsible for removal and disposal of material. Asbestos shall be removed in accordance with OSHA 29 CFR 1926.1101 and Kansas Asbestos Regulations (KAR) 28-50-1 thru 50-14. See Section 13280A Asbestos Abatement for more information.

3.4 FILLING

Holes, open basements and other hazardous openings shall be filled in accordance with Section 02300 as should materials suspected to contain asbestos be encountered other than as described below. Contractor shall be responsible for testing and removal of material. Removal shall be in accordance with OSHA 29 CFR 1926.1101 and KAR 28-50-1 thru 50-14.

3.5 DISPOSITION OF MATERIAL

Title to material and equipment to be demolished, except Government salvage and historical items, is vested in the Contractor upon receipt of notice to proceed. The Government will not be responsible for the condition, loss or damage to such property after notice to proceed. The installation has rights of removal for reuse and recycling until turnover.

3.5.1 Salvageable Items and Material

Contractor shall salvage items and material to the maximum extent possible.

3.5.1.1 Material Salvaged for the Contractor

Material salvaged for the Contractor shall be stored as approved by the Contracting Officer and shall be removed from Government property before completion of the contract. Material salvaged for the Contractor shall not be sold on the site.

3.5.1.2 Items Salvaged for the Government

Salvaged items to remain the property of the Government shall be removed in a manner to prevent damage, and packed or crated to protect the items from damage while in storage or during shipment. Items damaged during removal or storage shall be repaired or replaced to match existing items. Containers shall be properly identified as to contents. The following items reserved as property of the Government shall be delivered to the areas designated: Fluorescent bulbs are to be drummed and freon captured and turned into DRMO, Camp Funston. Transformers are also to be taken to the DRMO.

3.5.1.3 Items Salvaged for the Using Service

3.5.1.4 Historical Items

Historical items shall be removed in a manner to prevent damage. The following historical items shall be delivered to the Government for disposition: Corner stones, contents of corner stones, and document boxes wherever located on the site.

3.5.2 Unsalvageable Material

Concrete, masonry, and other noncombustible material, except concrete permitted to remain in place, shall be disposed of in the disposal area located at the construction landfill. After disposal of fill is completed, the disposal area shall be uniformly graded to drain. Combustible material shall be disposed of off the site.

3.6 CLEAN UP

Debris and rubbish shall be removed from basement and similar excavations. Debris shall be removed and transported in a manner that prevents spillage on streets or adjacent areas. Local regulations regarding hauling and disposal shall apply.

3.7 PAVEMENTS

Existing pavements designated for removal shall be saw cut and removed in accordance with the details shown on the drawings and to the bottom of the base material.

-- End of Section --

SECTION 02555A

PREFABRICATED UNDERGROUND HEATING/COOLING DISTRIBUTION SYSTEM

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 518 (1998) Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

ASTM C 591 (1994) Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation

1.2 SYSTEM DESCRIPTION

The system consists of a buried prefabricated chilled water distribution system including service connections to a point 150 mm inside of the building. The contract drawings show the specific arrangement of piping, sizes and grades of pipe, and other details. The system is designed for an operating pressure of kPa and an operating temperature of 6 degrees C for chilled water.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Distribution System; G, EC

Detail drawings consisting of fabrication and assembly drawings, for all parts of the work in sufficient detail to check conformity with the requirements of the contract documents, prior to installation. Detail drawings shall also contain complete piping, wiring and schematic diagrams and any other details to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout, method of compensation for pipe expansion and contraction, anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances required for maintenance and operation. The drawings shall clearly identify any proposed deviations from the requirements of the contract documents.

SD-03 Product Data

Provide product data as follows:

Distribution System; G, EC

Data composed of catalog cuts, brochures, circulars, specifications and product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

SD-07 Certificates

Distribution System; G, RE

The manufacturer's or system fabricator's written certification stating that the distribution system furnished meets all the requirements of this specification.

Welding;

Prior to welding operations, a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.

SD-10 Operation and Maintenance Data

Distribution System; G, RE

Six copies of operation and 6 copies of maintenance manuals for the equipment furnished, 1 complete set prior to performance testing and the remainder upon acceptance. Operation manuals shall detail the step-by-step procedures required for equipment startup, operation, and shutdown. Operation manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include piping and equipment layout and simplified wiring and control diagrams of the equipment system as installed. Manuals shall be approved prior to the field performance testing.

1.4 DELIVERY AND STORAGE

After delivery to the jobsite, all materials and equipment shall be protected from anything which could cause damage to the material or equipment. Pipe shall be sealed at each end to keep the interior clean and free of dirt and debris. Fittings shall be kept together and their interior surfaces shall remain clean. Insulation shall be kept dry and clean.

1.5 FIELD MEASUREMENTS

The Contractor shall become familiar with all details of the work, verify all dimensions in the field and shall advise the Contracting Officer of any discrepancy before performing the work.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

System components shall be standard products of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. The system shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2 PIPING AND CASING MATERIALS

2.2.1 General

All underground chilled waterlines, as indicated on the contract drawings, shall be non-corrosive, non-metallic, structurally strong, completely water-proof, and entirely resistant to all ground chemicals normally encountered in an underground environment. All section shall be factory fabricated in 12 meters lengths, with polyethylene disks provided on both ends of each piece. Factory trained field technical assistance shall be provided for the critical period of the installation; i.e. unloading, field joint instructions and testing. A minimum of 40 days of field technical assistance is required.

2.2.2 Piping

2.2.2.1 Polyethylene Pipe and Fittings

Polyethylene pipe shall conform to ASTM D 1248, Type III, Class C, Category 5, Grade P 34. All service piping shall be manufactured to SDR 11 and shall have a pressure rating of 1103 kPa.

2.2.3 Casings

2.2.3.1 Polyethylene (PE) Casing

Polyethylene casings shall conform to ASTM D 3350, Type III, Class C, Category 3 or 4, Grade P 34 with thickness as follows:

| Casing Diameter (mm) | Minimum Thickness (mm) |
|-------------------------|---------------------------|
| 250 and smaller | 3 |
| 250 to 450 | 4 |
| 450 to 600 | 5 |
| over 600 | 6 |

2.3 PIPING CONNECTIONS

2.3.1 Plastic Pipe

All joints shall be thermal butt fusion welded. The service pipe and jacket shall be simultaneously welded so as to maintain the pressure rating of both the service pipe and jacket. "Sticks and kits" type systems will not be allowed. "Sleeved" field joint closures will not be allowed. Weld pressures, temperatures and time shall be in accordance with the manufacturer's recommendation. The manufacturer shall supply all butt fusion welding equipment. Field joints may be made either inside the trench or on top of the trench. For joints made on top of the trench, the piping may be rolled or dropped in place inside the trench. Pipe, fittings, flanges, and couplings shall have end connections of the adhesive bell and spigot type. Threaded piping, including pipe, fittings, flanges, and couplings, will not be permitted.

2.3.1.1 General

Plastic fittings shall be made of the same type and grade of material as the piping to which they will be connected and shall be furnished by the manufacturer who supplies the pipe. Fittings shall have temperature and pressure ratings not less than those of the connecting piping.

2.4 END SEALS

2.4.1 General

Each preinsulated section of piping shall have a complete sealing of the insulation to provide a permanent water and vapor seal at each end of the preinsulated section of piping. Preinsulated sections of piping modified in the field shall be provided with an end seal which is equivalent to the end seals

furnished with the preinsulated section of piping. End seals must be tested and certified in accordance with paragraph Casing and End Seal Testing and Certification.

2.4.2 Casing and End Seal Testing and Certification

Testing and certification procedures by an independent testing laboratory shall demonstrate that casings and end seals are capable of resisting penetration of water into the casing and insulation. The test shall be performed on the type of prefabricated system to be furnished. If more than one type of prefabricated system is to be used, then the tests shall be performed on each type. The test shall consist of hot and cold cycle testing followed by immersion in a water filled chamber with a head pressure. The hot and cold cycle testing shall consist of 14 days of temperature cycling. A fluid with a temperature of 5 degrees C shall circulate through the carrier pipe alternating every 24-hours with a fluid with a temperature of 95 degrees C circulating through the carrier pipe for a low temperature hot water or dual temperature service or 24 degrees for a chilled water service. While the hot and cold cycle test is being performed, the test sample is either buried or encased in dry bedding sand with a minimum of 300 mm of sand all around the test sample. The carrier pipe size of the test sample shall be 80 mm in diameter and shall be restrained during the test period. The insulation thickness shall not exceed the maximum thickness provided for the piping in the project. Transition time for temperature cycle testing shall not exceed 15 minutes in going from cold to hot and 30 minutes in going from hot to cold. The fluid in the carrier pipe may be water, oil or heat transfer fluid. Following the hot and cold cycling test, the test sample shall be immersed in a water filled chamber. The pressure on the highest point of the test sample shall not be less than 60 kPa subjected over the entire length of the 2.4 m test sample of prefabricated pipe. The water shall contain a dye penetrant, which will be used to check for end seal leakage. The pressure in the chamber must be held for not less than 48 hours. Upon completion of this pressure test, the test sample shall be cut open. With the use of a light that will readily show the presence of the dye that was in the water, the test sample shall be inspected. Evidence of the dye inside the test sample shall indicate that the end seal is not acceptable and cannot be certified. A pipe manufacturer who has a current Federal Letter of Acceptability for a system furnished under this section will be exempt from the testing specified in this paragraph.

2.5 INSULATION

2.5.1 Factory Applied Insulation

Prefabricated pipe and fittings shall be insulated in the factory. Foam insulation for prefabricated insulated pipe and fittings shall be polyurethane foam meeting the requirements of ASTM C 591 having a density not less than 32 kg per cubic meter. The polyurethane foam shall completely fill the annular space between the carrier pipe and the casing. Insulation thickness shall be a minimum of 20 mm. The insulation thermal conductivity factor shall not exceed the numerical value of 0.02 W/mK at 24 degrees C, when tested in accordance with ASTM C 518. Manufacturer shall certify that the insulated pipe is free of insulation voids.

2.5.2 Field Applied Insulation

Field applied insulation for fittings, and field casing closures, if required, and other piping system accessories shall be polyurethane matching the pipe insulation. Thickness shall match adjacent piping insulation thickness. Buried fittings and accessories shall have field applied polyurethane insulation to match adjacent piping and shall be protected with a covering matching the pipe casing. Shrink sleeves with a minimum thickness of 1.3 mm shall be provided over casing connection joints.

2.6 GATE VALVES

Gate Valves shall be designed for a working pressure of not less than 1.03 MPa. Valve connections shall be as required for the piping system in which they are installed. Valves shall have a clear waterway equal to the full nominal diameter of the valve, and shall be opened by turning counterclockwise. The operating nut or wheel shall have an arrow, cast in metal, indicating direction of opening.

- a. Valves 80 mm and larger shall be iron body, bronzed mounted, and shall conform to AWWA C500. Flanges shall not be buried. An approved valve pit of box shall be provided for all flanged connections.

2.7 VACUUM AND AIR RELIEF VALVES

Vacuum and air relief valves shall be of the size shown and shall be of a type that will release air and prevent the formation of a vacuum. The valves shall automatically release air when the lines are being filled with water and shall admit air into the lines when water is being withdrawn in excess of the inflow. Valves shall be iron body with brass trim and stainless steel float.

2.8 VALVE BOXES

Valve boxes shall cast iron or concrete except that concrete boxes may be installed in locations not subject to vehicular traffic. Cast-iron boxes shall be extension type with slide-type adjustment and with flared base. The minimum thickness of the metal shall be 5 mm. Concrete boxes shall be the standard product of a manufacturer of precast concrete equipment. The words "CHILLED WATER" shall be cast in the cover. The box length shall adapt, without full extension, to the depth of cover required over the pipe at the valve location.

PART 3 EXECUTION

3.1 INSTALLATION

For all preinsulated, prefabricated systems, the Contractor shall obtain the services of a trained representative of the pipe system manufacturer to instruct the Contractor's work forces in the installation procedures to ensure that the system is installed in accordance with the manufacturer's published instructions and the plans and specifications. The manufacturer's representative shall be a person who regularly performs such duties for the manufacturer. The Contractor shall furnish the Contracting Officer a list of names of personnel trained and certified by the pipe system manufacturer in the installation of this system. Only personnel whose names appear on the list will be allowed to install the system. The list shall not be more than 1 year old.

3.2 PIPING SYSTEMS

3.2.1 Buried Insulated Systems

Buried insulated systems shall consist of carrier pipe, insulation, casing, end seals, fittings and accessories as specified.

3.3 SETTING OF VALVES AND VALVE BOXES

After delivery, valves shall be drained to prevent freezing and shall have the interiors cleaned of all foreign matter before installation. Stuffing boxes shall be tightened and valves shall be fully opened and fully closed to ensure that all parts are in working condition. Vacuum relief valves shall be installed in concrete valve manholes. Valves and valve boxes shall be installed where shown or specified, and shall be set plumb. Valve boxes shall be centered on the valves. Boxes shall be installed over each outside gate valve unless otherwise shown. Earth shall be carefully tamped around each valve box to a distance of 1.2 m.

3.4 THRUST BLOCKS

Thrust blocks shall be installed at the locations shown or recommended by the pipe system manufacturer. Thrust blocks may not be required on all systems, and the need for thrust blocks shall be as recommended by the system manufacturer. Thrust blocks, if necessary, shall be installed at all changes in direction, changes in size, valves and terminal ends, such as plugs, caps and tees. Thrust blocks shall be concrete having a compressive strength of not less than 14 MPa after 28 days and shall be in accordance with Section 03300CAST-IN-PLACE STRUCTURAL CONCRETE. Thrust blocks shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and the thrust bearing sides of the thrust blocks shall be poured directly against undisturbed earth. The sides of the thrust blocks not subject to thrust may be poured against forms. Thrust blocks shall be placed so that the joints for all fittings will be accessible for repair wherever possible. No pipe joint shall be embedded in concrete unless the assembly has previously been hydrostatically tested. The thrust blocks shall provide for transfer of thrusts and reactions without exceeding the allowable stress of the concrete and shall be installed in accordance with pipe manufacturer's instructions. In muck or peat, all thrusts shall be resisted by piles or tie rods to solid foundations or by removal of peat or muck which shall be replaced with ballast of sufficient stability to resist thrusts.

3.5 INSTALLATION OF PIPING SYSTEMS

The piping system furnished shall be installed in accordance with the piping system manufacturer's instructions. Piping shall be installed without springing or forcing other than what has been calculated for cold spring. Pipe ends shall have burrs removed by reaming and shall be installed to permit free expansion and contraction without damage to joints or hangers. Nonmetallic pipe cut in the field shall be machined to fit couplings or joints and shall be coated or treated to match standard factory coated ends. Connections between different types of pipe and accessories shall be made with transition fittings approved by the manufacturer of the piping system.

3.5.1 Pitching of Horizontal Piping

Horizontal piping shall be pitched at a grade of not less than 40 mm in 1 m toward the drain points unless otherwise indicated.

3.5.2 Open Ends

Open ends of pipelines and equipment shall be properly capped or plugged during installation to keep dirt and other foreign matter out of the system.

3.5.3 Cutting Prefabricated Piping Sections

Where prefabricated pipe sections are field cut, new end seals similar to the factory applied end seal shall be provided and installed in accordance with the manufacturer's instructions.

3.5.4 Joints

3.5.4.1 Nonmetallic Pipe Joints

Nonmetallic pipe joints shall be installed in accordance with the written instructions of the manufacturer.

3.5.5 Anchors

Anchor design shall be in accordance with the published data of the manufacturer and for prefabricated systems shall be factory fabricated by the prefabricated system manufacturer. In all cases, the design shall be such that water penetration, condensation, or vapor transmission will not wet the insulation.

3.5.6 Field Casing Closures

Field insulation and encasement of joints shall be accomplished after the visual and pressure tests specified are completed. Field insulation and encasement shall be in accordance with the manufacturer's written instructions. Thickness dimensions of the insulation and casing materials shall not be less than those of the adjoining prefabricated section. Insulating material shall be foamed in place polyurethane. Care should be taken to ensure that field closures are made under conditions of temperature and cleanliness required to produce a sound, continuous vapor barrier. A standard polyethylene heat shrink sleeve shall be installed over the casing and shall have a 150 mm minimum overlap at each end.

3.5.7 Underground Warning Tape

Underground warning tape shall be buried above the piping during the trench backfilling and shall be buried approximately 300 mm deep. Tape shall be specified in section 02316 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS.

3.6 EARTHWORK

Earthwork shall be performed in accordance with Section 02316A EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS.

3.7 ELECTRICAL WORK

Electrical work shall be performed in accordance with either Section 16375A ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND or Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL.

3.8 TESTING

Tests shall be conducted before, during, and after installation of the system. All instruments, equipment, facilities, and labor required to properly conduct the tests shall be provided by the Contractor. Test pressure gauges for a specific test shall have dials indicating not less than 1-1/2 times nor more than 2 times the test pressure. It shall be the Contractor's responsibility to make the pipe system workable at his expense.

3.8.1 Carrier Pipe Cleaning and Testing

Distribution piping shall be tested as required before backfilling and with all joints exposed. The area between joints may be backfilled as necessary to prevent pipe movement.

3.8.1.1 Cleaning Carrier Pipe

Prior to testing, the interior of the carrier pipe shall be cleaned of foreign materials by thorough flushing with clean water. Water shall be circulated at a velocity between 2 and 3 m/s for a minimum of 4 hours. If required, temporary and/or supplementary pumps shall be provided to ensure that required velocity is achieved. System strainers shall be cleaned after the flushing operation is complete. Temporary strainers shall be installed as required. After flushing, the water shall remain in the piping system for testing of the system. All air shall be removed from the system prior to starting the tests.

3.8.1.2 Hydrostatic Pressure Cycling and Tests

Hydrostatic pressure cycling shall have 4 cycles. Each cycle shall consist of a 10 minute period at 1000 kPa followed by a 5 minute period at a pressure less than 350 kPa. The next cycle shall begin immediately following the completion of the previous cycle. Pressure rise and drop shall not exceed 690 kPa per minute.

The pressure gauge shall be located and the pressure measured at the opposite end of the system from where the pressure is applied. After completion of the hydrostatic pressure cycling, the first hydrostatic pressure test shall be performed. During the first hydrostatic pressure test, the system shall be proven tight at a pressure of 1-1/2 times the working pressure up to 1000 kPa. This pressure shall be held for a minimum of 1 hour. The method of pressurizing the system shall be disconnected from the system before starting the 1 hour pressure holding period. If the pressure cannot be held for the specified length of time, the cause of pressure loss shall be determined, corrected and the hydrostatic pressure cycling and first hydrostatic pressure test shall be repeated until the system can hold the required pressure for at least 1 hour. After successful completion of the first hydrostatic pressure test, the water shall be drained out of the piping system and the piping system filled with treated water as defined in paragraph TREATED WATER for the remaining tests and for permanent operation of the system. The hydrostatic pressure cycling and tests shall be repeated after the system has been filled with treated water, using the same test conditions and criteria.

3.8.1.3 Operational Test

Operational test shall be performed on the complete system or testable portions thereof. The test shall be conducted with full design flows and operating temperatures in all runs of piping as if in service, to demonstrate satisfactory function and operating effectiveness. The operational test will have two cycles. Each cycle shall consist of a 6-hour period with treated water in the system at the maximum operating temperature of 12 degrees C and maximum flow rate, and a period of at least 6-hours with no flow. The Contractor shall supply temporary pumps, piping connections, boilers, chillers and the gauges required to circulate the water at the desired temperatures and flow rates. Water shall be circulated through supply lines and returned through the return piping to demonstrate that the pressure drop is compatible with the flow rate and size of pipe and to show that obstructions do not exist in the piping system. Any unusual indicated pressure drop will be investigated and any obstructions removed. Any leaks found shall be repaired. After any obstructions have been removed and any leaks repaired, the operational test shall be repeated until successfully passed.

3.8.1.4 Final Hydrostatic Test

After successful completion of the operational test, the system shall be pressurized to 1-1/2 times the working pressure up to 1000 kPa. This pressure shall be held for a minimum of 4 hours. Means of pressurizing shall be disconnected prior to the start of the 4-hour pressure holding period. If the pressure cannot be held for the specified length of time, the cause of the pressure loss shall be determined, corrected, and all of the hydrostatic pressure cycling and tests repeated.

-- End of Section --

SECTION 07311A

ROOFING, STRIP SHINGLES
08/98

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|-------------|----------------------------------------------------------------------------------------------------------------------------|
| ASTM D 225 | (2000) Asphalt Shingles (Organic Felt) Surfaced with Mineral Granules |
| ASTM D 226 | (1997a) Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing |
| ASTM D 1970 | (2000) Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection |
| ASTM D 3018 | (1990; R 1994e1) Class A Asphalt Shingles Surfaced With Mineral Granules |
| ASTM D 3161 | (1999a) Wind-Resistance of Asphalt Shingles (Fan-Induced Method) |
| ASTM D 3462 | (1999) Asphalt Shingles Made From Glass Felt and Surfaced with Mineral Granules |
| ASTM D 4869 | (1988; R 1993e1) Asphalt-Saturated Organic Felt Shingle Underlayment Used in Roofing |
| ASTM E 108 | (1999) Fire Tests of Roof Coverings |

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

| | |
|---------------------|---------------------------------------|
| NRCA Shingle Manual | (1996) Asphalt Shingle Roofing Manual |
|---------------------|---------------------------------------|

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Application of Roofing Materials; G, RE.

Manufacturer's catalog data, description of underlayment, shingles, fasteners, ridge vents, and flashing. Manufacturer's instructions, annotated or supplemented by the Contractor to indicate configuration and method for installing the materials, and for waterproofing of joints where flashings change direction. The number, spacing and orientation of

fasteners shall be specified.

SD-04 Samples

Shingles; G, RE.

Full shingle sample and manufacturer's standard size samples of materials and products requiring color or finish selection.

1.3 DELIVERY AND STORAGE OF MATERIALS

Materials shall be delivered in manufacturer's unopened bundles and containers with the manufacturer's brand and name marked clearly thereon. Shingles shall be stored in accordance with manufacturer's printed instructions. Roll goods shall be stored on end in an upright position or in accordance with manufacturer's recommendations. Immediately before laying, roofing felt shall be stored for 24 hours in an area maintained at a temperature not lower than 10 degrees C.

1.4 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period shall be provided.

PART 2 PRODUCTS

2.1 MATERIALS

Materials shall conform to the following requirements:

2.1.1 Metal Drip Edges

Metal drip edges shall be minimum 26 gauge galvanized steel or an equivalent non-corrosive non-staining material, as shown.

2.1.2 Underlayment

Organic felt; ASTM D 4869 or ASTM D 226, non perforated Type II, heavy-duty number 30.

2.1.3 Leak Barrier Underlayment

Self-adhering leak barrier or ice dam underlayment shall comply with ASTM D 1970 for sealability around nails.

2.1.4 Ventilators

2.1.4.1 Aluminum Ridge Vents

Ridge vents shall be constructed of prefinished aluminum in minimum 3 m long sections and shall be approximately 0.30 m wide. Vents shall be designed to prevent infiltration of insects, rain, and snow.

2.1.4.2 Nailable Plastic Shingle Over Type Ridge Vents

Ridge vents shall be constructed of UV stabilized nailable rigid polypropylene material, approximately 0.30 m wide and 25 mm thick, and shall be in 1.2 m long interlocking sections with self-aligning ends or corrugated polyethylene rigid roll or rigid strip ridge vent with aluminum wind deflectors on each side. Vents shall be designed to prevent infiltration of insects, rain, and snow.

2.1.4.3 Nailable Mesh Shingle Over Type Ridge Vents

Ridge vents shall be constructed of UV stabilized nailable polyester mesh

material, approximately 0.30 m wide. Vents shall be designed to prevent infiltration of insects, rain, and snow.

2.1.5 Nails

Nails shall be round head 11 or 12 gauge galvanized steel or equivalent corrosion resistant roofing nails. Nail heads shall be 9.5 mm minimum diameter, with flat and smooth low profile. Shanks shall be barbed or otherwise deformed for added pull-out resistance. Nails shall be long enough to penetrate all layers of roofing materials and achieve secure anchorage into the roof deck. Nails shall extend through the underside of plywood or wood panel roof decks, and shall penetrate at least 19 mm into wood plank decks.

2.1.6 Shingles

Shingles shall be approximately 333 by 1000 mm in dimension and architectural design. Starter Strip is required for enhanced 110 MPH limited wind warranty for shingles. Shingles shall be manufacturer's standard type for project area Glass felt shingles shall comply with ASTM D 3018 Type I - Self-Sealing; UL Certification of ASTM D 3462, ASTM D 3161 Class "F" (110-mph)/UL997 Wind Resistance, and UL Class A Fire Resistance, and shall weigh not less than 16 kg Shingles shall have 50-year limited product warranty at 110 MPH (6 nails only with starter strip)] maximum wind velocity; including hip and ridge shingles used in conjunction with shingles. Contractor's option for inverted strip shingle is not allowed for enhanced 110 MPH limited wind warranty. Shingles shall be installed on the following buildings: Barracks and Soldier Community Building.

2.1.7 Ice and Water Barrier

Special roofing membranes shall be a self-adhering, self-sealing product such as "WinterGuard" manufactured by CertainTeed Corps., "Ice and Water Shield" manufactured by Grace Construction Products, or "Weather Watch Ice and Water Barrier" manufactured by GAF Building Materials Corps. They shall be conforming to ASTM D 146 and ASTM D 412 (composite of polyethylene film and rubberized asphalt) or ASTM D 1970 (polymer modified bituminous sheet materials).

2.2 COLOR

Shingle color shall be in accordance with EXTERIOR FINISH AND COLOR SCHEDULE.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACES

The construction of any bay or section of roof decking shall be completed before roofing work is started. Roof surfaces shall be smooth, firm, dry, and free from loose boards, large cracks, and projecting ends that might damage the roofing. Vents and other projections through roofs shall be properly flashed and secured in position, and projecting nails shall be driven flush with the deck.

3.2 APPLICATION OF ROOFING MATERIALS

3.2.1 Flashings

Metal flashings shall conform to Section 07600 SHEET METALWORK, GENERAL. Metal flashings shall be provided at the intersections of roofs and adjoining walls and at projections through the deck such as chimneys and vent stacks. Valley flashing shall be of the open, in accordance with NRCA Shingle Manual.

3.2.2 Metal Drip Edges

Metal drip edges shall be provided along the eaves and rakes. The metal drip edge shall be applied directly over the underlayment along the rakes and directly

on the wood deck at the eaves. Metal drip edges shall extend back from the edge of the deck not less than 75 mm and shall be secured with compatible nails spaced not more than 250 mm on center along the inner edge.

3.2.3 Underlayment

Before any shingles are applied, a single layer of asphalt-saturated-felt underlayment shall be applied to the roof deck sheathing. A ice and water barrier underlayment shall be applied at the following locations: Starting from the eaves to a point 600mm inside the interior wall line ; starting from the gable roof ridges to a point 1200mm inward; 600mm down on both sides from the roof ridge; 600mm up on both sides from the valleys. Roof surfaces to receive ice and water barrier membrane shall be prepared in accordance with manufacturer's instructions prior to application of the membrane. Membrane shall be applied directly to the roof deck (plywood) at locations indicated by the specs and on the drawings. Installation procedures shall follow manufacturer's printed instructions.

3.2.4 Ridge Vents

Ridge vents shall be provided along the ridge lines where shown. Ridge vents shall be installed in accordance with the manufacturer's printed instructions.

3.2.5 Shingles

Shingles with the correct recommended exposure shall be applied in accordance with the manufacturer's printed instructions as they appear on the bundle wrapping. Roof shingles shall be resistant to blow-off due to wind velocities, including gusts, provided that the shingles shall be installed using six (6) fasteners, in the common bond area, per shingle.

-- End of Section --

SECTION 13851A

FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE
02/02

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S3.41 (1990; R 1996) Audible Emergency Evacuation Signal

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41 (1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 1221 (1999) Installation, Maintenance and Use of Public Fire Service Communication Systems

NFPA 70 (1999) National Electrical Code

NFPA 72 (1999) National Fire Alarm Code

NFPA 90A (1999) Installation of Air Conditioning and Ventilating Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15 Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1242 (1996; Rev Mar 1998) Intermediate Metal Conduit

UL 1971 (1995; Rev thru Apr 1999) Signaling Devices for the Hearing Impaired

UL 268 (1996; Rev thru Jan 1999) Smoke Detectors for Fire Protective Signaling Systems

UL 268A (1998) Smoke Detectors for Duct Application

UL 38 (1999) Manually Actuated Signaling Boxes for Use with Fire-Protective Signaling Systems

UL 464 (1996; Rev thru May 1999) Audible Signal Appliances

UL 521 (1999) Heat Detectors for Fire Protective Signaling Systems

UL 6 (1997) Rigid Metal Conduit

UL 797 (1993; Rev thru Mar 1997) Electrical Metallic Tubing

UL 864 (1996; Rev thru Mar 1999) Control Units for Fire Protective Signaling Systems

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fire Alarm Reporting System; G, RE.

Detail drawings, prepared and signed by a Registered Professional Engineer consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical detectors. The Contractor shall check the layout based on the actual detectors to be installed and make any necessary revisions in the detail drawings. The detail drawings shall also contain complete wiring and schematic diagrams for the equipment furnished, equipment layout, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Detailed point-to-point wiring diagram shall be prepared and signed by a Registered Professional Engineer showing points of connection. Diagram shall include connections between system devices, appliances, control panels, supervised devices, and equipment that is activated or controlled by the panel.

SD-03 Product Data

Storage Batteries; G, DF.

Substantiating battery calculations for supervisory and alarm power requirements. Ampere-hour requirements for each system component and each panel component, and the battery recharging period shall be included.

Voltage Drop; G, DF.

Voltage drop calculations for notification appliance circuits to indicate that sufficient voltage is available for proper appliance operation.

Special Tools and Spare Parts; G, RE.

Spare parts data for each different item of material and equipment specified, not later than 3 months prior to the date of beneficial occupancy. Data shall include a complete list of parts and supplies with the current unit prices and source of supply and a list of the parts recommended by the manufacturer to be replaced after 1 year of service.

Technical Data and Computer Software; G, DF.

Technical data which relates to computer software.

Training; G, RE.

Lesson plans, operating instructions, maintenance procedures, and training data, furnished in manual format, for the training courses. The operations training shall familiarize designated government personnel with proper operation of the fire alarm system. The maintenance training course shall provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

Testing; G, RE.

Detailed test procedures, prepared and signed by a Registered Professional Engineer for the fire detection and alarm system 60 days prior to performing system tests.

SD-06 Test Reports

Testing; G, RE.

Test reports, in booklet form, showing field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall document readings, test results and indicate the final position of controls. The Contractor shall include the NFPA 72 Certificate of Completion and NFPA 72 Inspection and Testing Form, with the appropriate test reports.

SD-07 Certificates

Equipment; G, RE.

Certified copies of current approvals or listings issued by an independent test lab if not listed by UL, FM or other nationally recognized testing laboratory, showing compliance with specified NFPA standards.

Qualifications; G, RE.

Proof of qualifications for required personnel. The installer shall submit proof of experience for the Professional Engineer, fire alarm technician, and the installing company.

SD-10 Operation and Maintenance Data

Technical Data and Computer Software.

Six copies of operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual shall include the manufacturer's name, model number, service manual, parts list, and complete description of equipment and their basic operating features. Six copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed. The manuals shall include complete procedures for system revision and expansion, detailing both equipment and software requirements. Original and backup copies of all software delivered for this project shall be provided, on each type of media utilized. Manuals shall be approved prior to training.

1.3 GENERAL REQUIREMENTS

1.3.1 Standard Products

Material and equipment shall be the standard products of a manufacturer regularly

engaged in the manufacture of the products for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that can provide service within 24 hours of notification.

1.3.2 Nameplates

Major components of equipment shall have the manufacturer's name, address, type or style, voltage and current rating, and catalog number on a noncorrosive and nonheat-sensitive plate which is securely attached to the equipment.

1.3.3 Keys and Locks

Locks shall be keyed alike. Four keys for the system shall be provided.

1.3.4 Tags

Tags with stamped identification number shall be furnished for keys and locks.

1.3.5 Verification of Dimensions

After becoming familiar with details of the work, the Contractor shall verify dimensions in the field and shall advise the Contracting Officer of any discrepancy before performing the work.

1.3.6 Compliance

The fire detection and alarm system and the central reporting system shall be configured in accordance with NFPA 72; exceptions are acceptable as directed by the Contracting Officer. The equipment furnished shall be compatible and be UL listed, FM approved, or approved or listed by a nationally recognized testing laboratory in accordance with the applicable NFPA standards.

1.3.7 Qualifications

1.3.7.1 Engineer and Technician

a. Registered Professional Engineer with verification of experience and at least 4 years of current experience in the design of the fire protection and detection systems.

b. National Institute for Certification in Engineering Technologies (NICET) qualifications as an engineering technician in fire alarm systems program with verification of experience and current NICET certificate.

c. The Registered Professional Engineer may perform all required items under this specification. The NICET Fire Alarm Technician shall perform only the items allowed by the specific category of certification held.

1.3.7.2 Installer

The installing Contractor shall provide the following: NICET Fire Alarm Technicians to perform the installation of the system. A NICET Level 4 Fire Alarm Technician shall supervise the installation of the fire alarm system. NICET Level 2 or higher Fire Alarm Technician shall install and terminate fire alarm devices, cabinets and panels. An electrician or NICET Level 1 Fire Alarm Technician shall install conduit for the fire alarm system. The Fire Alarm technicians installing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.3.7.3 Design Services

Installations requiring designs or modifications of fire detection, fire alarm,

or fire suppression systems shall require the services and review of a qualified fire protection engineer. For the purposes of meeting this requirement, a qualified fire protection engineer is defined as an individual meeting one of the following conditions:

- a. An engineer having a Bachelor of Science or Masters of Science Degree in Fire Protection Engineering from an accredited university engineering program, plus a minimum of 2 years' work experience in fire protection engineering.
- b. A registered professional engineer (P.E.) in fire protection engineering.
- c. A registered PE in a related engineering discipline and member grade status in the National Society of Fire Protection Engineers.
- d. An engineer with a minimum of 10 years' experience in fire protection engineering and member grade status in the National Society of Fire Protection Engineers.

1.4 SYSTEM DESIGN

1.4.1 Operation

The fire alarm and detection system shall be a complete, supervised fire alarm reporting system. The system shall be activated into the alarm mode by actuation of any alarm initiating device. The system shall remain in the alarm mode until the initiating device is reset and the fire alarm control panel is reset and restored to normal. Alarm initiating devices shall be connected Style D, to signal line circuits (SLC), Style , in accordance with NFPA 72. Alarm notification appliances shall be connected to notification appliance circuits (NAC), Style Z in accordance with NFPA 72. A looped conduit system shall be provided so that if the conduit and all conductors within are severed at any point, all IDC, NAC and SLC will remain functional. The conduit loop requirement is not applicable to the signal transmission link from the local panels (at the protected premises) to the Supervising Station (fire station, fire alarm central communication center). Textual, audible, and visual appliances and systems shall comply with NFPA 72. Fire alarm system components requiring power, except for the control panel power supply, shall operate on 24 Volts dc. Addressable system shall be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits and shall provide the following features:

- a. Sufficient memory to perform as specified and as shown for addressable system.
- b. Individual identity of each addressable device for the following conditions: alarm; trouble; open; short; and appliances missing/failed remote detector - sensitivity adjustment from the panel for smoke detectors
- c. Capability of each addressable device being individually disabled or enabled from the panel.
- d. Each SLC shall be sized to provide 40 percent addressable expansion without hardware modifications to the panel.

1.4.2 Operational Features

The system shall have the following operating features:

- a. Monitor electrical supervision of SLC, and NAC. Smoke detectors shall have combined alarm initiating and power circuits.
- b. Monitor electrical supervision of the primary power (ac) supply, battery

voltage, placement of alarm zone module (card, PC board) within the control panel, and transmitter tripping circuit integrity.

- c. A trouble buzzer and trouble LED/LCD (light emitting diode/liquid crystal diode) to activate upon a single break, open, or ground fault condition which prevents the required normal operation of the system. The trouble signal shall also operate upon loss of primary power (ac) supply, low battery voltage, removal of alarm zone module (card, PC board), and disconnection of the circuit used for transmitting alarm signals off-premises. A trouble alarm silence switch shall be provided which will silence the trouble buzzer, but will not extinguish the trouble indicator LED/LCD. Subsequent trouble and supervisory alarms shall sound the trouble signal until silenced. After the system returns to normal operating conditions, the trouble buzzer shall again sound until the silencing switch returns to normal position, unless automatic trouble reset is provided.
- d. A one person test mode. Activating an initiating device in this mode will activate an alarm for a short period of time, then automatically reset the alarm, without activating the transmitter during the entire process.
- e. A transmitter disconnect switch to allow testing and maintenance of the system without activating the transmitter but providing a trouble signal when disconnected and a restoration signal when reconnected.
- f. Evacuation alarm silencing switch which, when activated, will silence alarm devices, but will not affect the zone indicating LED/LCD nor the operation of the transmitter. This switch shall be over-ridden upon activation of a subsequent alarm from an unalarmed device and the NAC devices will be activated.
- g. Electrical supervision for circuits used for supervisory signal services (i.e., sprinkler systems, valves, etc.). Supervision shall detect any open, short, or ground.
- h. Confirmation or verification of all smoke detectors. The control panel shall interrupt the transmission of an alarm signal to the system control panel for a factory preset period. This interruption period shall be adjustable from 1 to 60 seconds and be factory set at 20 seconds. Immediately following the interruption period, a confirmation period shall be in effect during which time an alarm signal, if present, will be sent immediately to the control panel. Fire alarm devices other than smoke detectors shall be programmed without confirmation or verification.
- i. The fire alarm control panel shall provide supervised addressable relays for HVAC shutdown. An override at the HVAC panel shall not be provided.
- j. Provide one person test mode - Activating an initiating device in this mode will activate an alarm for a short period of time, then automatically reset the alarm, without activating the transmitter during the entire process.
- k. The fire alarm control panel shall provide the required monitoring and supervised control outputs needed to accomplish elevator recall.
- l. The fire alarm control panel shall monitor the fire sprinkler system, or other fire protection extinguishing system.
- m. The control panel and field panels shall be software reprogrammable to enable expansion or modification of the system without replacement of hardware or firmware. Examples of required changes are: adding or

deleting devices or zones; changing system responses to particular input signals; programming certain input signals to activate auxiliary devices.

1.4.3 Alarm Functions

An alarm condition on a circuit shall automatically initiate the following functions:

- a. Transmission of signals over the station radio fire reporting system. The devices are further described on the fire alarm matrix for each building.

Company Operations Facilities

1. Alarm Initiation Devices
2. Water Flow
3. All valve and transmitter door tamper switches
4. All trouble conditions

Barracks/Soldier Community Building

All barracks and soldier community building alarms will be transmitted in the soldier community building. The zones will be as indicated.

Barracks 7815A & 7815B

1. Alarm Initiating Devices (One zone for each floor per building)
2. Water flow (One zone for each floor per building)
3. All valve and transmitter door tamper switches (One zone per building)
4. All fire alarm panel trouble conditions (One zone per building)
5. An alarm condition from a single smoke detector in room module shall cause the sounding of the detector audible base within the room/module only and transmit trouble signal to FA and fire station.
6. Alarm for multiple smoke detectors in the same module (One zone for each floor per building)

Soldier Community Building

1. Alarm Initiation Devices
 2. Water Flow
 3. All valve and transmitter door tamper switches
 4. All trouble conditions
- b. Visual indications of the alarmed devices on the fire alarm control panel display and on the remote audible/visual display.
 - c. Continuous sounding or operation of alarm notification appliances throughout the building as required by ANSI S3.41.
 - f. Deactivation of the air handling units throughout the building.
 - g. Exit to flash when system is in alarm mode.

1.4.4 Primary Power

Operating power shall be provided as required by paragraph Power Supply for the System. Transfer from normal to emergency power or restoration from emergency to normal power shall be fully automatic and not cause transmission of a false alarm. Loss of ac power shall not prevent transmission of a signal via the fire

reporting system upon operation of any initiating circuit.

1.4.5 Battery Backup Power

Battery backup power shall be through use of rechargeable, sealed-type storage batteries and battery charger.

1.5 TECHNICAL DATA AND COMPUTER SOFTWARE

Technical data and computer software (meaning technical data which relates to computer software) which is specifically identified in this project, and which may be defined/required in other specifications, shall be delivered, strictly in accordance with the CONTRACT CLAUSES, and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. Data to be submitted shall include complete system, equipment, and software descriptions. Descriptions shall show how the equipment will operate as a system to meet the performance requirements of this contract. The data package shall also include the following:

- (1) Identification of programmable portions of system equipment and capabilities.
- (2) Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.
- (3) Provision of operational software data on all modes of programmable portions of the fire alarm and detection system.
- (4) Description of Fire Alarm Control Panel equipment operation.
- (5) Description of auxiliary and remote equipment operations.
- (6) Library of application software.
- (7) Operation and maintenance manuals as specified in SD-19 of the Submittals paragraph.

1.6 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variation, dirt, dust, and any other contaminants.

PART 2 PRODUCTS

2.1 CONTROL PANEL

Control Panel shall comply with the applicable requirements of UL 864. Panel shall be modular, installed in a surface mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly assembled panel containing components and equipment required to provide the specified operating and supervisory functions of the system. The panel shall have prominent rigid plastic, phenolic or metal identification plates for LED/LCDs, zones, SLC, controls, meters, fuses, and switches. Nameplates for fuses shall also include ampere rating. The LED/LCD displays shall be located on the exterior of the cabinet door or be visible through the cabinet door. Control panel switches shall be within the locked cabinet. A suitable means (single operation) shall be provided for testing the control panel visual indicating devices (meters or LEDs/LCDs). Meters and LEDs shall be plainly visible when the cabinet door is closed. Signals and LEDs/LCDs shall be provided to indicate by zone any alarm, supervisory or trouble condition on the system. Loss of power, including batteries, shall not require the manual reloading of a program. Upon

restoration of power, startup shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals. Visual annunciation shall be provided for LED/LCD visual display as an integral part of the control panel and shall identify with a word description and id number each device. Cabinets shall be provided with ample gutter space to allow proper clearance between the cabinet and live parts of the panel equipment. If more than one modular unit is required to form a control panel, the units shall be installed in a single cabinet large enough to accommodate units. Cabinets shall be painted red.

2.1.1 Remote System Audible/Visual Display

Audible appliance shall have a minimum sound level output rating of 85 dBA at and operate in conjunction with the panel integral display. The audible device shall be silenced by a system silence switch on the remote system. The audible device shall be silenced by the system silence switch located at the remote location, but shall not extinguish the visual indication. The remote LED/LCD visual display shall provide identification, consisting of the word description and id number for each device as displayed on the control panel. A rigid plastic, phenolic or metal identification sign which reads "Fire Alarm System Remote Display" shall be provided at the remote audible/visual display. The remote visual appliance located with the audible appliance shall not be extinguished until the trouble or alarm has been cleared.

2.1.2 Circuit Connections

Circuit conductors entering or leaving the panel shall be connected to screw-type terminals with each conductor and terminal marked for identification.

2.1.3 System Expansion and Modification Capabilities

Any equipment and software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as part of this contract.

2.1.4 Addressable Control Module

The control module shall be capable of operating as a relay (dry contact form C) for interfacing the control panel with the PA system. The module shall be UL listed as compatible with the control panel. The indicating device or the external load being controlled shall be configured as a Style Y notification appliance circuits. The system shall be capable of supervising, audible, visual and dry contact circuits. The control module shall have both an input and output address. The supervision shall detect a short on the supervised circuit and shall prevent power from being applied to the circuit. The control model shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. The control module shall contain an integral LED that flashes each time the control module is polled.

2.1.5 Addressable Initiating Device Circuits Module

The initiating device being monitored shall be configured as a Style D initiating device circuits. The system shall be capable of defining any module as an alarm module and report alarm trouble, loss of polling, or as a supervisory module, and reporting supervisory short, supervisory open or loss of polling. The module shall be UL listed as compatible with the control panel. The monitor module shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. Monitor module shall contain an integral LED that flashes each time the monitor module is polled. Pull stations with a monitor module in a common backbox are not required to have an LED.

2.2 STORAGE BATTERIES

Storage batteries shall be provided and shall be 24 Vdc sealed, lead-calcium type requiring no additional water. The batteries shall have ample capacity, with primary power disconnected, to operate the fire alarm system for a period of 72 hours. Following this period of battery operation, the batteries shall have ample capacity to operate all components of the system, including all alarm signaling devices in the total alarm mode for a minimum period of 15 minutes. Batteries shall be located at the bottom of the panel. Batteries shall be provided with overcurrent protection in accordance with NFPA 72. Separate battery cabinets shall have a lockable, hinged cover similar to the fire alarm panel. The lock shall be keyed the same as the fire alarm control panel. Cabinets shall be painted to match the fire alarm control panel.

2.3 BATTERY CHARGER

Battery charger shall be completely automatic, 24 Vdc with high/low charging rate, capable of restoring the batteries from full discharge (18 Volts dc) to full charge within 48 hours. A pilot light indicating when batteries are manually placed on a high rate of charge shall be provided as part of the unit assembly, if a high rate switch is provided. Charger shall be located in control panel cabinet or in a separate battery cabinet.

2.4 ADDRESSABLE MANUAL FIRE ALARM STATIONS

Addressable manual fire alarm stations shall conform to the applicable requirements of UL 38. Manual stations shall be connected into signal line circuits. Stations shall be installed on surface or mounted outlet boxes. Manual stations shall be mounted at Stations shall be double action type. Stations shall be finished in red, with raised letter operating instructions of contrasting color. Stations requiring the breaking of glass or plastic panels for operation are not acceptable. Stations employing glass rods are not acceptable. The use of a key or wrench shall be required to reset the station. Gravity or mercury switches are not acceptable. Switches and contacts shall be rated for the voltage and current upon which they operate. Addressable pull stations shall be capable of being field programmed, shall latch upon operation and remain latched until manually reset. Stations shall have a separate screw terminal for each conductor. Surface mounted boxes shall be painted red..

2.5 FIRE DETECTING DEVICES

Fire detecting devices shall comply with the applicable requirements of NFPA 72, NFPA 90A, UL 268, UL 268A, and UL 521. The detectors shall be provided as indicated. Detector base shall have screw terminals for making connections. No solder connections will be allowed. Detectors located in concealed locations (above ceiling, raised floors, etc.) shall have a remote visible indicator LED/LCD. Addressable fire detecting devices, except flame detectors, shall be dynamically supervised and uniquely identified in the control panel. All fire alarm initiating devices shall be individually addressable, except where indicated. Installed devices shall conform to NFPA 70 hazard classification of the area where devices are to be installed.

2.5.1 Heat Detectors

Heat detectors shall be designed for detection of fire by combination fixed temperature and rate-of-rise principle. Heat detector spacing shall be rated in accordance with UL 521. Detectors located in areas subject to moisture, exterior atmospheric conditions, or hazardous locations as defined by NFPA 70, shall be types approved for such locations. Heat detectors located in attic spaces or similar concealed spaces below the roof shall be intermediate temperature rated.

2.5.1.1 Combination Fixed-Temperature and Rate-of-Rise Detectors

Detectors shall be designed for surface outlet box mounting and supported

independently of wiring connections. Contacts shall be self-resetting after response to rate-of-rise principle. Under fixed temperature actuation, the detector shall have a permanent external indication which is readily visible. Detector units located in boiler rooms, showers, or other areas subject to abnormal temperature changes shall operate on fixed temperature principle only. The UL 521 test rating for the fixed temperature portion shall be 57.2 degrees C. The UL 521 test rating for the Rate-of-Rise detectors shall be rated for

2.5.2 Smoke Detectors

Smoke detectors shall be designed for detection of abnormal smoke densities. Smoke detectors shall be photoelectric type. Detectors shall contain a visible indicator LED/LCD that shows when the unit is in alarm condition. Detectors shall not be adversely affected by vibration or pressure. Detectors shall be the plug-in type in which the detector base contains terminals for making wiring connections. Detectors that are to be installed in concealed (above false ceilings, etc.) locations shall be provided with a remote indicator LED/LCD suitable for mounting in a finished, visible location.

2.5.2.1 Photoelectric Detectors

Detectors shall operate on a light scattering concept using an LED light source. Failure of the LED shall not cause an alarm condition. Detectors shall be factory set for sensitivity and shall require no field adjustments of any kind. Detectors shall have an obscuration rating in accordance with UL 268. Addressable smoke detectors shall be capable of having the sensitivity being remotely adjusted by the control panel.

2.5.2.2 Duct Detectors

Duct detectors shall be as specified in section 15951A DIRECT DIGITAL CONTROL FOR HVAC

2.6 NOTIFICATION APPLIANCES

Audible appliances shall conform to the applicable requirements of UL 464. Devices shall be connected into notification appliance circuits. Devices shall have a separate screw terminal for each conductor. Audible appliances shall generate a unique audible sound from other devices provided in the building and surrounding area. Surface mounted audible appliances shall be painted RED. Recessed audible appliances shall be installed with a grill that is painted RED.

2.6.1 Alarm Horns

Horns shall be surface mounted, with the matching mounting back box surface mounted vibrating type suitable for use in an electrically supervised circuit. Horns shall produce a sound rating of at least 85 dBA at 10 feet. Horns used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grilles.

2.6.2 Visual Notification Appliances

Visual notification appliances shall conform to the applicable requirements of UL 1971 and the contract drawings. Appliances shall have clear high intensity optic lens, xenon flash tubes, and output white light. Strobe flash rate shall be between 1 to 3 flashes per second and a minimum of 75 candela. Strobe shall be semi-flush mounted.

2.6.3 Combination Audible/Visual Notification Appliances

Combination audible/visual notification appliances shall provide the same requirements as individual units except they shall mount as a unit in standard backboxes. Units shall be factory assembled. Any other audible notification

appliance employed in the fire alarm systems shall be approved by the Contracting Officer.

2.6.4 Voice Evacuation System

The voice evacuation system shall provide for one-way voice communications, routing and pre-amplification of digital alarm tones and voice (digital and analog) messages. The system shall be zoned for messages (Custom and prerecorded). The following electronic tones shall be available from the amplifier: Slow Whoop, High/Low, Horn, Chime, Beep, Stutter, Wail and Bell. The system shall be interfaced with the Manoco Transceiver to broadcast a message on initiation of the voice evacuation system from the Fire Station. The voice evacuation system shall have blue strobes and speakers located throughout the building. On activation of the system, the message will be broadcast on the speakers, the blue strobes will flash and all the indicating devices of FA system will be silenced/deactivated for that period the voice activation system is on.

2.7 FIRE DETECTION AND ALARM SYSTEM PERIPHERAL EQUIPMENT

2.7.1 Conduit

Conduit and fittings shall comply with NFPA 70, UL 6, UL 1242, and UL 797.

2.7.2 Wiring

Wiring shall conform to NFPA 70. Wiring for 120 Vac power shall be No. 12 AWG minimum. The SLC wiring shall be copper cable in accordance with the manufacturers requirements. Wiring for fire alarm dc circuits shall be No. 14 AWG minimum. Voltages shall not be mixed in any junction box, housing, or device, except those containing power supplies and control relays. Wiring shall conform to NFPA 70. System field wiring shall be solid copper and installed in metallic conduit or electrical metallic tubing, except that rigid plastic conduit may be used under slab-on-grade. Conductors shall be color coded. Conductors used for the same functions shall be similarly color coded. Wiring code color shall remain uniform throughout the circuit. Pigtail or T-tap connections to initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited. T-tapping using screw terminal blocks is allowed for style 5 addressable systems.

2.7.3 Special Tools and Spare Parts

Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment shall be furnished to the Contracting Officer. Two spare fuses of each type and size required shall be furnished. Two percent of the total number of each different type of detector, but no less than two each, shall be furnished. Spare fuses shall be mounted in the fire alarm panel.

2.8 TRANSMITTERS

2.8.1 Radio Alarm Transmitters

Transmitters shall be compatible with proprietary supervising station receiving equipment. Each radio alarm transmitter shall be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters shall be provided in accordance with applicable portions of NFPA 72, NFPA 1221, and 47 CFR 15. Transmitter electronics module shall be contained within the physical housing as an integral, removable assembly. The proprietary supervising station receiving equipment is Monaco D-21, BT-XM Building Transceiver and the transceiver shall be fully compatible with this equipment. Transmitter transmitting zones shall be as specified in supara Alarm Functions of this section. Provide 12 spare zones in transmitter for future use. Install building transceiver BT-XM

only if the Supervising station has followed through with the upgrade of D-21; otherwise, notify the COR for further instructions. Provide adequate zones in the transmitter to transmit one trouble signal from the module detectors (one per floor) and another trouble signal to report trouble from all other devices.

2.8.1.1 Transmitter Power Supply

Each radio alarm transmitter shall be powered by a combination of locally available 120-volt ac power and a sealed, lead-calcium battery.

a. Operation: Each transmitter shall operate from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter shall automatically switch to battery operation. Switchover shall be accomplished with no interruption of protective service, and shall automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall also be automatic.

b. Battery Power: Transmitter standby battery capacity shall provide sufficient power to operate the transmitter in a normal standby status for a minimum of 72 hours and be capable of transmitting alarms during that period.

2.8.1.2 Radio Alarm Transmitter Housing

Transmitter housing shall be NEMA Type 1. The housing shall contain a lock that is keyed identical to the fire alarm system for the building. Radio alarm transmitter housing shall be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

2.8.1.3 Antenna

The Contractor shall provide omnidirectional, coaxial, halfwave dipole antennas for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts shall be corrosion resistant and designed to withstand wind velocities of Antennas shall not be mounted to any portion of the building roofing system.

PART 3 EXECUTION

3.1 INSTALLATION

All work shall be installed as shown, and in accordance with NFPA 70 and NFPA 72, and in accordance with the manufacturer's diagrams and recommendations, unless otherwise specified. Smoke detectors shall not be installed until construction is essentially complete and the building has been thoroughly cleaned.

3.1.1 Power Supply for the System

A single dedicated circuit connection for supplying power from a branch circuit to each building fire alarm system shall be provided. The power shall be supplied as shown on the drawings. The power supply shall be equipped with a locking mechanism and marked in red with the words "FIRE ALARM CIRCUIT CONTROL".

3.1.2 Wiring

Conduit size for wiring shall be in accordance with NFPA 70, and the minimum size shall be 1/2 inch. Wiring for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting and power systems. Not more than two conductors shall be installed under any device screw terminal. The wires under the screw terminal shall be straight when placed under the terminal then clamped in place under the screw terminal. The wires shall be broken and not twisted around the terminal. Circuit conductors entering or leaving any mounting box, outlet box enclosure, or cabinet shall be connected to screw terminals with each terminal and conductor marked in accordance with the

wiring diagram. Connections and splices shall be made using screw terminal blocks. The use of wire nut type connectors in the system is prohibited. Wiring within any control equipment shall be readily accessible without removing any component parts. The fire alarm equipment manufacturer's representative shall be present for the connection of wiring to the control panel.

3.1.3 Control Panel

The control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than nor more than above the finished floor. Manually operable controls shall be between above the finished floor. Panel shall be installed to comply with the requirements of UL 864.

3.1.4 Detectors

Detectors shall be located and installed in accordance with NFPA 72. Detectors shall be connected into signal line circuits or initiating device circuits as indicated on the drawings. Detectors shall be at least from any part of any lighting fixture. Detectors shall be located at least from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location. Detectors which mount in open space shall be mounted directly to the end of the stubbed down rigid conduit drop. Conduit drops shall be firmly secured to minimize detector sway. Where length of conduit drop from ceiling or wall surface exceeds sway bracing shall be provided. Contractor shall coordinate smoke detector sensitivities with COR. Contractor should adjust the system and if required, make further adjustments during construction until final acceptance. Indicated detector shall be provided with an audible base that is connected to the notification appliance circuit. This system shall be capable of individually commanding the audible bases to sound without sounding the other notification appliances. The audible base shall be capable of producing 85dBA at 10 feet. Smoke detectors in living unit shall be rated for 1200 ft per minute of air movement.

3.1.5 Notification Appliances

Notification appliances shall be mounted above the finished floor or below the ceiling, whichever is lower.

3.1.6 Annunciator Equipment

Annunciator equipment shall be mounted where indicated on the drawings.

3.1.7 Addressable Initiating Device Circuits Module

The initiating device circuits module shall be used to connect supervised conventional initiating devices (water flow switches, water pressure switches, manual fire alarm stations, high/low air pressure switches, and tamper switches).

The module shall mount in an electrical box adjacent to or connected to the device it is monitoring and shall be capable of Style B supervised wiring to the initiating device. In order to maintain proper supervision, there shall be no T-taps allowed on style B lines. Addressable initiating device circuits modules shall monitor only one initiating device each. Contacts in suppression systems and other fire protection subsystems shall be connected to the fire alarm system to perform supervisory and alarm functions as specified in NFPA 72, as indicated on the drawings and as specified herein.

3.1.8 Addressable Control Module

Addressable and control modules shall be installed in the outlet box or adjacent to the device they are controlling. If a supplementary suppression releasing panel is provided, then the monitor modules shall be mounted in a common enclosure adjacent to the suppression releasing panel and both this enclosure and the suppression releasing panel shall be in the same room as the releasing

devices. All interconnecting wires shall be supervised unless an open circuit or short circuit abnormal condition does not affect the required operation of the fire alarm system. If control modules are used as interfaces to other systems, such as HVAC or elevator control, they shall be within the control panel or immediately adjacent to it. Control modules that control a group of notification appliances shall be adjacent to the first notification appliance in the notification appliance circuits. Control modules that connect to devices shall supervise the notification appliance circuits. Control modules that connect to auxiliary systems or interface with other systems (non-life safety systems) and where not required by NFPA 72, shall not require the secondary circuits to be supervised. Contacts in suppression systems and other fire protection subsystems shall be connected to the fire alarm system to perform required alarm functions as specified in NFPA 72, as indicated on the drawings and as specified herein.

3.2 OVERVOLTAGE AND SURGE PROTECTION

3.2.1 Power Line Surge Protection

All equipment connected to alternating current circuits shall be protected from surges per IEEE C62.41 B3 combination waveform and NFPA 70. Fuses shall not be used for surge protection. The surge protector shall be rated for a maximum let thru voltage of 350 Volts ac (line-to-neutral) and 350 Volt ac (neutral-to-ground).

3.2.2 Low Voltage DC Circuits Surge Protection

All IDC, NAC, and communication cables/conductors, except fiber optics, shall have surge protection installed at each point where it exits or enters a building. Equipment shall be protected from surges per IEEE C62.41 B3 combination waveform and NFPA 70. The surge protector shall be rated to protect the 24 Volt dc equipment. The maximum dc clamping voltages shall be 36 V (line-to-ground) and 72 Volt dc (line-to-line).

3.2.3 Signal Line Circuit Surge Protection

All SLC cables/conductors, except fiber optics, shall have surge protection/isolation circuits installed at each point where it exits or enters a building. The circuit shall be protected from surges per IEEE C62.41 B3 combination waveform and NFPA 70. The surge protector/isolator shall be rated to protect the equipment.

3.3 GROUNDING

Grounding shall be provided by connecting to building ground system.

3.4 TESTING

The Contractor shall notify the Contracting Officer at least 10 days before the preliminary and acceptance tests are to be conducted. The tests shall be performed in accordance with the approved test procedures in the presence of the Contracting Officer. The control panel manufacturer's representative shall be present to supervise tests. The Contractor shall furnish instruments and personnel required for the tests.

3.4.1 Preliminary Tests

Upon completion of the installation, the system shall be subjected to functional and operational performance tests including tests of each installed initiating and notification appliance, when required. Tests shall include the meggering of system conductors to determine that the system is free from grounded, shorted, or open circuits. The megger test shall be conducted prior to the installation of fire alarm equipment. If deficiencies are found, corrections shall be made and the system shall be retested to assure that it is functional. After completing

the preliminary testing the Contractor shall complete and submit the NFPA 72, Certificate of Completion.

3.4.2 Acceptance Test

Acceptance testing shall not be performed until the Contractor has completed and submitted the Certificate of Completion. Testing shall be in accordance with NFPA 72. The recommended tests in NFPA 72 shall be considered mandatory and shall verify that previous deficiencies have been corrected. The Contractor shall complete and submit the NFPA 72, Inspection and Testing Form. The test shall include all requirements of NFPA 72 and the following:

- a. Test of each function of the control panel.
- b. Test of each circuit in both trouble and normal modes.
- c. Tests of each alarm initiating devices in both normal and trouble conditions.
- d. Tests of each control circuit and device.
- e. Tests of each alarm notification appliance.
- f. Tests of the battery charger and batteries.
- g. Complete operational tests under emergency power supply.
- h. Visual inspection of wiring connections.
- i. Opening the circuit at each alarm initiating device and notification appliance to test the wiring supervisory feature.
- j. Ground fault
- k. Short circuit faults
- l. Stray voltage
- m. Loop resistance

3.5 TRAINING

Training course shall be provided for the operations and maintenance staff. The course shall be conducted in the building where the system is installed or as designated by the Contracting Officer. The training period for systems operation & MAINTENANCE shall consist of 1 training days (8 hours per day) and shall start after the system is functionally completed but prior to final acceptance tests.

The instructions shall cover items contained in the operating and maintenance instructions. In addition, training shall be provided on performance of expansions or modifications to the fire detection and alarm system.

-- End of Section --

SECTION 15951A

DIRECT DIGITAL CONTROL FOR HVAC

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 500 (11989; Rev994) Test Methods for Louvers, Dampers and Shutters

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (1995) Code for Electricity Metering

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 269 (1996) Seamless and Welded Austenitic Stainless Steel Tubing for General Service

ASTM B 88 (1996) Seamless Copper Water Tube

ASTM B 88M (1996) Seamless Copper Water Tube (Metric)

ASTM D 1693 (1997a) Environmental Stress-Cracking of Ethylene Plastics

ASTM D 635 (1997) Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

ASME INTERNATIONAL (ASME)

ASME B40.1 (1991) Gauges - Pressure Indicating Dial Type - Elastic Element

ASME BPVC SEC VIII D1 (1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA ANSI/EIA/TIA-232-F (1991) Interface Between Data Technical Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41 (1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits

IEEE Std 142 (1991) IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems

INSTRUMENT SOCIETY OF AMERICA (ISA)

| | |
|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| ISA S7.0.01 | (1996) Quality Standard for Instrument Air |
| NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA) | |
| NEMA 250 | (1991) Enclosures for Electrical Equipment (1000 Volts Maximum) |
| NEMA ICS 1 | (1993) Industrial Control and Systems |
| NEMA ST 1 | (1988) Specialty Transformers (Except General-Purpose Type) |
| NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) | |
| NFPA 90A | (1996) Installation of Air Conditioning and Ventilating Systems |
| UNDERWRITERS LABORATORIES (UL) | |
| UL 268A | (1998) Smoke Detectors for Duct Application |
| UL 508 | (1993; Rev thru Oct 1997) Industrial Control Equipment |
| UL 94 | (1996; Rev thru Jul 1998) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances |

1.2 GENERAL REQUIREMENTS

The direct digital control (DDC) shall be a complete system suitable for the heating, ventilating and air-conditioning (HVAC) system. The DDC system shall be a complete control system consisting of a building automation system and an automatic temperature control system suitable for the HVAC system. The direct digital control system shall be connected to the existing Johnson Controls Metasys System (EMCS) at Fort Riley that has been accepted as an approved interface by the Contracting Officer. All controls added under this project shall be connected to a global network control unit located as shown, and shall communicate to the basewide EMCS via the LAN serving the base. The system shall demonstrate 100% capability to remotely control and respond to all panels, sensors and actuators via graphical display. The contractor shall supply all materials required and software generation necessary to enable the DDC to communicate with the Fort Riley EMCS engineering control station located in building 364. The system shall be capable of downloading new software updates and programs, uploading of setpoints, and optimization analysis and reporting all from the building 364 control station. Fort Riley will supply the necessary LAN drops and IP addresses. The Contractor shall generate all software and install all hardware required to connect the new facilities to the existing EMCS. The Contractor shall update all EMCS workstation networks with all the new 7800 and 7400 area buildings. At the completion of the project, the contractor shall load all new building software onto the archive workstation. System shall be able to automatically download the new buildings in the event that the software programs are lost or corrupt. Also, at the project completion, the existing Metasys web access software shall be updated with all new building information as required for remote access via web browser.

1.2.1 Dynamic Color Graphic Displays

Color graphic floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, shall be generated to optimize system performance analysis

and speed alarm recognition. the existing operator interface workstation located in Building 364 shall be utilized for operator interface.

1.2.1 Nameplates, Lens Caps, and Tags

Nameplates and lens caps bearing legends and tags bearing device-unique identifiers as shown shall have engraved or stamped characters. A plastic or metal tag shall be mechanically attached directly to each device or attached by a metal chain or wire. Each airflow measurement station shall have a tag showing flow rate range for signal output range, duct size, and identifier as shown.

1.2.2 Verification of Dimensions

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

1.2.3 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall furnish all work necessary to meet such conditions.

1.2.4 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected from power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

1.2.5 Surge Protection for Transmitter and Control Wiring

DDC system control-panel equipment shall be protected against surges induced on control and transmitter wiring installed outside. The equipment protection shall be tested in the normal mode and in the common mode, using the following two waveforms:

a. A 10-microsecond by 1,000-microsecond waveform with a peak voltage of 1,500 volts and a peak current of 60 amperes.

b. An eight microsecond by 20-microsecond waveform with a peak voltage of 1,000 volts and a peak current of 500 amperes.

1.2.6 System Overall Reliability Requirement

The system shall be configured and installed to yield a mean time between failure (MTBF) of at least 40,000 hours. Each DDC controller shall be designed, configured, installed and programmed to provide for stand alone operation with minimal performance degradation on failure of other system components to which it is connected or with which it communicates.

1.2.7 DDC System Network Accessibility

Where the systems to be controlled by the DDC system are located in multiple mechanical rooms, each mechanical room shall have at least one communication port for the portable workstation/tester. DDC controllers shall be located in the same room as the equipment being controlled or in an adjacent space which has direct access to the equipment room.

1.2.8 System Accuracy and Display

The system shall maintain an end-to-end accuracy for one year from sensor to

operator's console display for the applications specified and shall display the value as specified. Each temperature shall be displayed and printed to nearest 0.05 degree C.

1.2.8.1 Space Temperature

Space temperature with a range of 10 to 30 degrees C plus or minus 0.5 degrees C for conditioned space; minus 1 to plus 55 degrees C plus or minus 0.5 degrees C for unconditioned space.

1.2.8.2 Duct Temperature

Duct temperature with a range of 5 to 60 degrees C plus or minus 1 degree C.

1.2.8.3 Outside Air Temperature

Outside air (OA) temperature with a range of minus 35 to plus 55 degrees C plus or minus 1 degree C; with a subrange of minus 1 to plus 40 degrees C plus or minus 0.5 degree C.

1.2.8.4 Water Temperature

Water temperature with a range of minus 1 to plus 40 degrees C plus or minus 0.5 degree C; the range of 40 to 120 degrees C plus or minus 1 degree C; and water temperatures for the purpose of performing energy calculations using differential temperatures to plus or minus 0.5 degree C using matched sensors.

1.2.8.5 High Temperature

High temperature with a range of 100 to 260 degrees C plus or minus 1 degree C.

1.2.8.6 Relative Humidity

Relative humidity, within a range of 20 to 80 percent, plus or minus 6.0 percent of range (display and print to nearest 1.0 percent).

1.2.8.7 Pressure

Pressure with a range for the specific application plus or minus 2.0 percent of range (display and print to nearest kPa.)

1.2.8.8 Flow

Flow with a range for the specific application plus or minus 3.0 percent of range, and flows for the purpose of thermal calculations to plus or minus 2.0 percent of actual flow (display and print to nearest unit, such as liters per second).

1.2.8.9 KWh and kW Demand

KWh and kW demand with a range for the specific application plus or minus 1.0 percent of reading (display and print to nearest kWh or kW).

1.2.8.10 Analog Value Input

An analog value input to the system's equipment via an AI with a maximum error of 0.50 percent of range, not including the sensor or transmitter error. This accuracy shall be maintained over the specified environmental conditions.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals

not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. All items designated with a G, DF, including product literature, calculations, component data, certificates, diagrams and drawings, shall be submitted concurrently in one complete system submittal. Omission of any required submittal item from the package shall be sufficient cause for disapproval of the entire submittal. Unless otherwise indicated in the submittal review commentary, disapproval of any item within the package shall require a re-submittal of the entire system package, in which all deficiencies shall be corrected. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

HVAC Control System; G, DF.

Drawings shall be on A1 (841 by 594 mm) sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control system element on a drawing shall have a unique identifier as shown. The HVAC Control System Drawings shall be delivered together as a complete submittal. Deviations must be approved by the Contracting Officer. Drawings shall be submitted along with Submittal SD-01, Data.

a. HVAC Control System Drawings shall include the following:

Sheet One: Drawing Index, HVAC Control System Legend.
 Sheet Two: Valve Schedule, Damper Schedule.
 Sheet Three: Compressed Air Station Schematic.
 Sheet Four: Control System Schematic and Equipment Schedule.
 Sheet Five: Sequence of Operation and Data Terminal Strip Layout.
 Sheet Six: Control Loop Wiring Diagrams.
 Sheet Seven: Motor Starter and Relay Wiring Diagram.
 Sheet Eight: Communication Network and Block Diagram.
 Sheet Nine: DDC Panel Installation and Block Diagram.

(Repeat Sheets Four through Seven for each AHU System.)

b. The HVAC Control System Drawing Index shall show the name and number of the building, military site, State or other similar designation, and Country. The Drawing Index shall list HVAC Control System Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The HVAC Control System Legend shall show generic symbols and the name of devices shown on the HVAC Control System Drawings.

c. The valve schedule shall include each valve's unique identifier, size, flow coefficient K_v , pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure data, dimensions, and access and clearance requirements data. Valve schedules may be submitted in advance but shall be included in the complete submittal.

d. The damper schedule shall contain each damper's and each actuator's identifier, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, spring ranges, operation rate, positive positioner ranges, locations of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The Damper Schedule shall include the maximum leakage rate at the operating static-pressure differential. The Damper Schedule shall contain actuator selection data supported by calculations of the torque required to move and seal the dampers, access and clearance requirements. Damper schedules may be

submitted in advance but shall be included in the complete submittal.

e. The compressed air station schematic diagram shall show all equipment, including: compressor with motor horsepower and voltage; starter; isolators; manual bypasses; tubing sizes; drain piping and drain traps; reducing valves; dryer; and data on manufacturer's names and model numbers, mounting, access, and clearance requirements. Air Compressor and air dryer data shall include calculations of the air consumption of all current-to-pneumatic transducers and of any other control system devices to be connected to the compressed air station, and the compressed air supply dewpoint temperature at 140 kPa . Compressed air station schematic drawings shall be submitted for each compressed air station.

f. The HVAC control system schematics shall be in the form shown, and shall show all control and mechanical devices associated with the HVAC system. A system schematic drawing shall be submitted for each HVAC system.

g. The HVAC control system equipment Schedule shall be in the form shown. All devices shown on the drawings having unique identifiers shall be referenced in the equipment schedule. Information to be included in the equipment schedule shall be the control loop, device unique identifier, device function, setpoint, input range, and additional important parameters (i.e., output range). An equipment schedule shall be submitted for each HVAC system.

h. The HVAC control system sequence of operation shall reflect the language and format of this specification, and shall refer to the devices by their unique identifiers as shown. No operational deviations from specified sequences will be permitted without prior written approval of the Contracting Officer. Sequences of operation shall be submitted for each HVAC control system including each type of terminal unit control system.

i. The HVAC control system wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to HVAC control panel terminal blocks and to the identified terminals of devices, starters and package equipment. The wiring diagrams shall show necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for HVAC control systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, HVAC system control panel, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring diagrams shall be submitted for each HVAC control system.

SD-03 Product Data

Surge Protection;G, DF.

Regulated Power Supplies;G, DF.

Power Line Conditioners;G, DF.

Wiring;G, DF.

Valve Actuators and positive positioners;G, DF.

Damper Actuators and positive positioners;G, DF.

Control Valves;G, DF.

Control Dampers;G, DF.

Temperature Switches;G, DF.

Temperature and Pressure Instruments;G, DF.

Thermostats;G, DF.

Thermometers and Gauges;G, DF.

DDC Control Panels and Accessories;G, DF.

Relays;G, DF.

Tubing;G, DF.

Compressed Air Station;G, DF.

Compressed Air Station Specialities;G, DF.

IP Transducers;G, DF.

Manual Switches;G, DF.

Equipment Compliance Booklet; G, DF.

Dynamic Color Graphic Display Layout Proposals; G, DF.

Input Output (I/O) Summary Tables; G, DF.

The HVAC Control System Equipment Compliance Booklet (ECB) shall be in booklet form and indexed, with numbered tabs separating the information on each device. It shall consist of, but not be limited to, data sheets and catalog cuts which document compliance of all devices and components with the specifications. The ECB shall be indexed in alphabetical order by the unique identifiers. Devices and components which do not have unique identifiers shall follow the devices and components with unique identifiers and shall be indexed in alphabetical order according to their functional name. The ECB shall include a Bill of Materials for each HVAC Control System. The Bill of Materials shall function as the Table of Contents for the ECB and shall include the device's unique identifier, device function, manufacturer, model/part/catalog number used for ordering, and tab number where the device information is located in the ECB. The ECB shall be submitted along with Submittal SD-04, Drawings.

Service Organizations; G, RE

Six copies of a list of service organizations qualified to service the HVAC control system. The list shall include the service organization name, address, technical point of contact and telephone number, and contractual point of contact and telephone number.

Commissioning Procedures; G, DF

Six copies of the HVAC control system commissioning procedures, in booklet form and indexed, 60 days prior to the scheduled start of commissioning. Commissioning procedures shall be provided for each HVAC control system, and for each type of terminal unit control system. The Commissioning procedures shall reflect the format and language of this specification, and refer to devices by their unique identifiers as shown. The Commissioning procedures shall be specific for each HVAC

system, and shall give detailed step-by-step procedures for commissioning of the system.

a. The Commissioning procedures shall include detailed, product specific set-up procedures, configuration procedures, adjustment procedures, and calibration procedures for each device. Where the detailed product specific commissioning procedures are included in manufacturer supplied manuals, reference may be made in the HVAC control system commissioning procedures to the manuals.

b. An HVAC control system commissioning procedures equipment list shall be included that lists the equipment to be used to accomplish commissioning. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Performance Verification Test Procedures; G, RE.

Six copies of the HVAC Control System Performance Verification Test Procedures, in booklet form and indexed, 60 days before the Contractor's scheduled test dates. The performance verification test procedures shall refer to the devices by their unique identifiers as shown, shall explain, step-by-step, the actions and expected results that will demonstrate that the HVAC control system performs in accordance with the sequences of operation, and other contract documents. An HVAC control system performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Training; G, RE.

An outline for the HVAC control system training course with a proposed time schedule. Approval of the planned training schedule shall be obtained from the Government at least 60 days prior to the start of the training. Six copies of HVAC control system training course material 30 days prior to the scheduled start of the training course. The training course material shall include the operation manual, maintenance and repair manual, and paper copies of overheads used in the course.

SD-06 Test Reports

Commissioning Report; G, DF.

Six copies of the HVAC Control System Commissioning Report, in booklet form and indexed, within 30 days after completion of the system commissioning. The commissioning report shall include data collected during the HVAC control system commissioning procedures and shall follow the format of the commissioning procedures. The commissioning report shall include all configuration checksheets with final values listed for all parameters, setpoints, P, I, D setting constants, calibration data for all devices, results of adjustments, and results of testing.

Performance Verification Test; G, RE.

Six copies of the HVAC Control System Performance Verification Test Report, in booklet form and indexed, within 30 days after completion of the test. The HVAC control system performance verification test report shall include data collected during the HVAC control system performance verification test. The original copies of all data gathered during the performance verification test shall be turned over to the Government after Government approval of the test results.

SD-07 Certificates

Air Storage Tank; G, RE.

An ASME Air Storage Tank Certificate for each storage tank.

SD-10 Operation and Maintenance Data.

Operation Manual; G, RE.

Maintenance and Repair Manual; G, RE.

Six copies of the HVAC Control System Operation Manual and HVAC Control System Maintenance and Repair Manual, for each HVAC control system, 30 days before the date scheduled for the training course.

1.4 DELIVERY AND STORAGE

Products shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer. Dampers shall be stored so that seal integrity, blade alignment and frame alignment are maintained.

1.4 OPERATION MANUAL

An HVAC control system operation manual in indexed booklet form shall be provided for each HVAC control system. The operation manual shall include the HVAC control system sequence of operation, and procedures for the HVAC system start-up, operation and shut-down. The operation manual shall include as-built HVAC control system detail drawings. The operation manual shall include the as-built configuration checksheets, the procedures for changing HVAC control system setpoints, and the procedures for placing HVAC system controllers in the manual control mode.

a. The procedures for changing HVAC control system setpoints shall describe the step-by-step procedures required to change the process variable setpoints, the alarm setpoints, the bias settings, and setpoint reset schedules.

b. The procedures for placing HVAC system controllers in the manual control mode shall describe step-by-step procedures required to obtain manual control of each controlled device and to manually adjust their positions.

1.5 MAINTENANCE AND REPAIR MANUAL

An HVAC control system maintenance and repair manual in indexed booklet form in hardback binders shall be provided for each HVAC control system. The maintenance and repair manual shall include the routine maintenance checklist, a recommended repair methods list, a list of recommended maintenance and repair tools, the qualified service organization list, the as-built commissioning procedures and report, the as-built performance verification test procedures and report, and the as-built equipment data booklet.

a. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all devices listed in the equipment compliance booklet, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

b. The recommended repair methods list shall be arranged in a columnar format and shall list all devices in the equipment data compliance booklet and state the guidance on recommended repair methods, either field repair, factory repair, or whole-item replacement.

c. The as-built equipment data booklet shall include the equipment compliance booklet and manufacturer supplied user manuals and information.

d. If the operation manual and the maintenance and repair manual are provided in a common volume, they shall be clearly differentiated and separately indexed.

1.6 MAINTENANCE AND SERVICE

Services, materials and equipment shall be provided as necessary to maintain the entire system in an operational state as specified for a period of one year after successful completion and acceptance of the Performance Verification Test. Impacts on facility operations shall be minimized.

1.6.1 Description of Work

The adjustment and repair of the system shall include the manufacturer's required adjustments of computer equipment, software updates, transmission equipment and instrumentation and control devices.

1.6.2 Personnel

Service personnel shall be qualified to accomplish work promptly and satisfactorily. The Government shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

1.6.3 Scheduled Inspections

Two inspections shall be performed at six-month intervals and all work required shall be performed. Inspections shall be scheduled in June and December. These inspections shall include:

- a. Visual checks and operational tests of equipment.
- b. Fan checks and filter changes for control system equipment.
- c. Clean control system equipment including interior and exterior surfaces.
- d. Check and calibrate each field device. Check and calibrate 50 percent of the total analog points during the first inspection. Check and calibrate the remaining 50 percent of the analog points during the second major inspection. Certify analog test instrumentation accuracy to be twice that of the device being calibrated. Randomly check at least 25 percent of all digital points for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital points during the second inspection.
- e. Run system software diagnostics and correct diagnosed problems.
- f. Resolve any previous outstanding problems.

1.6.4 Scheduled Work

This work shall be performed during regular working hours, Monday through Friday, excluding legal holidays.

1.6.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the system. A telephone number where the service supervisor can be reached at all times shall be provided. Service personnel shall be at the site within 4 hours after receiving a request for service. The control system shall be restored to

proper operating condition within 1 calendar day or 8 hours.

1.6.6 Operation

Scheduled adjustments and repairs shall include verification of the control system operation as demonstrated by the applicable tests of the performance verification test.

1.6.7 Records and Logs

Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

1.6.8 Work Requests

Each service call request shall be recorded as received and shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

1.6.9 System Modifications

Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

1.6.10 Software

Updates to the software shall be provided for system, operating and application software, and operation in the system shall be verified. Updates shall be incorporated into operations and maintenance manuals, and software documentation. There shall be at least one scheduled update near the end of the first year's warranty period, at which time the latest released version of the Contractor's software shall be installed and validated.

1.7 FACTORY TESTING

The Contractor shall assemble the factory test DDC system as specified and shall perform test to demonstrate that the performance of the system satisfies the requirements of this specification. Model numbers of equipment tested shall be identical to those to be delivered to the site. Original copies of data produced, including results of each test procedure during factory testing shall be delivered to the Government at the conclusion of testing, prior to Government approval of the test. The test results documentation shall be arranged so that commands, responses, and data acquired are correlated in a manner which will allow for logical interpretation of the data.

1.7.1 Factory Test Setup

The factory test setup shall include the following:

- a. Central workstation/tester.
- b. Printer.

- c. DDC test set.
- d. Portable workstation/tester.
- e. Communication links of each type and speed including MODEMS.
- f. Dial-up MODEM.
- g. Software.

PART 2 PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two years' use shall include applications of equipment and materials under similar circumstances and of similar size. The two years' experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6,000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components. Automatic temperature controls shall be direct digital controls that will provide the required sequence of operation.

2.1.1 Electrical and Electronic Devices

Electrical, electronic, and electropneumatic devices not located within a DDC panel shall have a NEMA ICS 1 enclosure in accordance with NEMA 250 unless otherwise shown.

2.1.2 Standard Signals

The output of all analog transmitters and the analog input and output of all DDC controllers shall manufacturer's standard signals (voltage or current).

2.1.3 Ambient Temperature Limits

DDC panels shall have ambient condition ratings of 1.7 to 49 degrees C and 10 to 95 percent relative humidity, noncondensing. Devices installed outdoors shall operate within limit ratings of minus 37 to plus 66 degrees C. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

2.1.4 Year 2000 Compliance

All equipment and software shall be Year 2000 compliant and shall be able to accurately process date/time data (including, but not limited to, calculating, comparing, and sequencing) from, into, and between the twentieth and twenty-first centuries, including leap year calculations, when used in accordance with the product documentation provided by the contractor, provided that all products (e.g. hardware, software, firmware) used in combination with other information technology, shall accurately process date/time data if other information

technology properly exchanges date/time data with it.

2.2 TUBING

2.2.1 Copper

Copper tubing shall conform to ASTM B 88, ASTM B 88M and shall have sweat fittings and valves.

2.2.2 Stainless Steel

Stainless steel tubing shall conform to ASTM A 269 and shall have stainless steel compression fittings.

2.2.3 Plastic

Plastic tubing shall have barbed fittings and valves. Plastic tubing shall have the burning characteristics of linear low-density polyethylene tubing, shall be self-extinguishing when tested in accordance with ASTM D 635, shall have UL 94 V-2 flammability classification, and shall withstand stress cracking when tested in accordance with ASTM D 1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

2.3 WIRING

2.3.1 Terminal Blocks

Terminal blocks shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

2.3.2 Control Wiring for 24-Volt Circuits

Control wiring for 24-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 300-volt service.

2.3.3 Wiring for 120-Volt Circuits

Wiring for 120-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 600-volt service.

2.3.4 Instrumentation Cable

Instrumentation cable shall be 18 AWG, stranded copper, single- or multiple-twisted, minimum 50 mm lay of twist, 100 percent shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.3.5 Transformers

Step down transformers shall be utilized where control equipment operates at lower than line circuit voltage. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Transformer shall be sized so that the connected load is 80 percent of the rated capacity or less. Transformers shall conform to UL 508 and NEMA ST 1.

2.4 ACTUATORS

Actuators shall be pneumatic for air handling unit control valves, zone dampers

and control dampers (OA, RA, and MA). Electric actuators may be utilized for VAV terminal unit valves, exhaust fan dampers, and for fan coil units valves. Electric damper actuators shall directly mount on the damper shaft without linkages and shall have sufficient torque for the application. Actuators shall be provided with mounting and connecting hardware. Actuators shall fail to their spring-return positions on signal or power failure, except that VAV terminal unit volume damper actuators may be of the floating type. The actuator stroke shall be limited in the direction of power stroke by an adjustable stop. Actuators shall have a visible position indicator. Actuators shall smoothly open or close the devices to which they are applied and shall have a full stroke response time of 90 seconds or less. Electric actuators shall have an oil-immersed gear train. Electric or electronic actuators operating in series shall have an auxiliary actuator driver. Electric or electronic actuators used in sequencing applications shall have an adjustable operating range and start point. Pneumatic actuators shall be rated for 172 kPa operating pressure except for high-pressure cylinder-type actuators.

2.4.1 Valve Actuators

Valve actuators shall be selected to provide a minimum of 125 percent of the motive power necessary to operate the valve over its full range of operation.

2.4.2 Positive Positioners

Positive positioners are required for pneumatic actuators except for multizone zone control dampers. Each positive positioner shall be a pneumatic relay with a mechanical feedback mechanism and an adjustable operating range and starting point.

2.5 AUTOMATIC CONTROL VALVES

Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Unless otherwise stated, valves shall have globe style bodies. Valve bodies shall be designed for not less than 862 kPa working pressure or 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be 0.01 percent of rated Kv. Unless otherwise specified, bodies for valves 40 mm and smaller shall be brass or bronze, with threaded or union ends; bodies for 50 mm valves shall have threaded ends; and bodies for valves 50 to 80 mm shall be of brass, bronze or iron. Bodies for valves 65 mm and larger shall be provided with flanged-end connections. Valve Kv shall be within 100 to 125 percent of the Kv shown.

2.5.1 Butterfly Valve Assembly

Butterfly valves shall be threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies and noncorrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from minus 29 to plus 121 degrees C. Valves shall have a manual means of operation independent of the actuator. The rated Kv for butterfly valves shall be the value Kv at 70% open (60 degrees open).

2.5.2 Two-Way Valves

Two-way modulating valves shall have equal-percentage characteristics.

2.5.3 Three-Way Valves

Three-way valves shall provide linear flow control with constant total flow throughout full plug travel.

2.5.4 Duct-Coil and Terminal-Unit-Coil Valves

Control valves with either flare-type or solder-type ends shall be provided for

duct or terminal-unit coils. Flare nuts shall be furnished for each flare-type end valve.

2.5.5 Valves for Chilled-Water Service

Internal valve trim shall be bronze except that valve stems may be type 316 stainless steel. Valve Kv shall be within 100 to 125 percent of the Kv shown. Valves 100 mm and larger shall be butterfly.

2.5.6 Valves for Hot-Water Service

For hot water service below 122 degrees C and dual-temperature service, internal trim (including seats, seat rings, modulating plugs, and springs) of valves controlling water hotter than 99 degrees C shall be Type 316 stainless steel. Internal trim for valves controlling water 99 degrees C or less shall be brass or bronze. Nonmetallic parts of hot-water control valves shall be suitable for a minimum continuous operating temperature of 121 degrees C or 28 degrees C above the system design temperature, whichever is higher. Valves 100 mm and larger shall be butterfly valves.

2.6 DAMPERS

2.6.1 Damper Assembly

A single damper section shall have blades no longer than 1.2 meters and shall be no higher than 1.8 meters. Maximum damper blade width shall be 203 mm. Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section shall not be located directly in the air stream. Damper axles shall be 13 mm minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 10 Pa at 5.1 m/s in the wide-open position. Frames shall not be less than 50 mm in width. Dampers shall be tested in accordance with AMCA 500.

2.6.2 Operating Links

Operating links external to dampers, such as crankarms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least twice the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crankarms shall control the open and closed positions of dampers.

2.6.3 Damper Types

Dampers shall be parallel-blade type.

2.6.3.1 Outside Air, Return Air, and Relief Air Dampers

Outside air, return air and relief air dampers shall be provided where shown. Blades shall have an airfoil shape with interlocking edges and shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Dampers shall not leak in excess of 36 L/s per square meter at 1000 Pa static pressure when closed. Seals shall be suitable for an operating temperature range of minus 40 to plus 94 degrees C. Dampers shall be rated at not less than 10 m/s air velocity.

2.6.3.2 Mechanical and Electrical Space Ventilation Dampers

Mechanical and electrical space ventilation dampers shall be as shown. Dampers shall not leak in excess of 102 L/s per square meter at 1000 Pa static pressure when closed. Dampers shall be rated at not less than 7.6 m/s air velocity.

2.6.4 Damper End Switches

Each end switch shall be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

2.7 SMOKE DETECTORS

Duct smoke detectors shall be provided in supply and return air ducts in accordance with NFPA 90A. Duct smoke detectors shall conform to the requirements of UL 268A. Duct smoke detectors shall have perforated sampling tubes extended into the air duct. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. Detectors shall have manual reset. Detectors shall be rated for air velocities that include air flows between 2.5 and 20 m/s. Detectors shall be powered from the fire alarm control panel (FACP). Detectors shall have two sets of normally open alarm contacts and two sets of normally closed alarm contacts. Detectors shall be connected to the building fire alarm panel for alarm initiation. A remote annunciation lamp and accessible remote reset switch shall be provided for duct detectors that are mounted eight feet or more above the finished floor and for detectors that are not readily visible. Remote lamps and switches as well as the affected fan units shall be properly identified in etched rigid plastic placards. Coordinate the requirements of duct detectors with the Fire Alarm System manufacturer for compatibility.

2.8 INSTRUMENTATION

2.8.1 Measurements

Transmitters shall be calibrated to provide the following measurements, over the indicated ranges, for an output of 4 to 20 mA_{dc}:

- a. Conditioned space temperature, from 10 to 30 degrees C .
- b. Duct temperature, from 5 to 60 degrees C .
- c. High-temperature hot-water temperature, from 94 to 260 degrees C .
- d. Chilled-water temperature, from minus 1 to plus 38 degrees C .
- e. Dual-temperature water, from minus 1 to plus 116 degrees C .
- f. Heating hot-water temperature, from 10 to 121 degrees C .
- g. Condenser-water temperature, from minus 1 to plus 55 degrees C .
- h. Outside-air temperature, from minus 35 to plus 55 degrees C .
- i. Relative humidity, 0 to 100 percent for space and duct high-limit applications.
- j. Differential pressure for VAV supply-duct static pressure from 0 to 500 Pa .
- k. Pitot-tube air-flow measurement station and transmitter, from 0 to 25 Pa for flow velocities of 3.5 to 6 m/s , 0 to 60 Pa for velocities of 3.5 to 9 m/s , or 0 to 125 Pa for velocities of 3.5 to 13 m/s .

1. Electronic air-flow measurement station and transmitter, from 0.6 to 13 m/s .

2.8.2 Temperature Instruments

2.8.2.1 Resistance Temperature Detectors (RTD)

Temperature sensors shall be 1000 ohms 2-wire RTD. Each RTD shall be platinum with a tolerance of 0.30 degrees C at 0 degrees C and shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

2.8.2.2 Continuous Averaging RTD

Continuous averaging RTDs shall have a tolerance of plus or minus 0.5 degrees C at the reference temperature, and shall be of sufficient length to ensure that the resistance represents an average over the cross section in which it is installed. The sensing element shall have a bendable copper sheath. Each averaging RTD shall be furnished with an RTD transmitter to match the resistance range of the averaging RTD.

2.8.3 Electronic Airflow Measurement Stations and Transmitters

2.8.3.1 Stations

Each station shall consist of an array of velocity sensing elements and an air-flow straightener. Air-flow straightener shall be contained in a flanged sheet metal or aluminum casing. The velocity sensing elements shall be of the RTD or thermistor type, producing a temperature compensated output. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published application data of the station manufacturer. The resistance to air flow through the airflow measurement station shall not exceed 20 Pa at an airflow of 10 m/s. Station construction shall be suitable for operation at airflows of up to 25 m/s over a temperature range of 4 to 49 degrees C , and accuracy shall be plus or minus three percent over a range of 0.6 to 12.5 m/s . In outside air measurement or in low-temperature air delivery applications, the station shall be certified by the manufacturer to be accurate as specified over a temperature range of minus 29 to plus 49 degrees C. In outside air measurement applications, the air flow straightener shall be constructed of 3 mm aluminum honeycomb and the depth of the straightener shall not be less than 40 mm.

2.8.4 Differential Pressure Instruments

The instrument shall be a pressure transmitter with an integral sensing element. The instrument over pressure rating shall be 300 percent of the operating pressure. The sensor/transmitter assembly accuracy shall be plus or minus two percent of full scale. The transmitter shall be a two-wire, loop-powered device. The transmitter shall produce a linear 4-to-20 mA dc output corresponding to the required pressure measurement.

2.8.5 Thermowells

Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 50 mm lagging neck and extension type well. Inside diameter and insertion length shall be as required for the application.

2.8.6 Sunshields

Sunshields for outside air temperature sensing elements shall prevent the sun from directly striking the temperature sensing elements. The sunshields shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings. The top of each sunshield shall have a

galvanized metal rainshield projecting over the face of the sunshield. The sunshields shall be painted white.

2.8.9 Space Carbon Dioxide (CO2) Sensors

CO2 sensors shall be wall or return duct mounted infrared absorption sampling type with a measurement range from 0 to 2000 ppm, plus or minus 75 ppm. Operating temperature shall be 0 to 50 degree C, 5 to 95% relative humidity. Sensor shall only require calibration every 3 years. Device shall have integral transmitter providing a proportional 4 - 20 mA signal scaled to range of sensor and shall have a response time of less than 90 seconds. Instrument must be designed to protect the sensing element from dust accumulation and mechanical damage.

2.8.10 Outside Air CO2 Sensors

CO2 sensors shall be duct mounted infrared absorption sampling type with a measurement range from 0 to 2000 ppm, plus or minus 100 ppm. Operating temperature shall be -25 to 45 degree C, 5 to 95% relative humidity. Sensor shall only require calibration every 3 years. Device shall have integral transmitter providing a proportional 4-20mA signal scaled to range of sensor. In lieu of this sensor, a space CO2 sensor downstream of the heating coil in a 100% outdoor air unit may be provided. Instrument must be designed to protect the sensing element from dust accumulation and mechanical damage.

2.9 THERMOSTATS

Thermostat ranges shall be selected so that the setpoint is adjustable without tools between plus or minus 5 degrees C of the setpoint shown. Thermostats shall be electronic or electric.

2.9.1 Nonmodulating Room Thermostats

Contacts shall be single-pole double-throw (SPDT), hermetically sealed, and wired to identified terminals. Maximum differential shall be 3 degrees C. Room thermostats shall be enclosed with separate locking covers (guards).

2.9.2 Temperature Switches

Temperature switches shall have a repetitive accuracy of plus or minus 1 percent of the operating ranges shown. Switch actuation shall be adjustable over the operating temperature range. The switch shall have a snap-action Form C contact rated for the application.

2.9.3 Nonmodulating Capillary Aquastats

Each aquastat shall have a capillary length of at least 1500 mm, shall have adjustable direct-reading scales for both setpoint and differential, and shall have a differential adjustable from 3 to 9 degrees C. Aquastats shall be of the strap on type, with 5 degrees C fixed differential.

2.9.4 Freezestats

Freezestats shall be automatic reset, low temperature safety thermostats, with NO and NC contacts and a 6000 mm element which shall respond to the coldest 450 mm segment.

2.9.5 Fan-Coil Unit Room Thermostats

Fan-coil unit thermostats in personnel living spaces shall be of the low voltage type with locking covers. Electrical rating shall not exceed 2.5 amperes at 30 volts ac. Housing shall be corrosion resisting metal or molded plastic. Transformer and fan relay shall be provided for the proper operation of each

thermostatic control system as necessary to suit the design of the control system using the thermostats specified below. Either separate heating thermostats and separate cooling thermostats or dual element heating cooling thermostats may be provided. Motor speed switches shall be provided for three-speed fan control.

2.9.5.1 Combination Thermostat

Fan coil unit combination heating-cooling thermostats shall be provided with separate temperature sensing elements for each system, and shall have a single-pole, single-throw (SPST) switch, hermetically sealed and actuated by a bimetallic or bellows type element. Each element shall operate switches to provide single stage control for heating and cooling. Scales and ranges shall be as specified for individual thermostats. Thermostats shall contain, or a subbase shall be provided which contains, selector switches for Heat-Off-Cool. A changeover controller providing automatic summer-winter changeover for thermostats by sensing the supplied fluid temperature shall be provided. A limited range heating-cooling dead band thermostat shall control cooling when temperature is above the upper setpoint and heating when temperature is below the lower setpoint and shall have a dead band, with no heating or cooling, when temperature is between the setpoints. Setpoint adjustment shall be concealed.

2.10 PRESSURE SWITCHES AND SOLENOID VALVES

2.10.1 Pressure Switches

Each switch shall have an adjustable setpoint with visible setpoint scale. Range shall be as shown. Differential adjustment shall span 20 to 40 percent of the range of the device.

2.10.2 Differential-Pressure Switches

Each switch shall be an adjustable diaphragm-operated device with two SPDT contacts, with taps for sensing lines to be connected to duct pressure fittings designed to sense air pressure. These fittings shall be of the angled-tip type with tips pointing into the air stream. The setpoint shall not be in the upper or lower quarters of the range and the range shall not be more than three times the setpoint. Differential shall be a maximum of 35 Pa at the low end of the range and 85 Pa at the high end of the range.

2.10.3 Pneumatic Electric (PE) Switches

Each switch shall have an adjustable setpoint range of 20 to 140 kPa with a switching differential adjustable from 15 to 35 kPa. The switch action shall be SPDT.

2.10.4 Solenoid-Operated Pneumatic (EP) Valves

Each valve shall have three-port operation: common, normally open, and normally closed. Each valve shall have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection shall be a 10 mm NPT threaded connection. Valves shall be rated for 345 kPa when used in a control system that operates at 172 kPa or less, or 1035 kPa when used in a control system that operates in the range of 172 to 690 kPa.

2.11 INDICATING DEVICES

2.11.1 Thermometers

Mercury shall not be used in thermometers.

2.11.1.1 System Thermometers

Thermometers shall have brass, malleable iron or aluminum alloy case and frame,

clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 230 mm scale. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern.

2.11.1.2 Thermometer Stems

Thermometer stems shall have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem shall be filled with a heat-transfer medium.

2.11.1.3 Air-Duct Thermometers

Non-averaging air-duct thermometers shall have perforated stem guards. Thermometers shall have 45-degree adjustable duct flanges with locking mechanism.

2.11.1.4 Accuracy

Thermometers shall have an accuracy of plus or minus one percent of scale range. Thermometers shall have a range suitable for the application.

2.11.2 Pressure Gauges

Gauges shall be 50 mm (nominal) size, back connected, suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Accuracy shall be plus or minus three percent of scale range. Gauges shall meet requirements of ASME B40.1.

2.11.2.1 Pneumatic Actuator Gauges

Gauges for indicating signal output to pneumatic actuators shall have an outer scale of 21 to 103 kPa in 7 kPa graduations.

2.11.2.2 Air Storage Tank and Filter and Dryer Gauge

Gauges for air storage tanks or for use before and after dirt and oil filters or dryers, shall have a scale of 0 to 1100 kPa with 20 kPa graduations.

2.11.2.3 Hydronic System Gauges

Gauges for hydronic system applications shall have ranges suitable for the application.

2.11.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements shall be a minimum of 90 mm (nominal) size with two sets of pressure taps, and shall have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauges shall have ranges and graduations as shown. Accuracy shall be plus or minus two percent of scale range.

2.12 CONTROL DEVICES AND ACCESSORIES

2.12.1 Relays

Control relay contacts shall have utilization category and ratings selected for the application, with a minimum of two sets of contacts (two normally open, two normally closed) enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150 percent of rated coil voltage. Time delay relays shall be 2PDT with eight-pin connectors, dust cover, and a matching rail-mounted socket. Adjustable timing range shall be 0 to 5 minutes. Power consumption

shall not be greater than three watts.

2.12.2 Current to Pneumatic (IP) Transducers

The transducers shall be two-wire current-to-pressure transmitters that convert a 4-to-20 mA dc input signal to a 21 to 103 kPa (3 to 15 psig) , or a 103 to 21 kPa (15 to 3 psig) , pneumatic output, with a conversion accuracy of plus or minus two percent of full scale, including linearity and hysteresis. Input impedance shall not exceed 250 ohms. Air consumption shall not be greater than 0.12 L/s.

2.12.3 Joule or Watthour Meters

Joule meters shall be in accordance with ANSI C12.1 and have pulse initiators for remote monitoring of Joule consumption. Pulse initiator shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with ANSI C12.1.

2.12.4 Current Sensing Relays (Current Switches)

Current sensing relays shall provide a normally-open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, noninductive. There shall be a single hole for passage of current carrying conductors. The devices shall be sized for operation at 50 percent rated current based on the connected load. Voltage isolation shall be a minimum of 600 volts.

2.12.5 Power-Line Conditioners (PLC)

Power line conditioners shall be furnished for each DDC panel. The PLCs shall provide both voltage regulation and noise rejection. The PLCs shall be of the ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power-line side. The PLCs shall be sized for 125 percent of the actual connected kVA load. Characteristics of the PLC shall be as follows:

a. At 85 percent load, the output voltage shall not deviate by more than plus or minus one percent of nominal when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.

b. During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus three percent of nominal voltage. Full correction of load switching disturbances shall be accomplished within five cycles, and 95 percent correction shall be accomplished within two cycles of the onset of the disturbance.

c. Total harmonic distortion shall not exceed 3-1/2 percent at full load.

2.13 COMPRESSED AIR STATIONS

2.13.1 Air Compressor Assembly

The air compressor shall be a high pressure compressing unit with electric motor. The compressors shall be of the oil-less type and shall be equipped with a motor with totally enclosed belt guard, an operating-pressure switch, safety relief valves, gauges, intake filter and intake silencer, and combination type magnetic starter with undervoltage protection and thermal-overload protection for each phase, and shall be supported by a steel base mounted on an air storage tank. The air compressor shall provide the compressed air required for control operation while operating not more than one-third of the time. The air storage tank shall be fabricated for a working pressure of not less than 1380 kPa, and constructed and certified in accordance with ASME BPVC SEC VIII D1. The tank shall be of sufficient volume so that no more than six compressor starts per hour are required with the starting pressure switch differential set at 140 kPa. The

tank shall be provided with an automatic condensate drain trap with manual override feature. A second (duplex arrangement) compressor of capacity equal to the primary compressor shall be provided, with interlocked control to provide automatic changeover upon malfunction or failure of either compressor. A manual selector switch shall be provided to index the lead compressor including the automatic changeover.

2.13.2 Compressed Air Station Specialties

2.13.2.1 Refrigerated Dryer, Filters and, Pressure Regulator

A refrigerated dryer shall be provided in the air outlet line of the air storage tank. The dryer shall be of the size required for the full delivery capacity of the compressor. The air shall be dried at a pressure of not less than 483 kPa to a temperature not greater than 2 degrees C. The dryer shall be provided with an automatic condensate drain trap with manual override feature. The refrigerant used in the dryer shall be one of the fluorocarbon gases and have an Ozone Depletion Potential of not more than 0.05. A five micron prefilter and coalescing-type 0.03 micron oil removal filter with shut-off valves shall be provided in the dryer discharge. Each filter bowl shall be rated for 1034 kPa maximum working pressure. A pressure regulator, with high side and low side pressure gauges, and a safety valve shall be provided downstream of the filter. Pressure regulators of the relieving type shall not be used.

2.13.2.2 Flexible Pipe Connections

The flexible pipe connectors shall be designed for 1034 kPa and 120 degree C service, and shall be constructed of rubber, tetrafluoroethylene resin, or braided corrosion-resistant steel, bronze, monel, or galvanized steel. The connectors shall be suitable for the service intended and may have threaded or soldered ends. The length of the connectors shall be as recommended by the manufacturer for the service intended.

2.13.2.3 Vibration Isolation Units

The vibration isolation units shall be standard products with published loading ratings, and shall be single rubber-in-shear, double rubber-in-shear, or spring type.

2.13.2.4 Compressed Air Piping

Control air delivered to the system shall conform to ISA S7.0.01. Air lines for pneumatic controls shall be seamless copper tubing. Air lines shall be concealed except in mechanical rooms and other areas where other tubing and piping is exposed. Air lines in exposed and concealed locations, free standing or enclosed in the conduit or other protective coverings, shall be run parallel to the building lines and shall be adequately supported from the building structure, at least every 2 m horizontally and every 2.5 m vertically. Copper tubing shall be hard-drawn in exposed areas and either hard-drawn or annealed in concealed areas. Only tool-made bends shall be used. Fittings for copper tubing shall be brass or copper solder joint type except at connections to apparatus, where fittings shall be brass compression type. Nonmetallic tubing shall be compounded from polyethylene, meeting the stress crack test of ASTM D 1693. Nonmetallic individual tube polyethylene or multitube instrument tubing bundle shall be classified as flame retardant under UL 94. The polyethylene material shall be rated as self-extinguishing when tested in accordance with ASTM D 635. Air lines concealed in walls shall be hard-drawn copper tubing or nonmetallic tubing in rigid conduit. Terminal single lines shall be hard-drawn copper tubing, except when the run is less than 300 mm in length, flexible polyethylene may be used. Air lines shall be tested periodically for leaks during installation. Air lines shall be purged of dirt, impurities and moisture before connecting to the control equipment. Fittings for nonmetallic tubing shall be for instrument service and may be brass or acetal resin of the compression or barbed push-on

type. Air lines shall be number coded or color coded and keyed to the submittal drawings for future identification and servicing the control system.

2.14 DIRECT DIGITAL CONTROL (DDC) HARDWARE

All functions, constraints, data base parameters, operator developed programs and any other data shall be downloadable from a portable workstation/tester or the central workstation/tester to network control panels, RIU's, universal programmable controllers, and unitary controllers. Download shall be accomplished through both the primary network and the local DDC portable workstation/tester port.

2.14.1 Network Control Panel

Network control panels shall be microcomputer-based with sufficient memory provided to perform all specified and shown network control panel functions and operations, including spare capacity for all spares and its I/O functions specified. Each network control panel and remote I/O units (RIU) shall have a minimum of 10% of its I/O functions as spare capacity but not less than 2 of each type used in each. The type of spares shall be in the same proportion as the implemented I/O functions on the panel, but in no case shall there be less than two spare points of each type. The panel I/O functions shall be furnished complete, with no changes or additions necessary to support implementation of spare functions. Output relays associated with digital signals shall be considered part of the I/O function, whether physically mounted in the enclosure or separately mounted. Implementation of spare points shall necessitate only providing the additional field sensor or control device, field wiring including connection to the system, and point definition assignment by the operator using the central workstation/tester or portable workstation/tester. The panel shall contain all necessary I/O functions to connect to field sensors and control panels. I/O function operation shall be fully supervised to detect I/O function failures. Network control panels shall operate in an independent stand-alone mode, which is defined as all network control panel operations performed by the network control panel without any continuing input from other Direct digital controls or portable workstation/tester. The network control panel shall be capable of controlling a mix of at least 32 RIUs, unitary controllers, and universal programmable controllers.

2.14.1.1 Integral Features

The network control panel shall include:

- a. Main power switch.
- b. Power on indicator.
- c. Portable workstation/tester port, connector, and if necessary power supply.
- d. Manufacturers control network port.
- e. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the field panel, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the panel for further processing.
- f. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.
- g. An intrusion detection device, connected as an alarm.

2.14.1.2 Communication Interfaces

The following communication capabilities shall function simultaneously.

a. Manufacturers Control Network. Manufacturers control network communications interfaces for each data transmission systems (DTS) circuit between network control panels and RIUs, unitary controllers, and universal programmable controllers, shall be provided. Communication interfaces shall be provided between each network control panel and associated I/O functions. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the network control panel enclosure.

b. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. Network control panel workstation/tester port other than RS-232, shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel.

c. Primary Network Port. The network control panel shall either have a built in primary network Port or be capable of accepting a primary network port expansion card for future networking to a base wide utility monitoring and control system (UMCS). The primary network port expansion card shall be either Ethernet (IEEE802.3) or ARCNET.

2.14.1.3 Memory and Real Time Clock (RTC) Backup

The network control panel memory and real time clock functions shall continue to operate for a minimum of 72 hours in the event of a power failure. If rechargeable batteries are provided, automatic charging of batteries shall be provided. Whenever a either a permanent workstation/tester or portable workstation/tester is monitoring the network control panel, a low battery alarm message shall be sent to it.

2.14.1.4 Duplex Outlet

A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within 2 meters of the network control panel enclosure.

2.14.1.5 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each network control panel.

2.14.1.6 Failure Mode

Upon failure of the network control panel, either due to failure of the network control panel hardware or of the manufacturers control network, the network control panel shall revert to the failure mode as shown.

a. Manufacturers Control Network Failure: Upon failure of the manufacturers control network, the network control panel shall operate in an independent stand-alone mode.

b. Network Control Panel Hardware Failure: Upon failure of the network control panel hardware, the network control panel shall cease operation and stop communications with other network control panels, RIUs, unitary controllers and universal programmable controllers connected to the affected network control panel. The affected network control panel shall respond to this failure as specified and shown.

2.14.2 RIU

The RIU shall be functionally a part of the network control panel as specified, but may be remotely located from the network control panel and communicate over a dedicated communication circuit. When remotely located, the I/O functions shall be subject to the same requirements as for the network control panel hardware. RIUs shall be used to connect remote inputs and outputs to a network control panel and shall contain all necessary I/O functions to connect to field sensors and control devices. RIU operation shall be fully supervised by the network control panel to detect failures. Each RIU shall have a minimum of 10 % of its I/O functions as spare capacity. The type of spares shall be in the same proportion as the implemented I/O functions on the RIU, but in no case shall there be less than two spare points of each type. The RIU shall be furnished complete, with no changes or additions necessary to support implementation of spare functions. Output relays associated with digital signals shall be considered part of the I/O function, whether physically mounted in the enclosure or separately mounted. Implementation of spare points by others shall require only providing the additional field sensor or control device, field wiring including connection to the system, and point definition assignment by the operator. The RIU shall either report the status of all connected points on each scan, or report the status of all points which have changed state or value since the previous scan.

2.14.2.1 Integral Features

The RIU shall include:

- a. Main power switch.
- b. Power on indicator.
- c. Portable workstation/tester port, connector, and if necessary power supply.
- d. Manufacturers control network port.
- e. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the RIU, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the RIU for further processing.
- f. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.
- g. An intrusion detection device, connected as an alarm.

2.14.2.2 Duplex Outlet

A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within 2 meters of the RIU.

2.14.2.3 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each RIU.

2.14.2.4 Failure Mode

Upon failure of the RIU, either due to failure of the RIU hardware or of the DTS, the RIU shall revert to the failure mode shown.

2.14.3 Universal Programmable Controller (UPC)

The universal programmable controller shall be a microprocessor based controller designed and programmed to control and monitor systems as shown. Resident programs shall be contained in reprogrammable nonvolatile memory. Each universal programmable controller shall contain necessary power supplies, transformers, memory, I/O functions and communications interfaces necessary to perform its required functions and to provide control and monitoring of connected equipment and devices. It shall contain all necessary I/O functions to connect to field sensors and controls. I/O operation shall be fully supervised to detect I/O function failures. It shall provide for operation as a device connected to the system via the manufacturers control network.

2.14.3.1 Integral Features

The universal programmable controller shall include as a minimum:

- a. Main power switch.
- b. Power on indicator.
- c. Portable workstation/tester port, connector, and if necessary power supply.
- d. Manufacturers control network port.
- e. I/O functions
 - (1) 8 DI
 - (2) 4 DO
 - (3) 8 AI
 - (4) 4 AO
 - (5) 1 PA
- f. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the universal programmable controller, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the panel for further processing.
- g. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.

2.14.3.2 Communication Interfaces

The UPC shall have the following communication capabilities which shall function simultaneously.

- a. Manufacturers Control Network. The manufacturers control network communications interface for a data transmission systems (DTS) circuit between the UPC and a network control panels shall be provided. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the UPC Panel enclosure.
- b. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. A UPC workstation/tester port other than RS-232, shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel.

2.14.3.3 Memory and RTC Backup

The UPC memory and real time clock functions shall continue to operate for a minimum of 72 hours in the event of a power failure. If rechargeable batteries are provided, automatic charging of batteries shall be provided. Whenever a either a permanent workstation/tester or portable workstation/tester is monitoring the network control panel, a low battery alarm message shall be sent to it.

2.14.3.4 Specific Requirements

Each universal programmable controller shall be accessible for purposes of application selection, control parameters, set point adjustment, and monitoring from any DDC controller connected to the same manufacturers control network as the universal programmable controller. This shall be done using a portable workstation/tester connected to a portable workstation/tester port either directly or via modem.

2.14.3.5 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each enclosure.

2.14.3.6 Failure Mode

Upon failure of the universal programmable controller, it shall revert to the failure mode of operation as shown.

2.14.4 Unitary Controller

The unitary controller shall be a microprocessor based, stand-alone, dedicated purpose controller, communicating with the network control panel, designed and programmed to control air distribution system mixing boxes, terminal units, heat pumps, fan coil units, self-contained DX units or VAV boxes. Each unitary controller shall contain resident programs in nonvolatile memory for each specific application implemented. Each unitary controller shall contain necessary power supplies, transformers, memory, I/O functions and communications interfaces necessary to perform its required functions and to provide control and monitoring of connected equipment and devices. It shall contain all necessary I/O functions to connect to field sensors and controls. I/O operation shall be fully supervised to detect I/O function failures and shall provide for operation as a device connected to the network control panel via the manufacturers control network.

2.14.4.1 Integral Features

The unitary controller shall include:

- a. Main power switch.
- b. Power on indicator.
- c. Portable workstation/tester port, connector, and power supply.
- d. Manufacturers control network port.
- e. All I/O functions required to implement the requirements as shown.
- f. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the field panel, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the panel for further

processing.

g. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.

2.14.4.2 Communication Interfaces

The unitary controller shall have the following communication capabilities which shall function simultaneously.

a. Manufacturers Control Network. The manufacturers control network communications interface for a data transmission systems (DTS) circuit between the unitary controller and a network control panel shall be provided. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the unitary control panel enclosure.

b. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. A unitary controller workstation/tester port other than RS-232, shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel. For unitary controller applications where the controller is not mounted in an enclosure, such as for fan-coil units or VAV terminal units, a portable conversion device for an RS-232 connection to the portable workstation/tester may be provided.

2.14.4.3 Specific Requirements

Unitary controller components for new air distribution terminal units shall be furnished to the air distribution terminal unit manufacturer for factory mounting and calibration. Existing air distribution terminal units shall be controlled by field installed unitary controllers.

a. Accessibility and Interfaces: Each unitary controller shall be accessible for purposes of application selection, control parameters, set point adjustment, and monitoring using a portable workstation/tester connected to the manufacturers control network. They shall also be accessible with a portable workstation/tester connected to the unitary controller portable workstation/tester port.

b. Air Distribution Terminal Unit Controls - Pressure Independent: Controls shall consist of a transducer for connection to the velocity-sensing device provided by the terminal unit supplier in the primary air entering the terminal unit, a room temperature sensor, a damper actuator, and an adjustable microprocessor-based controller. The room temperature sensor shall have occupant setpoint adjustment and temperature display, timed override of unoccupied mode, and a communication port. The controller shall operate the damper for cooling and heating and provide control outputs for duct heating coil if applicable. This controller capability shall allow the sequencing of the damper and the heating coil to maintain conditions in the space.

c. Air Distribution Terminal Unit Controls - Pressure Independent with Recirculating Fan: Controls for pressure-independent boxes with recirculating fans shall consist of a transducer for connection to the velocity-sensing device provided by the terminal unit supplier in the primary air entering the terminal unit, a room temperature sensing element, a damper actuator, an adjustable microprocessor-based terminal unit controller, and a switch to operate the recirculation fan, provided by the terminal unit supplier. The room temperature sensor shall have occupant setpoint adjustment and temperature display, timed override of unoccupied mode, and a communication port. The controller shall operate the damper for cooling and shall provide outputs for controlling the recirculation fan and duct heating coil in sequence for heating.

d. Air Distribution Terminal Unit Damper Actuator: Air distribution terminal unit damper actuator shall open or close the device to which it is connected within 60 seconds.

2.14.4.4 Failure Mode

Upon failure of the unitary controller, it shall revert to the failure mode of operation as shown.

2.14.5 Chiller Control Panel

Chiller control panel shall be microprocessor-based and shall provide, both locally and through the Manufacturers Control Network, the control, monitoring, and safety equipment functions provided by the chiller manufacturer's control panel(s) (two communications ports total). The chiller control panel instrumentation and control ranges and accuracies shall match those of the chiller manufacturer's control devices. The chiller panel shall have a communication port for interface to a Portable Workstation/Tester through either the Manufacturers Control Network or modem for chiller(s) start/stop, chilled water temperature reset, and monitoring of chiller operating status, alarms, and power consumption.

2.14.6 Boiler Control Panel

Boiler control panel shall be microprocessor-based and shall provide, both locally and through the Manufacturers Control Network, the control, monitoring, and safety equipment functions provided by the boiler manufacturer's control panel(s) (two communications ports total). The boiler control panel instrumentation and controls ranges and accuracies shall match those of the boiler manufacturer's control devices. The boiler panel shall have a communication port for interface to a Portable Workstation/Tester through either the Manufacturers Control Network or modem for boiler(s) and start/stop, boiler water temperature reset, and monitoring of boiler operating status, alarms.

2.14.7 I/O Functions

2.14.7.1 DDC Hardware I/O Functions

I/O Functions shall be provided as part of the DDC system and shall be in accordance with the following:

a. The analog input (AI) function shall monitor each analog input, perform A-to-D conversion, and hold the digital value in a buffer for interrogation. The A-to-D conversion shall have a minimum resolution of 10 bits plus sign. Signal conditioning shall be provided for each analog input. Analog inputs shall be individually calibrated for zero and span, in hardware or in software. The AI shall incorporate common mode noise rejection of 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of 20 dB at 60 Hz from a source impedance of 10,000 ohms. Input ranges shall be within the range of 4-to-20 mAdc.

b. The analog output (AO) function shall accept digital data, perform D-to-A conversion, and output a signal within the range of 4-to-20 mAdc. D-to-A conversion shall have a minimum resolution of eight bits plus sign. Analog outputs shall be individually calibrated for zero and span. Short circuit protection on voltage outputs and open circuit protection on current outputs shall be provided. An individual gradual switch for manual override of each analog output and means of physically securing access to these switches shall be provided. Each AO shall have a three-position switch for selection of the DDC control signal, no control, or a locally generated control signal for connection to the controlled device. Feedback shall be provided to the system as to the status of the output (manual control or automatic). Switches for pneumatic

control outputs shall provide a connection for an externally generated pneumatic signal. All switches shall be either of a key operated design with the same keying system used for other outputs or otherwise suitably protected from unauthorized access .

c. The digital input (DI) function shall accept on-off, open-close, or other change of state (two state data) indications. Isolation and protection against an applied steady-state voltage up to 180 Vac peak shall be provided.

d. The digital output (DO) function shall provide contact closures for momentary and maintained operation of output devices. Closures shall have a minimum duration of 0.1 second. DO relays shall have an initial breakdown voltage between contacts and coil of at least 500 V peak. Electromagnetic interference suppression shall be furnished on all output lines to limit transients to nondamaging levels. Protection against an applied steady-state voltage up to 180 Vac peak shall be provided. Minimum contact rating shall be one ampere at 24 Vac. Key locked HOA switches shall be provided for manual override of each digital output. Feedback shall be provided to the system as to the status of the output (manual control or automatic). Switches shall be common keyed .

e. The pulse accumulator function shall have the same characteristics as the DI. In addition, a buffer shall be provided to totalize pulses and allow for interrogation by the DDC system. The pulse accumulator shall accept rates up to 20 pulses per second. The totalized value shall be reset to zero upon operator's command.

f. Signal conditioning for sensors shall be provided as specified.

g. The binary coded decimal (BCD) function: The BCD function shall have the same characteristics as the DI, except that, in addition, a buffer shall be provided to totalize inputs and allow for interrogation by the network control panel. The BCD function shall have 16-channel optically isolated buffered inputs to read four digit numbers. The BCD function shall accumulate inputs at rates up to 10 inputs per second.

2.14.7.2 Failure Mode

Upon failure of the I/O function, including data transmission failure, logic power supply failure, DDC processor malfunction, software failure, interposing relay power failure, or any other failure which prevents stand alone operation of any DDC normally capable of stand alone operation, connected outputs shall be forced to the failure mode shown.

2.14.8 Portable Workstation/Tester

A portable workstation/tester shall be provided and shall be able to connect to any DDC hardware. The portable workstation/tester shall consist of a portable computer with a nominal 15-inch TFT active matrix XGA display, capable of displaying at a minimum resolution of 1600 X 1200 pixels, 64 MB DDR video memory utilizing 4X AGP interface, Pentium 4 microprocessor operating at a minimum of 2.0 GHZ, 256 MB DDR system memory. The portable workstation/tester shall have, as a minimum, a 60 GB hard drive, integral pointing device, serial and parallel ports, color VGA video port for an external color monitor, 3.5 inch floppy disk drive, v.92, 56K modem, Ethernet 10/100 network adaptor, CD-RW/DVD-Rom combo optical disk drive, integral sound card with speakers, rechargeable battery, battery charger and 120 Vac power supply, type III card connector, and Windows XP operating system. It shall include carrying case, extra battery, charger and a compatible network adapter. The workstation/tester shall:

- a. Run DDC diagnostics.
- b. Load all DDC memory resident programs and information, including

parameters and constraints.

c. Display any AI, DI, AO, DO, or PA point in engineering units for analog points or status for digital points.

d. Control any AO or DO.

e. Provide an operator interface, contingent on password level, allowing the operator to use full English language words and acronyms, or an object oriented graphical user interface.

f. Display database parameters.

g. Modify database parameters.

h. Accept DDC software and information for subsequent loading into a specific DDC. Provide all necessary software and hardware required to support this function, including an EIA ANSI/EIA/TIA-232-F port.

i. Disable/enable each DDC.

j. Perform all workstation functions as specified.

2.14.9 Central Workstation/Tester

The existing central workstation located in building 364 shall be utilized.

2.15 DDC SOFTWARE

All DDC software described in this specification shall be furnished as part of the complete DDC System.

2.15.1 Operating System

Each DDC shall contain an operating system that controls and schedules that DDC's activities in real time. The DDC shall maintain a point database in its memory that includes all parameters, constraints, and the latest value or status of all points connected to that DDC. The execution of DDC application programs shall utilize the data in memory resident files. The operating system shall include a real time clock function that maintains the seconds, minutes, hours, date and month, including day of the week. Each DDC real time clock shall be automatically synchronized with the network control panel real time clock at least once per day to plus or minus 10 seconds. When the network control panel is connected to a central workstation/tester, the network control panel RTC shall be updated by the central workstation/tester RTC. The time synchronization shall be accomplished without operator intervention and without requiring system shutdown. The operating system shall allow loading of software, data files data entry, and diagnostics from the central workstation/tester both locally through the central workstation/tester port and remotely through a network control panel and the manufacturers control network.

2.15.1.1 Startup

The DDC shall have startup software that causes automatic commencement of operation without human intervention, including startup of all connected I/O functions. A DDC restart program based on detection of power failure at the DDC shall be included in the DDC software. Upon restoration of power to the DDC, the program shall restart equipment and restore loads to the state at time of power failure, or to the state as commanded by time programs or other overriding programs. The restart program shall include start time delays between successive commands to prevent demand surges or overload trips. The startup software shall initiate operation of self-test diagnostic routines. Upon failure of the DDC, if the database and application software are no longer resident or if the clock

cannot be read, the DDC shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made. If the database and application programs are resident, the DDC shall resume operation after an adjustable time delay of from 0 to 600 seconds. The startup sequence for each DDC shall include a unique time delay setting for each control output when system operation is initiated.

2.15.1.2 Operating Mode

Each DDC shall control and monitor functions as specified, independent of communications with other DDC. This software shall perform all DDC functions and DDC resident application programs as specified using data obtained from I/O functions and based upon the DDC real time clock function. When communications circuits between the DDC are operable, the DDC shall obtain real time clock updates and any required global data values transmitted from other network control panels. The DDC software shall execute commands after performing constraints checks in the DDC. Status and analog values, including alarms and other data shall be transmitted from other network control panels when communications circuits are operable. If communications are not available, each DDC shall function in stand-alone mode and operational data, including the latest status and value of each point and results of calculations, normally transmitted from other network control panels shall be stored for later transmission to the network control panel. Storage for the latest 256 values shall be provided at each network control panel. Each DDC shall accept software downloaded from the network control panel. Constraints shall reside at the DDC.

2.15.1.3 Failure Mode

Upon failure for any reason, each DDC shall perform an orderly shutdown and force all DDC outputs to a predetermined (failure mode) state, consistent with the failure modes shown and the associated control device.

2.15.2 Functions

The Contractor shall provide software necessary to accomplish the following functions, as appropriate, fully implemented and operational, within each network control panel, RIU, unitary controller and universal programmable controller.

- a. Scanning of inputs.
- b. Control of outputs.
- c. Reporting of analog changes outside a selectable differential.
- d. Reporting of unauthorized digital status.
- e. Reporting of alarms automatically to network control panel.
- f. Reporting of I/O status to network control panel upon request.
- g. Maintenance of real time, updated by the network control panel at least once a day.
- h. Communication with the network control panel.
- i. Execution of DDC resident application programs.
- j. Averaging or filtering of AIs.
- k. Constraints checks (prior to command issuance).
- l. Diagnostics.

- m. Portable workstation/tester operation as specified.
- n. Reset of PA by operator based on time and value.

2.15.2.1 Analog Monitoring

The system shall measure and transmit analog values including calculated analog points. An analog change in value is defined as a change exceeding a preset differential value as specified. The record transmitted for each analog value shall include a readily identifiable flag which indicates the abnormal status of the value when it deviates from operator selectable upper and lower analog limits. Analog values shall be expressed in proper engineering units with sign. Engineering units conversions shall be provided for each measurement. Each engineering units conversion set shall include range, span, and conversion equation. A vocabulary of engineering unit descriptors shall be provided, using at least three alphanumeric characters to identify information in the system. The system shall support 255 different engineering units.

2.15.2.2 Logic (Virtual) Points

Logic (virtual) points shall be software points entered in the point database which are not directly associated with a physical I/O function. Logic (virtual) points shall be analog or digital points created by calculation from any combination of digital and analog points, or other data having the properties of real points, including alarms, without the associated hardware. Logic (virtual) points shall be defined or calculated and entered into the database by the Contractor. The calculated analog point shall have point identification in the same format as any other analog point. The calculated point shall be used in any program where the real value is not obtainable directly. Constants used in calculations shall be changeable on-line by the operator. Calculated point values shall be current for use by the system within 10 seconds of the time of any input changes.

2.15.2.3 State Variables

If an analog point represents more than two (up to eight) specific states, each state shall be nameable. For example, a level sensor shall be displayed at its measured engineering units plus a state variable with named states usable in programs or for display such as low alarm/low/normal/high/high alarm.

2.15.2.4 Analog Totalization

Any analog point shall be operator assignable to the totalization program. Up to eight analog values shall be totalized within a selectable time period. At the end of the period, the totals shall be stored. Totalization shall then restart from zero for the next time period. The program shall keep track of the peak and total value measured during the current period and for the previous period. The operator shall be able to set or reset each totalized value individually. The time period shall be able to be operator defined, modified or deleted on-line.

2.15.2.5 Energy Totalization

The system shall calculate the heat energy in Btus, for each energy source consumed by the mechanical systems specified, totalize the calculated Btus, the instantaneous rate in Btus per hour, and store totals in thousands of Btus (MBtu). The Btus calculated shall be totalized for an adjustable time period. The time period shall be defined uniquely for each Btu totalization. Software shall be capable of generating monthly energy savings reports. These reports shall include each HVAC system with the associates savings printed out in actual dollars and cents saved. The savings would be generated by utilizing energy saving routines included in the software.

Energy Saving Reports:

Software shall generate monthly energy savings reports. These reports shall include each HVAC system with the associated savings printed out in actual dollars and cents saved. The savings would be generated by utilizing energy saving routines included in software.

2.15.2.6 Trending

Any analog or calculated point shall be operator assignable to the trend program.

Up to eight points shall be sampled at individually assigned intervals, selectable between one minute and two hours. A minimum of the most recent 128 samples of each trended point shall be stored. The sample intervals shall be able to be defined, modified, or deleted on-line.

2.15.3 I/O Point Database/Parameter Definition

Each I/O point shall be defined in a database residing in the DDC. The definition shall include all physical parameters associated with each point. Each point shall be defined and entered into the database by the Contractor, including as applicable:

- a. Name.
- b. Device or sensor type (i.e., sensor, control relay, motors).
- c. Point identification number.
- d. Unit.
- e. Building number.
- f. Area.
- g. Island.
- h. DDC number and channel address.
- i. KW (running).
- j. KW (starting).
- k. Sensor range.
- l. Controller range.
- m. Sensor span.
- n. Controller span.
- o. Engineering units conversion (scale factor).
- p. Setpoint (analog).
- q. High reasonableness value (analog).
- r. Low reasonableness value (analog).
- s. High alarm limit differential (return to normal).
- t. Low alarm limit differential (return to normal).
- u. High alarm limit (analog).
- v. Low alarm limit (analog).

- w. Alarm disable time period upon startup or change of setpoint.
- x. Analog change differential (for reporting).
- y. Alarm class and associated primary message text.
- z. High accumulator limit (pulse).
- aa. Status description.
- bb. Run time target.
- cc. Failure mode as specified and shown.
- dd. Constraints as specified.

2.15.4 Alarm Processing

Each DDC shall have alarm processing software for AI, DI, and PA alarms for all real and virtual points connected to that DDC.

2.15.4.1 Digital Alarms Definition

Digital alarms are those abnormal conditions indicated by DIs as specified and shown.

2.15.4.2 Analog Alarms Definition

Analog alarms are those conditions higher or lower than a defined value, as measured by an AI. Analog readings shall be compared to predefined high and low limits, and alarmed each time a value enters or returns from a limit condition. Unique high and low limits shall be assigned to each analog point in the system. Analog alarm limits shall be stored in the DDC database. Each analog alarm limit shall have an associated unique limit differential specifying the amount by which a variable must return into the proper operating range before being annunciated as a return-to-normal-state. All limits and differentials shall be entered on-line by the operator in limits of the measured variable, without interruption or loss of monitoring of the point concerned. The program shall automatically change the high or low limits or both, of any analog point, based on time scheduled operations as specified, allowing for a time interval before the alarm limit becomes effective. In CPA applications, key the limit to a finite deviation traveling with the setpoint. The system shall automatically suppress analog alarm reporting associated with a digital point when that digital point is turned off.

2.15.4.3 Pulse Accumulator Alarms Definition

Pulse accumulator alarms are those conditions calculated from totalized values of accumulator inputs or PA input rates that are outside defined limits as specified and shown. PA totalized values shall be compared to predefined limits and alarmed each time a value enters a limit condition. Unique limits shall be assigned to each PA point in the system. Limits shall be stored in the DDC database.

2.15.5 Constraints

2.15.5.1 Equipment Constraints Definitions

Each control point in the database shall have DDC resident constraints defined and entered by the Contractor, including as applicable:

- a. Maximum starts (cycles) per hour.

- b. Minimum off time.
- c. Minimum on time.
- d. High limit (value in engineering units).
- e. Low limit (value in engineering units).

2.15.5.2 Constraints Checks

Control devices connected to the system shall have the DDC memory resident constraints checked before each command is issued to insure that no equipment damage will result from improper operation. Each command shall be executed by the DDC only after all constraints checks have been passed. Each command point shall have unique constraints assigned. High and low "reasonableness" values or one differential "rate-of-change" value shall be assigned to each AI. Values outside the reasonableness limits shall be rejected and an alarm message sent to the network control panel or portable workstation/tester. Status changes and analog point values shall be reported to the workstation upon operator request, such as for reports, alphanumeric displays, graphic displays, and application programs. Each individual point shall be capable of being selectively disabled by the operator from a workstation/tester. Disabling a point shall prohibit monitoring and automatic control of that point.

2.15.6 Diagnostics

Each DDC shall have self-test diagnostic routines implemented in firmware. The tests shall include routines that exercise memory. Diagnostic software shall be usable in conjunction with the central workstation/tester and portable workstation/tester. The software shall display messages in English to inform the tester's operator of diagnosed problems.

2.15.7 Summer-Winter Operation Monitoring

The system shall provide software to automatically change the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system from summer to winter and vice-versa. The software shall provide automatic commands to applications programs to coordinate proper summer or winter operation. Change over setpoints shall be operator selectable and settable.

2.15.8 Control Sequences and Control Loops

Sufficient memory shall be provided to implement the requirements specified and shown for each DDC. Specific functions to be implemented are defined in individual system control sequences and database tables shown in the drawings, and shall include, as applicable, the following:

- a. PI Control: This function shall provide proportional control and proportional plus integral control.
- b. Two Position Control: This function shall provide control for a two state device by comparing a set point against a process variable and an established deadband.
- c. Floating Point Control: This function shall exercise control when an error signal exceeds a selected deadband, and shall maintain control until the error is within the deadband limits.
- d. Signal Selection: This function shall allow the selection of the highest or lowest analog value from a group of analog values as the basis of control. The function shall include the ability to cascade analog values so that

large numbers of inputs can be reduced to one or two outputs.

e. Signal Averaging: This function shall allow the mathematical calculation of the average analog value from a group of analog values as the basis of control. The function shall include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control.

f. Reset Function: This function shall develop an AO based on up to two AIs and one operator specified reset schedule.

g. Cooling/Heating Operation Program: Software shall be provided to change, either automatically or on operator command, the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system where such a change from cooling to heating and vice versa is meaningful. The software shall provide commands to application programs to coordinate cooling or heating mode operation. Software shall automatically switch facilities from cooling to heating, and vice versa, based on schedules or temperatures. All HVAC equipment and systems shall be assigned to the program.

2.15.9 Command Priorities

A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the on and off states, insuring that the correct command shall be issued when the time constraint is no longer in effect or report the rejected command. Override commands entered by the operator shall have higher priority than those emanating from applications programs.

2.15.10 Resident Application Software

The Contractor shall provide resident applications programs to achieve the sequences of operation, parameters, constraints, and interlocks necessary to provide control of the systems connected to the DDC system. Application programs shall be resident and shall execute in the DDC, and shall coordinate with each other, to insure that no conflicts or contentions remain unresolved. The Contractor shall coordinate the application programs specified with the equipment and controls operation, and other specified requirements. A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the ON and OFF states, insuring that the correct command shall be issued when the time constraint is no longer in effect or the rejected command shall be reported. Override commands entered by the operator shall have higher priority than those emanating from application programs.

2.15.10.1 Program Inputs and Outputs

The Contractor shall select the appropriate program inputs listed for each application program to calculate the required program outputs. Where the specific program inputs are not available, a "default" value or virtual point appropriate for the equipment being controlled and the proposed sequence of operation shall be provided to replace the missing input, thus allowing the application program to operate. AIs to application programs shall have an operator adjustable deadband to preclude short cycling or hunting. Program outputs shall be real analog or digital outputs or logic (virtual) points as required to provide the specified functions. The Contractor shall select the appropriate input and output signals to satisfy the requirements for control of systems as shown.

2.15.10.2 DDC General Conditions

The Contractor shall provide software required to achieve the sequences of operation, parameters, constraints, and interlocks shown. Application software shall be resident in the DDC in addition to any other required software. In the event of a DDC failure, the controlled equipment shall continue to function in the failure mode shown.

2.15.10.3 Scheduled Start/Stop Program

This program shall start and stop equipment based on a time of day schedule for each day of the week, and on a holiday schedule. To eliminate power surges, an operator adjustable time delay shall be provided between consecutive start commands.

a. Program Inputs:

- (1) Day of week/holiday.
- (2) Time of day.
- (3) Cooling and heating high-low alarm limits.
- (4) Cooling and heating start-stop schedules.
- (5) Cooling or heating mode of operation.
- (6) Equipment status.
- (7) Equipment constraints.
- (8) Consecutive start time delay.

b. Program Outputs: Start/stop signal.

2.15.10.4 Optimum Start/Stop Program

This program shall start and stop equipment as specified for the scheduled start/stop program, but shall include a sliding schedule based on indoor and outdoor air conditions. The program shall take into account the thermal characteristics of the structure, and indoor and outdoor air conditions, using prediction software to determine the minimum time of HVAC system operation needed to satisfy space environmental requirements at the start of the occupied cycle, and determine the earliest time for stopping equipment at the day's end without exceeding space environmental requirements. An adaptive control algorithm shall be utilized to automatically adjust the constants used in the program.

a. Program Inputs:

- (1) Day of week/holiday.
- (2) Time of day.
- (3) Cooling or heating mode of operation.
- (4) Equipment status.
- (5) Cooling and heating building occupancy schedules.
- (6) Space temperature.
- (7) Building heating constant (operator adjustable and automatically optimized).

- (8) Building cooling constant (operator adjustable and automatically optimized).
- (9) OA temperature.
- (10) Required space temperature at occupancy (heating).
- (11) Required space temperature at occupancy (cooling).
- (12) Equipment constraints.
- (13) Cooling and heating high-low alarm limits.

b. Program Outputs: Start/stop signal.

2.15.10.5 Day-Night Setback Program

The software shall limit the rise or drop of space temperature (or specified fluid temperature) during unoccupied hours. Whenever the space temperature (or specified fluid temperature) is above (or below for heating) the operator assigned temperature limit, the system shall be turned on until the temperature is within the assigned temperature limit.

a. Program Inputs:

- (1) Day of week.
- (2) Time of day.
- (3) Cooling or heating mode of operation.
- (4) Cooling and heating occupancy schedules.
- (5) Equipment status.
- (6) Space temperature (or specified fluid temperature).
- (7) Minimum space temperature (or specified fluid temperature) during unoccupied periods.
- (8) Maximum space temperature (or specified fluid temperature) during unoccupied periods.
- (9) Equipment constraints.

b. Program Outputs: Start/stop signal.

2.15.10.6 Economizer Program I

The software shall reduce the HVAC system cooling requirements when the OA dry bulb temperature is less than the return air temperature. When the OA dry bulb temperature is above the return air temperature or changeover setpoint, the OA dampers, return air dampers, and relief air dampers shall be positioned to provide minimum required OA. When the OA dry bulb temperature is below a changeover setpoint temperature, the OA dampers, return air dampers, and exhaust air dampers shall be positioned to maintain the required mixed air temperature.

a. Program Input:

- (1) Changeover conditions.
- (2) OA dry bulb temperature.

- (3) RA dry bulb temperature.
- (4) Mixed air dry bulb temperature.
- (5) Equipment constraints.

b. Program Output: Damper actuator/cooling control signal.

2.15.10.7 Ventilation/Recirculation and Flush Programs

The software shall reduce the HVAC system thermal load for two modes of operation and provide for flushing of the building as follows:

a. Ventilation mode: In this mode, the system shall precool the space prior to building occupancy. When the outside air temperature is lower than the space temperature, the outside air damper and exhaust air damper shall open to their maximum positions and the return air damper shall close to its minimum position.

b. Recirculation mode: In this mode, the system shall preheat the space prior to building occupancy. When the outside air temperature is lower than the space temperature, the outside air damper and the exhaust air damper shall close to their minimum positions and the return air damper shall open to its maximum position.

c. Flush mode: The software shall use the HVAC supply system to provide 100% outside air for ventilation purpose and flush building spaces. The network control panel shall modulate the control valves to maintain the air supply temperature setpoints while the flush program is in effect. The flush mode shall be manually initiated and have the highest priority (it shall override all other programs). The outside air damper and the exhaust air damper shall be closed at other times during unoccupied periods, except for economizer operation during day/night setback periods. For systems without mechanical cooling, this program shall, in addition to the above requirements, act as an economizer. The outside, return, and exhaust air dampers shall be modulated to maintain the required mixed air temperature setpoint. When this program is released, the outside and exhaust air dampers shall return to their minimum positions, and the return air damper shall return to its maximum position.

d. Program Inputs:

- (1) Day of week.
- (2) Time of day.
- (3) Cooling or heating mode of operation.
- (4) Equipment status.
- (5) Cooling and heating occupancy schedules.
- (6) OA dry bulb temperature.
- (7) Space temperature.
- (8) Equipment constraints.

e. Program Output: Damper actuator control signal.

2.15.10.8 Hot Deck/Cold Deck Temperature Reset Program

The software shall use space, mixed air, and deck temperatures to calculate the

hot deck/cold deck temperature setpoints in dual duct and multizone HVAC systems.

The program shall select the zones with the greatest heating and cooling requirements; establish the HVAC minimum hot and cold deck temperature differentials required to meet the zone temperatures; modulate valves to maintain deck temperature setpoints; and modulate zone dampers to maintain space temperature setpoints, without exceeding space humidity limits (where shown).

a. Program Inputs:

- (1) Space temperature setpoint.
- (2) Space humidity limit (where shown).
- (3) Mixing box damper position or proportional signal from primary element.
- (4) Hot deck temperature.
- (5) Cold deck temperature.
- (6) Zone temperatures (where shown).
- (7) Space RH (where shown).
- (8) Minimum space temperature during occupied periods.
- (9) Maximum space temperature during occupied periods.
- (10) Equipment constraints.

b. Program Outputs:

- (1) Hot deck valve actuator control signal.
- (2) Cold deck valve actuator control signal.
- (3) Zone damper or mixing box actuator control output signal.

2.15.10.9 Reheat Coil Reset Program

The software shall select the zone with the least amount of heat required. The program shall reset the cold deck discharge temperature upward until it satisfies the zone with the lowest demand, or until the zone humidity control requirements cannot be met.

a. Program Inputs:

- (1) Zone RH high limit.
- (2) Zone temperature (where shown).
- (3) Zone RH (where shown).
- (4) Cold deck temperature.
- (5) Reheat coil valve positions or proportional signals from primary elements.
- (6) Minimum space temperature during occupied periods.
- (7) Maximum space temperature during occupied periods.
- (8) Equipment constraints.

- b. Program Output: Cold deck valve actuator control signal.

2.15.10.10 Heating and Ventilating Unit Program

The software shall control hot water/steam coil valve position to maintain space/supply air temperatures for heating and ventilating units. This program shall be coordinated with the ventilation-recirculation program for damper control and the scheduled or optimum start-stop program for fan control.

- a. Program Inputs

- (1) Space temperature.
- (2) Space temperature setpoint.
- (3) Supply air temperature.
- (4) Supply air temperature setpoint.

- b. Program Outputs

- (1) Heating or steam coil valve actuator control signal.
- (2) Damper actuator control signal.

2.15.10.11 Air Volume Control Program

The software shall monitor supply and return/exhaust air flow volumes and modulate fan controls to maintain required air flow volumes and/or ratio or fixed differential of supply to return air flows. This program shall be coordinated with the ventilation-recirculation program and the economizer program for damper control and with static pressure control requirements for fan control.

- a. Program Inputs

- (1) Supply air flow.
- (2) Return/exhaust air flow.
- (3) Required supply air flow - high and low limits.
- (4) Required return/exhaust air flow - high and low limits.
- (5) Volume offset or ratio, as appropriate.

- b. Program Outputs

- (1) Supply fan volume control.
- (2) Return/exhaust fan volume control.

2.15.10.12 Air Distribution Unitary Controller Software

Software shall be provided for the management and control of the air distribution terminal units. Software shall allow for operator definition of multiple air distribution terminal units as functional groups which may be treated as a single entity; monitoring, alarming and reporting of terminal unit parameters on an individual or group basis; and remote setpoint adjustment on an individual or group basis.

- a. Functions:

- (1) Volume control in response to temperature.
- (2) Volume flow limits, minimum and maximum.
- (3) Occupied and unoccupied operation with associated temperature and volume limits.
- (4) Temperature setpoint override.

- b. Program Inputs

- (1) Space temperature.

- (2) Space temperature setpoint.
- (3) Space temperature setpoint limits.
- (4) Supply airflow volume.
- (5) Supply airflow volume high and low limits.

c. Program Outputs

- (1) Supply volume control signal.
- (2) Auxiliary fan start/stop signal.
- (3) Supplemental heat control signal.

2.15.10.13 Chiller Selection Program

Chiller program shall be used for chiller selection as well as control and monitoring of chillers. The software shall select the most efficient chiller or combination of chillers based on chiller operating data to satisfy the cooling load. Based on chiller operating data, energy input vs chilled water output, the chiller with the highest efficiency shall be selected to satisfy the cooling load calculated by prediction software. The program shall calculate equipment electrical energy input based on percent full load, current, or other inputs provided, and equipment nameplate data. The program shall prevent the chiller from going to full load for a predetermined period to allow the system to stabilize, in order to determine the actual cooling load. The program shall follow the chiller manufacturer's startup and shutdown sequence requirements. Interlocks between chilled water pumps, condenser water pumps, and chiller shall be in accordance with the chiller manufacturer's requirements.

a. Program Inputs

- (1) Efficiency curves.
- (2) Chiller water supply temperatures.
- (3) Chiller water return temperatures.
- (4) Chiller water flows.
- (5) Entering condenser water temperatures.
- (6) Leaving condenser water temperatures.
- (7) Condenser water flows.
- (8) Instantaneous KW to chillers.
- (9) Instantaneous KW to chilled water pumps (if variable).
- (10) Instantaneous KW to condenser water pumps (if variable).
- (11) Instantaneous KW to cooling tower fans (if variable).
- (12) Common chilled water supply temperatures.
- (13) Common chilled water return temperatures.
- (14) Total chilled water flow.
- (15) Chilled water pumps status.
- (16) Refrigerant pressure, suction and discharge.
- (17) Equipment constraints.
- (18) Steam flow.

b. Program Outputs

- (1) Start/stop signals for chillers (manual or automatic to control panel).
- (2) Start/stop signals for chilled water pumps (manual or automatic to control panel).
- (3) Start/stop signals for condenser water pumps (manual or automatic to control panel).
- (4) Start/stop signals for cooling tower fans (manual or automatic to control panel).
- (5) Chilled water supply temperature setpoint control signal.
- (6) Chiller efficiency.

2.15.10.14 Chilled Water Temperature Reset Program

The software shall reset the chilled water temperature supplied by a water chiller. The program shall reset the chilled water temperature upward or downward to meet the required space temperature or humidity setpoints. The program shall monitor the positions of the chilled water control valves (percent of opening) and space temperatures.

a. Program Input:

- (1) Chilled water valve position.
- (2) High limit for space dry bulb temperature.
- (3) Chiller supply water temperature.
- (4) High chilled water operating temperature.
- (5) Low chilled water operating temperature.
- (6) High limit for space RH.
- (7) Equipment constraints.

b. Program Output: Chilled water supply temperature setpoint control signal.

2.15.10.15 Condenser Water Temperature Reset Program

The software shall reset the condenser water temperature from a fixed temperature downward when the OA wet bulb temperature will produce lower condenser water temperature. Program shall be coordinated with the chiller control loop algorithms for chiller supply, return water temperatures and safety interlocks.

a. Program Inputs:

- (1) Maximum condenser water operating temperature.
- (2) Minimum condenser water operating temperature.
- (3) Condenser water supply temperature.
- (4) OA dry bulb temperature.
- (5) OA RH.
- (6) Condenser water cooling equipment thermal approach characteristics.
- (7) Equipment constraints.

b. Program Output: Condenser water supply temperature setpoint control signal.

2.15.10.16 Chiller Demand Limit Program

The software shall limit maximum available chiller cooling capacity in fixed steps as shown to limit electrical demand. Each fixed step shall be considered as one point in the demand limiting program. Each chiller demand control step shall be assigned an equipment priority level.

a. Program Inputs:

- (1) Chiller percent capacity.
- (2) Minimum cooling capacity.
- (3) Equipment priority schedules.
- (4) Equipment constraints.

b. Program Output

- (1) Calculated percent load point.
- (2) Control signal to chiller controller/panel, new setpoint (manual or automatic as shown).

2.15.10.17 Hot Water OA Reset Program

The software shall reset the hot water temperature supplied by the boiler or converter in accordance with the OA temperature or other specified independent-

dent variable. The hot water supply temperature shall be reset downward or upward from a fixed temperature proportionally, as a function of OA temperature or other specified independent variable.

a. Program Inputs

- (1) Reset schedule.
- (2) OA dry bulb temperature or other specified independent variable.
- (3) Hot water supply temperature.
- (4) Maximum hot water supply temperature.
- (5) Minimum hot water supply temperature.
- (6) Equipment constraints.

b. Program Output: Valve actuator control signal.

2.15.10.18 Boiler Monitoring and Control

The software shall remotely monitor and control boiler operation based on boiler operational data. The program shall monitor inputs and discontinue boiler operation if any monitored point exceeds a predetermined value or changes status incorrectly. The operator shall be able to add or delete individual program input points from the list of points that will discontinue boiler operation.

a. Program Inputs

- (1) Fuel flow.
- (2) Fuel pressure (natural gas).
- (3) Fuel temperature (heated fuel oil).
- (4) Flame status.
- (5) Flue gas oxygen.
- (6) Flue gas temperature.
- (7) Make-up or feed water flow.
- (8) Furnace draft.
- (9) Flue gas carbon monoxide (for boilers over 20 million BTUs).
- (10) Hot water flow.
- (11) Hot water pressure.
- (12) Hot water supply temperature.
- (13) Hot water return temperature.
- (14) Hot water BTUs.
- (15) Steam flow.
- (16) Steam pressure.
- (17) Steam temperature.
- (18) Steam BTUs.
- (19) Feedwater temperature.
- (20) Boiler drum level.

b. Program Outputs

- (1) Boiler enable/disable control signal.
- (2) Boiler enable/disable permission to boiler operator for manual control.
- (3) Boiler efficiency.

2.15.10.19 Hot Water Distribution Program

The software shall control the hot water distribution temperature to individual building zones. The zone hot water distribution temperature shall be reset downward or upward from a fixed temperature proportionally as a function of OA temperature or other specified independent variable by modulating the respective zone mixing valve. The zone pump shall be stopped when the OA temperature exceeds the specified setpoint. When parallel pumps are used, the software shall alternate pump operation and shall start the standby pump (after a time delay) upon failure of the operating pump.

a. Program Inputs

- (1) Zone hot water distribution temperature.
- (2) Reset schedule.
- (3) OA dry bulb temperature or other specified independent variable.
- (4) Maximum zone hot water distribution temperature.
- (5) Zone pump status.
- (6) Equipment constraints.

b. Program Outputs

- (1) Zone mixing valve control.
- (2) Zone pump start/stop signal(s).

2.15.10.20 Domestic Hot Water Generator Program

The software shall control the domestic hot water temperature by adjusting the hot water heating control valve.

a. Program Inputs

- (1) Domestic hot water temperature.
- (2) Domestic hot water temperature setpoint.

b. Program Output: Hot water heating control valve actuator control signal.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION CRITERIA

3.1.1 HVAC Control System

The HVAC control system shall be completely installed and ready for operation. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The HVAC control system installation shall provide clearance for control system maintenance by maintaining access space between coils, access space to mixed-air plenums, and other access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.2 Software Installation

Software shall be loaded for an operational system, including databases for all points, operational parameters, and system, command, and application software. The Contractor shall provide original and backup copies of source, excluding the general purpose operating systems and utility programs furnished by computer manufacturers and the non-job-specific proprietary code furnished by the system manufacturer, and object modules for software on each type of media utilized, within 30 days of formal Government acceptance. In addition, a copy of individual floppy disks of software for each DDC panel shall be provided.

3.1.3 Device Mounting Criteria

Devices mounted in or on piping or ductwork, on building surfaces, in mechanical/electrical spaces, or in occupied space ceilings shall be installed in accordance with manufacturer's recommendations and as shown. Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified.

3.1.4 Wiring Criteria

Wiring external to control panels, including low-voltage wiring, shall be installed in metallic raceways. Wiring shall be installed without splices between control devices and DDC panels. Instrumentation grounding shall be installed as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Ground rods installed by the contractor shall be tested as specified in IEEE Std 142. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings. Electrical work shall be as specified in Section 16415A ELECTRICAL WORK, INTERIOR and as shown.

3.2 CONTROL SYSTEM INSTALLATION

3.2.1 Damper Actuators

Actuators shall not be mounted in the air stream. Multiple actuators operating a common damper shall be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

3.2.2 Local Gauges for Actuators

Pneumatic actuators shall have an accessible and visible receiver gauge installed in the tubing lines at the actuator as shown.

3.2.3 Room Instrument Mounting

Room instruments, such as wall mounted thermostats, shall be mounted 1.5 m above the floor unless otherwise shown. Temperature setpoint devices shall be recess mounted.

3.2.4 Freezestats

For each 2 square meters of coil face area, or fraction thereof, a freezestat shall be provided to sense the temperature at the location shown. Manual reset freezestats shall be installed in approved, accessible locations where they can be reset easily. The freezestat sensing element shall be installed in a serpentine pattern.

3.2.5 Averaging Temperature Sensing Elements

Sensing elements shall have a total element minimum length equal to 3 m per square meter of duct cross-sectional area.

3.2.6 Foundations and Housekeeping Pads

Foundations and housekeeping pads shall be provided for the HVAC control system air compressors.

3.2.7 Compressed Air Stations

The air compressor assembly shall be mounted on vibration eliminators, in accordance with ASME BPVC SEC VIII D1 for tank clearance. The air line shall be connected to the tank with a flexible pipe connector. Compressed air station specialties shall be installed with required tubing, including condensate tubing to a floor drain.

3.2.8 Duct Static Pressure Sensing Elements and Transmitters

The duct static pressure sensing element and transmitter sensing point shall be

located at 75% to 100% of the distance between the first and last air terminal units.

3.2.9 Indication Devices Installed in Piping and Liquid Systems

Gauges in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

3.2.10 Tubing

3.2.10.1 Control System Installation

The control system shall be installed so that pneumatic lines are not exposed to outside air temperatures. All tubes and tube bundles exposed to view shall be installed neatly in lines parallel to the lines of the building. Tubing between panels and actuators in mechanical/electrical spaces shall be routed so that the lines are easily traceable.

3.2.10.2 Pneumatic Lines In Mechanical/Electrical Spaces

In mechanical/electrical spaces, pneumatic lines shall be copper tubing. Horizontal and vertical runs of soft copper tubes shall be installed in raceways dedicated to tubing. Dedicated raceways and tubing not installed in raceways shall be supported every 2 m for horizontal runs and every 2.5 m for vertical runs.

3.2.10.3 Pneumatic Lines External To Mechanical/Electrical Spaces

Tubing external to mechanical/electrical spaces shall be soft copper with sweat fittings.

3.2.10.4 Connection to Liquid and Steam Lines

Tubing for connection of sensing elements and transmitters to liquid and steam lines shall be copper with brass compression fittings.

3.2.10.5 Connection to Ductwork

Tubing for connection of sensing elements and transmitters to ductwork shall be plastic tubing.

3.2.10.6 Final Connection to Actuators

Final connections to actuators shall be plastic tubing 300 mm long and unsupported at the actuator.

3.3 COMMISSIONING PROCEDURES

3.3.1 Evaluations

The Contractor shall make the observations, adjustments, calibrations, measurements, and tests of the control systems, set the time schedule, and make any necessary control system corrections to ensure that the systems function as described in the sequence of operation.

3.3.1.1 Item Check

Signal levels shall be recorded for the extreme positions of each controlled device. An item-by-item check of the sequence of operation requirements shall be performed using Steps 1 through 4 in the specified control system commissioning procedures. Steps 1, 2, and 3 shall be performed with the HVAC system shut down;

Step 4 shall be performed after the HVAC systems have been started. External input signals to the DDC system (such as starter auxiliary contacts, and external systems) may be simulated in steps 1, 2, and 3. With each operational mode signal change, DDC system output relay contacts shall be observed to ensure that they function.

3.3.1.2 Weather Dependent Test Procedures

The cooling system shall be commissioned when the outside air temperature is greater than 80 degrees F. The heating system shall be commissioned when the outside air temperature is less than 32 degrees F. All air handling systems which handle outdoor air shall be commissioned twice, once when outside air temperature is less than 32 degrees F, and also when outside air temperature is greater than 80 degrees F.

3.3.1.3 Two-Point Accuracy Check

A two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by comparing the DDC system readout to the actual value of the variable measured at the sensing element and transmitter or airflow measurement station location. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensing element-to-DDC system readout accuracy. The calibration of the test instruments shall be traceable to National Institute Of Standards And Technology standards. The first check point shall be with the HVAC system in the shutdown condition, and the second check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element-to-DDC system readout accuracies at two points are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the calibration check repeated.

3.3.1.4 Insertion and Immersion Temperatures

Insertion temperature and immersion temperature sensing elements and transmitter-to-DDC system readout calibration accuracy shall be checked at one physical location along the axis of the sensing element.

3.3.1.5 Averaging Temperature

Averaging temperature sensing element and transmitter-to-DDC system readout calibration accuracy shall be checked every 600 mm along the axis of the sensing element in the proximity of the sensing element, for a maximum of 10 readings. These readings shall then be averaged.

3.3.2 Space Temperature Controlled Perimeter Radiation

The heating medium shall be turned on, and the thermostat temperature setpoint shall be raised. The valve shall open. The thermostat temperature shall be lowered and the valve shall close. The thermostat shall be set at the setpoint shown.

3.3.3 Unit Heater and Cabinet Unit Heater

The "OFF/AUTO" switch shall be placed in the "OFF" position. Each space thermostat temperature setting shall be turned up so that it makes contact to turn on the unit heater fans. The unit heater fans shall not start. The "OFF/AUTO" switch shall be placed in the "AUTO" position. It shall be ensured that the unit heater fans start. Each space thermostat temperature setting shall be turned down, and the unit heater fans shall stop. The thermostats shall be set at their temperature setpoints. The results of testing of one of each type of unit shall be logged.

3.3.4 Fan Coil Unit

The dual-temperature hydronic system shall be set to heating. Each space thermostat temperature setting shall be turned up so that it makes contact and turns the fan coil unit on. It shall be ensured that the fan coil unit fan starts and the valves open to flow through the coils. Each space thermostat temperature setting shall be turned down and it shall be ensured that the fan coil unit fans stop. It shall be ensured that the valves close to flow through the coils. The dual-temperature hydronic system shall be switched to cooling. Each space thermostat temperature setting shall be turned up and it shall be ensured that contact is broken and the fan coil unit fans stop. It shall be ensured that the valves close to flow through the coil. Each space thermostat temperature setting shall be turned down. It shall be ensured that the fan coil unit fans start and the valves open to flow through the coils. The thermostats shall be set at their temperature setpoints. The results of testing of one of each type of unit shall be logged.

3.3.5 Single Building Hydronic Heating with Hot Water Boiler

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available where required.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air temperature and system supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: N/A.

d. Step 4 - Control System Commissioning:

(1) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments to setpoints or parameters shall be made to achieve the outside air temperature schedule.

(2) The outside air temperature shall be simulated through an operator entered value to be above the setpoint. It shall be verified that pumps and boilers stop. A value shall be entered to simulate that the outside air temperature is below the setpoint as shown. It shall be verified that pumps start and boilers are fired in sequence. It shall be verified that each boiler recirculation pump starts when its respective boiler is firing. Each current switch reading shall be verified at the operator's console.

(3) The two-point calibration accuracy check of the sensing element-to-DDC system readout for the hydronic system supply temperature shall be performed. The supply temperature setpoint shall be set for the temperature schedule as shown. Signals at two points sent to the DDC system from the outside air temperature sensor, to verify that the supply temperature setpoint changes to the appropriate values.

3.3.6 Single Building Cooling System

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available

where required.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air temperature and system supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: N/A.

d. Step 4 - Control System Commissioning:

(1) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments to setpoints or parameters shall be made to achieve the outside air temperature schedule.

(2) The outside air temperature shall be simulated through an operator entered value to be below the setpoint. It shall be verified that pumps stop. A value shall be entered to simulate that the outside air temperature is above the setpoint as shown. It shall be verified that pumps start. Each current switch reading shall be verified at the operator's console.

(3) The two-point calibration accuracy check of the sensing element-to-DDC system readout for the hydronic system supply temperature shall be performed. The supply temperature setpoint shall be set for the temperature schedule as shown. Signals at two points sent to the DDC system from the outside air temperature sensor, to verify that the supply temperature setpoint changes to the appropriate values.

3.3.7 Heating and Ventilating Unit

Steps for installation are as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside air damper and relief air damper are closed, and the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for space temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero to full range, and that the actuators travel from zero stroke to full stroke within the signal range shall be verified. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the system shall be placed in the ventilation delay mode and in the occupied mode through operator entered values. It shall be verified that supply fan starts. It shall be verified that the outside air and relief air dampers are closed, the

return air damper is open, and the heating coil valve is under control, by artificially changing the space temperature through operator entered values. The system shall be placed out of the ventilation delay mode, and it shall be verified that the outside air, return air, and relief air dampers come under control by simulating a change in space temperature.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The calibration accuracy check of sensing element-to-DDC system readout for the space temperature shall be performed. The space temperature setpoint shall be set as shown.

(4) The control system shall be placed in the unoccupied mode, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set as shown.

(5) With the HVAC system running, a filter differential pressure switch input signal shall be simulated, at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint as shown.

(6) With the HVAC system running, a signal shall be applied to simulate an outdoor-air temperature of 38 degrees F. It shall be verified that the cooling coil recirculation pump starts and runs continuously. A signal shall be applied to simulate a unit leaving air temperature of 34 degrees F. It shall be verified that a low temperature alarm is initiated at the operator's console and the unit shuts down. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(7) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and verification of control device actions and interlock functions as described in the Sequence of Operation shall be made. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm signal is changed to a return-to-normal signal.

(8) With the HVAC system running, an emergency shutdown switch signal shall be simulated. It shall be verified that the HVAC system shuts down and that the shutdown alarm is initiated at the operator's console.

(9) With the HVAC system running, the fan status current switches shall be verified at the operator's console.

3.3.8 Multizone Control System without Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required; that the outside air damper, and relief air damper are closed; and that the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, mixed air, cold-deck, and hot-deck temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fans ready to start, the system shall be placed in the ventilation delay mode (COF only) and in the occupied mode, and it shall be verified that supply fan starts. It shall be verified that the outside air and relief air dampers are closed, and the return air damper is open, by artificially changing the mixed air temperature through operator entered values. The system shall be placed in the occupied mode and it shall be verified that the outside air, return air, and relief air dampers come under control, by artificially changing the mixed air temperature.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The mixed air temperature shall be artificially changed through operator entered values to slightly open the outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and mixed air temperatures shall be performed. The temperature setpoint shall be set as shown.

(4) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments shall be made to setpoints or parameters to achieve the outside air temperature schedule as shown.

(5) The system shall be placed in economizer mode. The two-point calibration accuracy check of sensing element-to-DDC system readout for mixed-air temperatures shall be performed. The outside air temperature shall be artificially changed through operator entered values. Three values shall be entered simulating outside air temperature changes. The values shall be selected at midrange, lower 1/3 range, and upper 1/3 range of the temperature schedule. It shall be verified that the setpoint tracks the schedule.

(8) The control system shall be placed in the unoccupied mode, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. Where night setback is required, the space temperature shall be artificially changed to below the night setback setpoint and it shall be verified that the HVAC system

starts; the space temperature shall be artificially changed to above the night setback setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set as shown.

(9) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint.

(10) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. It shall be verified that the cooling coil recirculation pump starts and runs. It shall be verified that the outdoor air and return air dampers are modulated to raise the mixed air temperature until the freezestat resets. It shall be verified that a low temperature warning is initiated at the operator's console. A signal shall be applied to simulate a unit leaving air temperature of 34 degrees F. It shall be verified that a low temperature alarm is initiated at the operator's console and the unit shuts down. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(11) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarms any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. HVAC system shall be restarted by manual reset, and it shall be verified that the alarm signal is changed to a return-to-normal signal.

(12) The temperature setpoint of each zone thermostat shall be raised and it shall be verified that the zone damper closes to the cold-deck and opens to the hot-deck. Each zone thermostat shall be calibrated and set at its setpoint as shown.

(13) With the HVAC system running, an emergency shutdown switch signal shall be simulated. It shall be verified that the HVAC system shuts down and that the shutdown alarm is initiated at the operator's console.

(14) With the HVAC system running, the fan status current switches shall be verified at the operator's console.

3.3.9 Variable Air Volume Makeup Air Unit (Barracks AHU-1)

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside air and relief air dampers are closed, the return air damper is open, and the supply fan is off and coil valves are closed.

b. Step 2 - Calibration Accuracy Check with HVAC System in Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for AHU supply and laundry room temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuators through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and

it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the control system shall be placed in the the enabled mode through operator entered values. It shall be verified that supply fan starts. It shall be verified that the outside air damper is open, and the cooling coil valve, heating coil valve and fan speed are under control, by simulating a change in the fan discharge temperature.

(2) The two-point calibration accuracy check for sensing element-to-DDC system readout for the static pressure in the supply duct shall be performed.

(3) The two-point calibration accuracy check of sensing element-to-DDC system readout for the fan discharge temperature shall be performed. The setpoint for the fan discharge temperature shall be set as shown. A change shall be simulated in the discharge air temperature through an operator entered value and it shall be verified that the control valves are modulated.

(4) The control system shall be placed in the unoccupied mode and it shall be verified that the HVAC system shuts down and the control system assumes the specified shutdown conditions.

(5) With the HVAC system enabled and all clothes dryer current switches closed, it shall be verified that the air handler fan is stopped. Clothier dryer current switches for all dryers shall be closed to simulate operating dryers. It shall be verified that the fan starts and drives to full speed (60 HZ). One by one, the current switches shall be opened. For each opened switch, it shall be verified that the fan speed is reduced by 6.25% until only a single switch is left. It shall be verified that the fan operates at a speed corresponding to 5 HZ.

(6) The space temperature shall be simulated to be below the heating setpoint and it shall be verified that the VAV box fan starts. The space temp signal shall be simulated above the heating setpoint and it shall be verified that the fan stops.

(7) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated at the operator's console. The differential pressure switch shall be set at the setpoint. This shall be performed for each filter.

(8) With the HVAC system running, a signal shall be applied to simulate an outdoor-air temperature of 38 degrees F. It shall be verified that the cooling coil recirculation pump starts and runs continuously. A signal shall be applied to simulate a unit leaving air temperature of 34 degrees F. It shall be verified that a low temperature alarm is initiated at the operator's console and the unit shuts down. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(10) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarms any Life

Safety systems. It shall be verified that the HVAC system shuts down and the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm returns to normal.

(11) With the HVAC system running, an emergency shutdown switch signal shall be simulated. It shall be verified that the HVAC system shuts down and that the shutdown alarm is initiated at the operator's console.

(12) With the HVAC system running, the fan status current switches shall be verified at the operator's console.

3.3.10 Blower Coil Make-up Air Units

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. The system shall be checked to see that power and main air are available where required, that the outside air damper is closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, and space temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and the actuator travel from zero stroke to full stroke within the signal range shall be verified. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the control system shall be placed in the occupied (or enabled), and it shall be verified that supply fan starts. It shall be verified that the outside air damper opens, and the heating coil and cooling coil valves are under control, by simulating a change in the space temperature through an operator entered value.

(4) An unoccupied (disabled) mode signal shall be applied, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions.

(5) With the HVAC system running, a filter differential pressure switch input signal shall be simulated, at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint as shown.

(6) With the HVAC system running, a signal shall be applied to simulate an outdoor-air temperature of 38 degrees F. It shall be verified that the cooling coil recirculation pump starts and runs continuously. A signal shall be applied to simulate a unit leaving air temperature of 34 degrees F. It shall be verified that a low temperature alarm is initiated at the operator's console and the unit shuts down. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(7) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and verification of control device actions and interlock functions as described in the Sequence of Operation shall be made. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm signal is changed to a return-to-normal signal.

(8) With the HVAC system running, an emergency shutdown switch signal shall be simulated. It shall be verified that the HVAC system shuts down and that the shutdown alarm is initiated at the operator's console.

(9) With the HVAC system running, the fan status current switches shall be verified at the operator's console.

3.4 BALANCING, COMMISSIONING, AND TESTING

3.4.1 Coordination with HVAC System Balancing

Commissioning of the control system, except for tuning of controllers, shall be performed prior to or simultaneous with HVAC system balancing. The contractor shall tune the HVAC control system after all air system and hydronic system balancing has been completed, minimum damper positions set and a report has been issued.

3.4.2 Control System Calibration, Adjustments, and Commissioning

Control system commissioning shall be performed for each HVAC system, using test plans and procedures previously approved by the Government. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform commissioning and testing of the HVAC control system. All instrumentation and controls shall be calibrated and the specified accuracy shall be verified using test equipment with calibration traceable to NIST standards. Wiring shall be tested for continuity and for ground, open, and short circuits. Tubing systems shall be tested for leaks. Mechanical control devices shall be adjusted to operate as specified. HVAC control panels shall be pretested off-site as a functioning assembly ready for field connections, calibration, adjustment, and commissioning of the operational HVAC control system. Control parameters and logic (virtual) points including control loop setpoints, gain constants, and integral constraints, shall be adjusted before the system is placed on line. Communications requirements shall be as indicated. Written notification of any planned commissioning or testing of the HVAC Control systems shall be given to the Government at least 14 calendar days in advance.

3.4.3 Performance Verification Test

The Contractor shall demonstrate compliance of the HVAC control system with the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. The performance verification test shall show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the Commissioning Report and completion of balancing. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems.

3.4.4 Endurance Test

The endurance test shall be used to demonstrate the specified overall system reliability requirement of the completed system. The endurance test shall not be started until the Government notifies the Contractor in writing that the performance verification test is satisfactorily completed. The Government may terminate the testing at any time when the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, the Contractor shall commence an assessment period as described for Phase II. Upon successful completion of the endurance test, the Contractor shall deliver test reports and other documentation as specified to the Government prior to acceptance of the system.

a. Phase I (Testing). The test shall be conducted 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized by the Government in writing.

b. Phase II (Assessment). After the conclusion of Phase I, the Contractor shall identify failures, determine causes of failures, repair failures, and deliver a written report to the Government. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing should be resumed. After delivering the written report, the Contractor shall convene a test review meeting at the jobsite to present the results and recommendations to the Government. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing appropriate portions of the performance verification test. Based on the Contractor's report and test review meeting, the Government may require that the Phase I test be totally or partially rerun. After the conclusion of any retesting which the Government may require, the Phase II assessment shall be repeated as if Phase I had just been completed.

3.4.5 Posted and Panel Instructions

Posted and Panel Instructions, showing the final installed conditions, shall be provided for each system. The posted instructions shall consist of laminated half-size drawings and shall include the control system schematic, equipment schedule, sequence of operation, wiring diagram, communication network diagram, and valve and damper schedules. The posted instructions shall be permanently affixed, by mechanical means, to a wall near the control panel. Panel instructions shall consist of laminated letter-size sheets and shall include a Routine Maintenance Checklist and as-built configuration check sheets. Panel instructions and one copy of the Operation and Maintenance Manuals, previously described herein, shall be placed inside each control panel or permanently affixed, by mechanical means, to a wall near the panel.

3.5 TRAINING

3.5.1 Training Course Requirements

A training course shall be conducted for 5 operating staff members designated by the Contracting Officer in the maintenance and operation of the system, including specified hardware and software. The training period, for a total of 32 hours of normal working time, shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site. Audiovisual equipment and 5 sets of all other training materials and supplies shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.5.2 Training Course Content

For guidance in planning the required instruction, the Contractor shall assume that attendees will have a high school education or equivalent, and are familiar

with HVAC systems. The training course shall cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each HVAC control panel, the layout of one of each type of unitary equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the calibration, adjustment and commissioning report shall be presented as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

-- End of Section --

SECTION 16370A

ELECTRICAL DISTRIBUTION SYSTEM, AERIAL
07/02

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

| | |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ANSI C29.1 | (1988; R 1996) Electrical Power Insulators - Test Methods |
| ANSI C29.2 | (1992) Insulators - Wet-Process Porcelain and Toughened Glass - Suspension Type |
| ANSI C29.3 | (1986; R 1995) Wet Process Porcelain Insulators - Spool Type |
| ANSI C29.4 | (1989; R 1995) Wet-Process Porcelain Insulators - Strain Type |
| ANSI C29.5 | (1984; R 1995) Wet-Process Porcelain Insulators - Low- and Medium-Voltage Types |
| ANSI C29.6 | (1996) Wet-Process Porcelain Insulators - High-Voltage Pin Type |
| ANSI C29.8 | (1985; R 1995) Wet-Process Porcelain Insulators - Apparatus, Cap and Pin Type |
| ANSI C29.9 | (1983; R 1996) Wet-Process Porcelain Insulators - Apparatus, Post-Type |
| ANSI C37.32 | (1996) High-Voltage Air Switches, Bus Supports, and Switch Accessories - Schedules of Preferred Ratings, Manufacturing Specifications, and Application Guide |
| ANSI C57.12.20 | (1997) Overhead Type Distribution Transformers, 500 KVA and Smaller: High Voltage 34 500 Volts and Below: Low Voltage, 7970/13 800 Y Volts and Below |
| ANSI C135.1 | (1979) Galvanized Steel Bolts and Nuts for Overhead Line Construction |
| ANSI C135.2 | (1999) Threaded Zinc-Coated Ferrous Strand-Eye Anchor Rods and Nuts for Overhead Line Construction |
| ANSI C135.4 | (1987) Zinc-Coated Ferrous Eyebolts and Nuts for Overhead Line Construction |
| ANSI C135.14 | (1979) Staples with Rolled or Slash Points for Overhead Line Construction |

ANSI C135.22 (1988) Zinc-Coated Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction

ANSI C135.30 (1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

ANSI O5.1 (1992) Specifications and Dimensions for Wood Poles

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36/A 36M (2001) Carbon Structural Steel

ASTM A 123/A 123M (2001a) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153/A 153M (2001a) Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A 475 (1998) Zinc-Coated Steel Wire Strand

ASTM A 575 (1996; R 2002) Steel Bars, Carbon, Merchant Quality, M-Grades

ASTM A 576 (1990b; R 2000) Steel Bars, Carbon, Hot-Wrought, Special Quality

ASTM B 1 (2001) Hard-Drawn Copper Wire

ASTM B 8 (1999) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B 117 (1997) Operating Salt Spray (Fog) Apparatus

ASTM B 228 (1998) Concentric-Lay-Stranded Copper-Clad Steel Conductors

ASTM B 230/B 230M (1999) Aluminum 1350-H19 Wire for Electrical Purposes

ASTM B 231/B 231M (2001e1) Concentric-Lay-Stranded Aluminum 1350 Conductors

ASTM B 232/B 232M (2001e1) Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)

ASTM B 398/B 398M (1999) Aluminum-Alloy 6201-T81 Wire for Electrical Purposes

ASTM B 399/B 399M (1999) Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors

ASTM B 416 (1998) Concentric-Lay-Stranded Aluminum-Clad Steel Conductors

ASTM D 923 (1997) Sampling Electrical Insulating Liquids

ASTM D 1654 (1992; R 2000) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D 4059 (2000) Analysis of Polychlorinated Biphenyls in

Insulating Liquids by Gas Chromatography.

AMERICAN WOOD-PRESERVERS' ASSOCIATION (AWPA)

| | |
|-------------|---------------------------------------------------------------------------------|
| AWPA C4 | (1999) Poles - Preservative Treatment by Pressure Processes |
| AWPA C25 | (2001) Sawn Crossarms - Preservative Treatment by Pressure Processes |
| AWPA P1/P13 | (2001) Standard for Creosote Preservative |
| AWPA P5 | (2001) Standard for Waterborne Preservatives |
| AWPA P8 | (2001) Standard for Oil-Borne Preservatives |
| AWPA P9 | (2001) Standards for Solvents and Formulations for Organic Preservative Systems |

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

| | |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| IEEE C2 | (2002) National Electrical Safety Code |
| IEEE C37.34 | (1994) Test Code for High-Voltage Air Switches |
| IEEE C37.41 | (2000) Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories |
| IEEE C37.60 | (1981; R 1992) Requirements for Overhead, Pad Mounted, Dry Vault and Submersible Automatic Circuit Reclosers and Fault Interrupters for AC Systems |
| IEEE C37.63 | (1997) Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems |
| IEEE C57.12.00 | (2000) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers |
| IEEE C57.13.2 | (1991) Standard Conformance Test Procedures for Instrument Transformers |
| IEEE C57.15 | (1999) Requirements, Terminology, and Test Code for Step-Voltage Regulators |
| IEEE C57.19.00 | (1991; R 1997) Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings |
| IEEE C57.19.01 | (2000) Performance Characteristics and Dimensions for Outdoor Apparatus Bushings |
| IEEE C57.98 | (1994) Guide for Transformer Impulse Tests |
| IEEE C62.1 | (1989; R 1994) Surge Arresters for AC Power Circuits |
| IEEE C62.2 | (1987; R 1994) Guide for the Application of Gapped Silicon-Carbide Surge Arresters for Alternating Current Systems |

IEEE C62.11 (1999) Metal-Oxide Surge Arresters for AC Power Circuits

IEEE Std 18 (1992) Shunt Power Capacitors

IEEE Std 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)

IEEE Std 100 (2000) IEEE Standard Dictionary of Electrical and Electronics Terms

IEEE Std 242 (2001) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book

IEEE Std 399 (1997) Recommended Practice for Power Systems Analysis - Brown Book

IEEE Std 404 (2000) Cable Joints for Use with Extruded Dielectric Cable Rated 5000 V Through 138 000 V and Cable Joints for Use with Laminated Dielectric Cable Rated 2500 V Through 500 000 V

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-70-547 (2000) Weather Resistant Polyolefin Covered Conductors

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA HV 2 (1984; R 1996) Application Guide for Ceramic Suspension Insulators

NEMA ICS 6 (1993; R 2001) Industrial Control and Systems, Enclosures

NEMA LA 1 (1992; R 1999) Surge Arresters

NEMA SG 2 (1993) High Voltage Fuses

NEMA TP 1 (2002) Guide for Determining Energy Efficiency for Distribution Transformers

NEMA WC 74 (2000) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electrical Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2002) National Electrical Code

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1728H-701 (1993) REA Specification for Wood Crossarms (Solid and Laminated), Transmission Timbers and Pole Keys

UNDERWRITERS LABORATORIES (UL)

UL 467 (1993; Rev thru Feb 2001) Grounding and Bonding Equipment

UL 486A (1997; Rev thru May 2001) Wire Connectors and Soldering Lugs for Use with Copper Conductors

UL 486B (1997; Rev thru May 2001) Wire Connectors for Use with Aluminum Conductors

1.2 GENERAL REQUIREMENTS

1.2.1 Terminology

Terminology used in this specification is as defined in IEEE Std 100.

1.2.2 Service Conditions

Items provided under this section shall be specifically suitable for the following service conditions. Seismic details shall conform to Section SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT as indicated.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Electrical Distribution System; G, DF.

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams and other information necessary to define the installation and enable the Government to check conformity with the requirements of the contract drawings. Detail drawings shall as a minimum include:

- a. Constant current regulators.
- b. Poles.
- c. Calculations for steel poles and power installed screw foundations.
- d. Crossarms.
- e. Transformers.
- f. Automatic circuit reclosers.
- g. Pole top switches.
- h. Conductors.
- i. Insulators.
- j. Surge arresters.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures shall be submitted with the detail drawings. Approved departures shall be made at no additional cost to the Government.

Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and

drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall consist of the following:

a. Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded.

b. Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

As-Built Drawings; G, DF.

The as-built drawings shall be a record of the construction as installed. The drawings shall include the information shown on the contract drawings as well as deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be kept at the job site and updated daily. The as-built drawings shall be a full sized set of prints marked to reflect deviations, modifications, and changes. The as-built drawings shall be complete and show the location, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within ten calendar days from the time the drawings are returned to the Contractor.

SD-03 Product Data

Fault Current Analysis; G, DF.

Protective Device; G, DF.

Coordination Study; G, DF.

The study shall be submitted along with protective device equipment submittals. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device settings, ratings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Nameplates; G, RE.

Catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance

with the requirements of the contract documents.

Material and Equipment; G, RE.

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include the item number, the quantity of items proposed, and the name of the manufacturer of the item.

General Installation Requirements; G, RE.

As a minimum, installation procedures for regulators, transformers and reclosers. Procedures shall include diagrams, instructions, and precautions required to install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Factory Tests; G, RE.

Certified factory test reports shall be submitted when the manufacturer performs routine factory tests, including tests required by standards listed in paragraph REFERENCES. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory, and submitted within 7 days following successful completion of the tests specified in applicable publications or in these specifications.

Field Testing; G, RE.

A proposed field test plan 20 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Operating Tests; G, RE.

Six copies of the information described below in 215.9 by 279.4 mm (8-1/2 by 11 inch) binders having a minimum of 5 rings, and including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

- a. A list of equipment used, with calibration certifications.
- b. A copy of measurements taken.
- c. The dates of testing.
- d. The equipment and values to be verified.
- e. The condition specified for the test.
- f. The test results, signed and dated.
- g. A description of adjustments made.

SD-07 Certificates

Material and Equipment; G, RE.

Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories (UL) or to be constructed or tested, or both, in accordance with the standards of the American National Standards

Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), or the National Electrical Manufacturers Association (NEMA), the Contractor shall submit proof that the items provided under this section of the specifications conform to such requirements. The label of, or listing by, UL will be acceptable as evidence that the items conform thereto. Either a certification or a published catalog specification data statement, to the effect that the item is in accordance with the referenced ANSI or IEEE standard, will be acceptable as evidence that the item conforms thereto. A similar certification or published catalog specification data statement to the effect that the item is in accordance with the referenced NEMA standard, by a company listed as a member company of NEMA, will be acceptable as evidence that the item conforms thereto. In lieu of such certification or published data, the Contractor may submit a certificate from a recognized testing agency equipped and competent to perform such services, stating that the items have been tested and that they conform to the requirements listed, including methods of testing of the specified agencies.

SD-10 Operation and Maintenance Data

Electrical Distribution System; G, RE.

Six copies of Operation and Maintenance manuals electrical distribution system shall be provided, within 7 calendar days following the completion of tests and shall include assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked. Manuals shall also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements shall also be included. Documents shall be bound in a binder marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare-parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers. Three additional copies of the instructions manual shall be provided within 30 calendar days following the manuals.

Three additional copies of the instructions manual within 30 calendar days following the approval of the manuals.

1.4 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements. Wood poles held in storage for more than 2 weeks shall be stored in accordance with ANSI O5.1. Handling of wood poles shall be in accordance with ANSI O5.1, except that pointed tools capable of producing indentations more than inch in depth shall not be used. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

1.5 EXTRA MATERIALS

One additional spare fuse or fuse element for each furnished fuse or fuse element shall be delivered to the Contracting Officer when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall

be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

Products shall conform to the following requirements. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.2 STANDARD PRODUCT

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.3 NAMEPLATES

2.3.1 General

Each major component shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Equipment containing liquid-dielectrics shall have the type of dielectric on the nameplate. Nameplates shall be made of noncorrosive metal. As a minimum, nameplates shall be provided for transformers, regulators, circuit breakers, capacitors, meters and switches.

2.3.2 Liquid-Filled Transformer Nameplates

Power transformers shall be provided in accordance with IEEE C57.12.00. Nameplates shall indicate the number of liters and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. If transformer nameplate is not so marked, the Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 50 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 50 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

2.4 CORROSION PROTECTION

2.4.1 Aluminum Materials

Aluminum shall not be used.

2.4.2 Ferrous Metal Materials

2.4.2.1 Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M and ASTM A 123/A 123M.

2.4.2.2 Equipment

Equipment and component items, including but not limited to transformers and ferrous metal luminaires not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in

excess of 1.6 mm (1/16 inch) from the test mark. The described test mark and test evaluation shall be in accordance with ASTM D 1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.4.3 Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as specified in Section 09900 PAINTS AND COATINGS.

2.5 CONDUCTORS, CONNECTORS, AND SPLICES

2.5.1 Aluminum-Composition Conductors

2.5.2 Copper Conductors

Hard-drawn-copper conductors shall comply with ASTM B 1 and ASTM B 8 as appropriate for the conductor size.

2.5.3 Connectors and Splices

Connectors and splices shall be of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors. Aluminum-composition and aluminum-composition to copper shall comply with UL 486B, and copper-to-copper shall comply with UL 486A.

2.6 MEDIUM-VOLTAGE LINES

2.6.1 Bare Medium-Voltage Lines

Bare medium-voltage line conductors shall be hard-drawn-copper, CU. Conductor types shall not be mixed on any project, unless specifically indicated. Conductors larger than No. 2 AWG shall be stranded.

2.6.2 TEXT DELETED

TEXT DELETED

2.7 LOW-VOLTAGE LINES

Low-voltage line conductors shall be of the neutral-supported secondary and service drop type with cross-linked thermosetting polyethylene (XLP) insulation. Neutral-supported secondary and service drop conductors shall be insulated copper with bare hard-drawn-copper or copper-clad steel neutrals. Conductors on secondary racks may be provided in lieu of neutral-supported cable for pole line circuits where necessary clearances are available.

2.8 POLES AND HARDWARE

Poles shall be of lengths and classes indicated.

2.8.1 Wood Poles

Wood poles shall comply with ANSI O5.1, and shall be pressure treated in accordance with AWP A C4, with creosote conforming to AWP A P1/P13 or with oil-borne

preservatives and petroleum conforming to AWPA P8 and AWPA P9, respectively, and waterborne preservatives conforming to AWPA P5. Waterborne preservatives shall be either chromated or ammoniacal copper arsenate. Any species listed in ANSI O5.1 for which a preservative treatment is not specified in AWPA C4, shall not be used; northern white cedar, if treated as specified for western red cedar, and western fir, if treated as specified for Douglas fir, may be used. Wood poles shall have pole markings located approximately 3 m from pole butts for poles 15.2 m (50 feet) or less in length. Poles shall be machine trimmed by turning smooth full length, and shall be roofed, gained, and bored prior to pressure treatment. Where poles are not provided with factory-cut gains, metal gain plates shall be provided.

2.8.2 Steel Poles

Steel poles shall be designed to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors, shall be hot-dip galvanized in accordance with ASTM A 123/A 123M and shall not be painted. Poles shall have tapered tubular members, either round in cross-section or polygonal, and comply with strength calculations performed by a registered professional engineer. Calculations shall be submitted in accordance with the detail drawings portion of paragraph SUBMITTALS. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically approved. Pole markings shall be approximately 900 to 1270 mm above grade and shall include manufacturer, year of manufacture, top and bottom diameters, length, and a loading tree. Attachment requirements shall be provided as indicated, including grounding provisions. Climbing facilities are not required. Bases shall be of the anchor-bolt-mounted type.

2.8.3 Pole Line Hardware

Zinc-coated hardware shall comply with ANSI C135.1, ANSI C135.2, ANSI C135.4, ANSI C135.14 ANSI C135.22. Steel hardware shall comply with ASTM A 575 and ASTM A 576. Hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M. Pole-line hardware shall be hot-dip galvanized steel. Washers shall be installed under boltheads and nuts on wood surfaces and elsewhere as required. Washers used on through-bolts and double-arming bolts shall be approximately 57.2 mm square and 4.8 mm (3/16 inch) thick. The diameter of holes in washers shall be the correct standard size for the bolt on which a washer is used. Washers for use under heads of carriage-bolts shall be of the proper size to fit over square shanks of bolts. Eye bolts, bolt eyes, eyenuts, strain-load plates, lag screws, guy clamps, fasteners, hooks, shims, and clevises shall be used wherever required to support and to protect poles, brackets, crossarms, guy wires, and insulators.

2.8.4 Guy Assemblies

Guy assemblies shall be copper-clad steel in accordance with ASTM B 228 or zinc-coated steel in accordance with ASTM A 475. Guy assemblies, including insulators and attachments, shall provide a strength exceeding the required guy strength. Three-eye thimbles shall be provided on anchor rods to permit attachment of individual primary, secondary, and communication down guys. Anchors shall provide adequate strength to support all loads. Guy strand shall be 7 strand. Guy material shall be Class 30 HS copper-clad steel, except where two or more guys are used to provide the required strength. Guy rods shall be not less than 2.1 m (7 feet) in length by 15.9 mm (5/8 inch) in diameter.

2.9 INSULATORS

Insulators shall comply with NEMA HV 2 for general requirements. Suspension insulators shall be used at corners, angles, dead-ends, other areas where line insulators do not provide adequate strength, and as indicated. Mechanical strength of suspension insulators and hardware shall exceed the rated breaking strength of the attached conductors.

2.9.1 Medium-Voltage Line Insulators

Medium-voltage line insulators shall comply with ANSI C29.2, ANSI C29.5, and ANSI C29.6, and as applicable. Ratings shall not be lower than the ANSI classes indicated in TABLE I. Horizontal line-post insulators shall be used for armless construction and shall have the same mechanical and electrical ratings as vertical line-post insulators for the ANSI class indicated, but shall be modified to be suitable for horizontal installation. Where line-post insulators are used for angles greater than 15 degrees, clamp-top fittings shall be provided as well as for other locations shown. Conductor clamps for use with clamp-top, line-post insulators shall be hot-dip galvanized malleable iron for copper conductors and aluminum alloy for aluminum-composition conductors. Either line-post or pin insulators may be used for crossarm construction. Pin insulators for use on voltages in excess of 6 kV phase-to-phase shall be radio-interference-freed or else line-post insulators shall be used.

TABLE I

MINIMUM ANSI RATING OF MEDIUM-VOLTAGE INSULATORS BY CLASS

| Voltage Level | Line-Post | Pin | Suspension |
|----------------|------------|------|-----------------|
| Up to 5 kV | 57-1 or 11 | 55-3 | One 52-1 |
| | 57-1 or 11 | 55-5 | Two 52-1 |
| 6 kV to 15 kV | 57-1 or 11 | 55-5 | Two 52-2 |
| | 57-2 or 12 | 56-3 | Two 52-3 or 4 |
| 16 kV to 25 kV | 57-2 or 12 | 56-3 | Two 52-3 or 4 |
| | 57-3 or 13 | 56-4 | Three 52-3 or 4 |
| 26 kV to 35 kV | 57-3 or 13 | 56-4 | Three 52-3 or 4 |
| | 57-4 or 14 | 56-5 | Four 52-3 or 4 |

2.9.2 Low-Voltage Line Insulators

Low-voltage line insulators shall comply with ANSI C29.2 and ANSI C29.3 as applicable. Spool insulators for use on low-voltage lines shall be mounted on clevis attachments or secondary racks and shall be not smaller than Class 53-2. For No. 4/0 AWG and larger conductors, Class 53-4 shall be used. Suspension insulators on clevis attachments used at dead-ends shall be not smaller than Class 52-1.

2.9.3 Strain Insulators for Guy Wires

Strain insulators for use in insulated guy assemblies shall comply with ANSI C29.4 for porcelain or equivalent fiberglass, and shall have a mechanical strength exceeding the rated breaking strength of the attached guy wire. Insulators shall be not smaller than Class 54-1 for lines up to 5 kV, not smaller than Class 54-2 for lines of 6 kV to 15 kV, not smaller than Class 54-4 for lines of 16 kV to 25 kV, and not smaller than Class 54-4 with two in tandem for lines of 26 kV to 35 kV.

2.9.4 Apparatus Insulators

Apparatus insulators shall comply with IEEE C57.19.00, IEEE C57.19.01, ANSI C29.8, and ANSI C29.9 as applicable.

2.10 CROSSARM ASSEMBLIES

2.10.1 Crossarms

Crossarms shall comply with RUS Bull 1728H-701 and shall be solid wood,

distribution type, except cross-sectional area with pressure treatment conforming to AWPA C25, and a 6.4 mm (1/4 inch), 45 degree chamfer on all top edges. Cross-sectional area minimum dimensions shall be 108.0 mm (4-1/4 inches) in height by 82.6 mm (3-1/4 inches) in depth in accordance with IEEE C2 for Grade B construction. Crossarms shall be 2.4 m (8 feet) in length, except that 3.1 m (10 foot) crossarms shall be used for crossarm-mounted banked single-phase transformers or elsewhere as indicated. Crossarms shall be machined, chamfered, trimmed, and bored for stud and bolt holes before pressure treatment. Factory drilling shall be provided for pole and brace mounting, for four pin or four vertical line-post insulators, and for four suspension insulators, except where otherwise indicated or required. Drilling shall provide required climbing space and wire clearances. Crossarms shall be straight and free of twists to within 2.5 mm per 304.8 mm (1/10 inch per foot) of length. Bend or twist shall be in one direction only.

2.11 ILLUMINATION

2.12 SURGE ARRESTERS

Surge arresters shall comply with NEMA LA 1 and IEEE C62.1, IEEE C62.2, and IEEE C62.11, and shall be provided for protection of aerial-to-underground transitions, automatic circuit reclosers, capacitor equipment, group-operated load-interrupter switches, transformers and other indicated equipment. Arresters shall be distribution class, rated as shown. Arresters shall be equipped with mounting brackets suitable for the indicated installations. Arresters shall be of the metal-oxide varistor type suitable for outdoor installations.

2.13 GROUNDING AND BONDING

2.13.1 Driven Ground Rods

Ground rods shall be of copper-clad steel conforming to UL 467 not less than 15.9 mm (5/8 inch) in diameter by 2.4 meter (8 feet) in length of the sectional type driven full length into the earth.

2.13.2 Grounding Conductors

Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as the phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be ASTM B 8 soft-drawn unless otherwise indicated. Aluminum is not acceptable.

2.14 PADLOCKS

Padlocks shall comply with Section 08700 'Builders' Hardware.

2.15 WARNING SIGNS

Warning signs shall be porcelain enameled steel or approved equal. Voltage warning signs shall comply with IEEE C2.

2.16 FACTORY TESTS

Factory tests shall be performed, as follows, in accordance with the applicable publications and with other requirements of these specifications. The Contracting Officer shall be notified at least 10 days before the equipment is ready for testing.

- g. Electric Power Insulators: Manufacturer's standard tests in accordance with ANSI C29.1.

2.17 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for equipment ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last three years. The Contractor shall provide list of references complete with points of contact, address and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.17.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the nearest upstream device in the existing source system and extend through the downstream devices at the load end.

2.17.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. The Contractor shall coordinate with the commercial power company for fault current availability at the site.

2.17.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformer points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformer point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Locations of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.17.4 Fault Current Analysis

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242 and IEEE Std 399. Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedances shall be those proposed. Data shall be documented in the report.

2.17.5 Fault Current Availability

Balanced three-phased fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.17.6 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. Provide a written narrative that describes: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost changes (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.17.7 Study Report

- a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.
- b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.
- c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristics curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristics curves and protective device ratings and settings.
- d. The report shall contain fully coordinated composite time-current characteristic curves for each bus in the system, as required to ensure coordinated power system between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.
- e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Circuits installed in conduits or underground and splices and terminations for medium-voltage cable shall conform to the requirements of Section 16375A ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Secondary circuits installed in conduit on poles shall conform to the requirements of Section 16415A ELECTRICAL WORK, INTERIOR.

3.1.1 Conformance to Codes

The installation shall comply with the requirements and recommendations of IEEE C2 for medium loading districts, Grade B construction. No reduction in clearance shall be made. The installation shall also comply with the applicable parts of NFPA 70.

3.1.2 Verification of Dimensions

The Contractor shall become familiar with details of the work, shall verify dimensions in the field, and shall notify the Contracting Officer of any discrepancy before performing any work.

3.1.3 Disposal of Liquid Dielectrics

PCB-contaminated dielectric shall be marked as PCB and transported to and incinerated by an approved EPA waste disposal facility. The Contractor shall furnish certification of proper disposal. Contaminated dielectric shall not be diluted to lower the level of contamination.

3.2 POLE INSTALLATION

Joint-use electric/roadway-lighting poles for overhead electric and communication lines shall be wood poles utilizing crossarm construction. Pole equipment mounts shall be used for steel and concrete poles and may be used for wood poles rather than crossarm equipment mounts. Detail drawings shall be submitted for approval.

3.2.1 Wood Pole Setting

Wood Pole Setting: Wood poles shall be set straight and firm. In normal firm ground, minimum pole-setting depths shall be as listed in Table II. Poles in straight runs shall be in a straight line. Curved poles shall be placed with curvatures in the direction of the pole line. Poles shall be set to maintain as even a grade as practicable. When the average ground run is level, consecutive poles shall not vary more than 1.5 m in height. When the ground is uneven, poles differing in length shall be kept to a minimum by locating poles to avoid the highest and lowest ground points. If it becomes necessary to shorten a pole, a piece shall be sawed off the top end and roofed. If any pole is shortened after treatment, the shortened end of the pole shall be given an application of hot preservative. Where poles are set on hilly terrain, along edges of cuts or embankments, or where soil may be washed out, special precautions shall be taken to ensure durable pole foundations, and the setting depth shall be measured from the lower side of the pole. Holes shall be dug large enough to permit proper use of tampers to the full depth of a hole. Earth shall be placed into the hole in 300 mm maximum layers, then thoroughly tamped before the next layer is placed. Surplus earth shall be placed around each pole in a conical shape and packed tightly to drain water away from poles.

TABLE II

MINIMUM POLE-SETTING DEPTH (METERS)

| Length Overall Meters | Straight Lines | Curves, Corners, and Points of Extra Strain |
|-----------------------------|-------------------|------------------------------------------------------|
| 6.1 | 1.5 | 1.5 |
| 7.6 | 1.7 | 1.7 |
| 9.2 | 1.7 | 1.7 |
| 10.7 | 1.8 | 1.8 |
| 12.2 | 1.8 | 1.8 |
| 13.7 | 2.0 | 2.1 |
| 15.2 | 2.1 | 2.3 |
| 16.7 | 2.3 | 2.5 |
| 18.3 | 2.5 | 2.6 |
| 19.8 | 2.6 | 2.6 |
| 21.3 | 2.8 | 2.9 |
| 22.9 | 2.9 | 3.0 |
| 24.4 | 3.0 | 3.2 |
| 25.9 | 3.2 | 3.3 |

TABLE II
MINIMUM POLE-SETTING DEPTH (METERS)

| Length Overall Meters | Straight Lines | Curves, Corners, and Points of Extra Strain |
|-----------------------------|-------------------|------------------------------------------------------|
| 27.4 | 3.3 | 3.5 |
| 28.9 | 3.5 | 3.7 |
| 30.5 | 3.7 | 3.8 |

3.3 CROSSARM MOUNTING

Crossarms shall be bolted to poles with 15.9 mm (5/8 inch) through-bolts with square washers at each end. Bolts shall extend not less than 3 mm nor more than 50 mm beyond nuts. On single crossarm construction, the bolt head shall be installed on the crossarm side of the pole. Wood crossarm braces shall be provided on crossarms. Flat braces may be provided for 2.4 m (8 foot) crossarms and shall be 6.4 by 31.8 mm (1/4 by 1-1/4 inches), not less than 700 mm (28 inches) in length. Flat braces shall be bolted to arms with 9.5 mm (3/8 inch) carriage bolts with round or square washers between boltheads and crossarms, and secured to poles with 50.8 by 101.6 mm (1/2 by 4 inch) lag screws after crossarms are leveled and aligned. Angle braces are required for 3.1 m (10 foot) crossarms and shall be 1.5 m (60 inch) span by 457.2 mm (18 inch) drop formed in one piece from 38.1 by 38.1 by 4.8 mm (1-1/2 by 1-1/2 by 3/16 inch) angle. Angle braces shall be bolted to crossarms with 50.8 mm (1/2 inch) bolts with round or square washers between boltheads and crossarms, and secured to poles with 15.9 mm (5/8 inch) through-bolts. Double crossarms shall be securely held in position by means of 15.9 mm (5/8 inch) double-arming bolts. Each double-arming bolt shall be equipped with four nuts and four square washers.

3.3.1 Line Arms and Buck Arms

Line arms and buck arms shall be set at right angles to lines for straight runs and for angles 45 degrees and greater; and line arms shall bisect angles of turns of less than 45 degrees. Dead-end assemblies shall be used for turns where shown. Buckarms shall be installed, as shown, at corners and junction poles. Double crossarms shall be provided at ends of joint use or conflict sections, at dead-ends, and at angles and corners to provide adequate vertical and longitudinal strength. Double crossarms shall be provided at each line-crossing structure and where lines not attached to the same pole cross each other.

3.3.2 Equipment Arms

Equipment arms shall be set parallel or at right angles to lines as required to provide climbing space. Equipment arms shall be located below line construction to provide necessary wire and equipment clearances.

3.4 GUY INSTALLATION

Guys shall be provided where shown, with loads and strengths as indicated, and wherever conductor tensions are not balanced, such as at angles, corners, and dead-ends. Where a single guy will not provide the required strength, two or more guys shall be provided. Where guys are wrapped around poles, at least two guy hooks shall be provided and pole shims shall be provided where guy tension exceeds 27 kN (6000 pounds). Guy clamps 152.4 mm (6 inches) in length with three 15.9 mm (5/8 inch) bolts, or offset-type guy clamps, or approved guy grips shall be provided at each guy terminal. Guy-strain insulators shall be provided in each guy for wood poles. Multiple-helix screw anchors shall be provided in marshy ground; rock anchors shall be installed in rock at right angles to guys, elsewhere anchors shall be of an expanding type, except that power installed

screw anchors of equivalent holding power are acceptable. A half-round gray polyvinyl, fiberglass, or other suitable plastic guy marker, not less than 2.4 m (8 feet) in length, shall be provided at the anchor end of each guy shown, securely clamped to the guy or anchor at the bottom and top of the marker. Holding capacities for down guys shall be based on a lead angle of 45 degrees.

3.5 CONDUCTOR INSTALLATION

3.5.1 Line Conductors

Unless otherwise indicated, conductors shall be installed in accordance with manufacturer's approved tables of sags and tensions. Proper care shall be taken in handling and stringing conductors to avoid abrasions, sharp bends, cuts, kinks, or any possibility of damage to insulation or conductors. Conductors shall be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation. Conductors shall not be drawn over rough or rocky ground, nor around sharp bends. When installed by machine power, conductors shall be drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Initial sag and tension shall be checked by the Contractor, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

3.5.2 Connectors and Splices

Connectors and splices shall be mechanically and electrically secure under tension and shall be of the nonbolted compression type. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be noncorrosive and shall not adversely affect conductors. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools shall be of types recommended by the connector manufacturer. Primary line apparatus taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Low-voltage connectors for copper conductors shall be of the solderless pressure type. Noninsulated connectors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.

3.5.3 Conductor-To-Insulator Attachments

Conductors shall be attached to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as indicated in TABLE II.

TABLE II

TIE-WIRE REQUIREMENTS

| CONDUCTOR Copper (AWG) | TIE WIRE Soft-Drawn Copper (AWG) |
|---------------------------|-------------------------------------|
| 6 | 8 |
| 4 and 2 | 6 |
| 1 through 3/0 | 4 |
| 4/0 and larger | 2 |

AAC, AAAC, or ACSR (AWG)

AAAC OR AAC (AWG)

Any size

6 or 4

3.5.4 Armor Rods

Armor rods shall be provided for AAC, AAAC, and ACSR conductors. Armor rods shall be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 61 m, flat aluminum armor rods may be used. Flat armor rods, not less than 762.0 micrometers by 6.4 mm (0.03 by 0.25 inch) shall be used on No. 1 AWG AAC and AAAC and smaller conductors and on No. 5 AWG ACSR and smaller conductors. On larger sizes, flat armor rods shall be not less than 1.3 by 7.6 mm (0.05 by 0.30 inches). For span lengths of 61 m or more, preformed round armor rods shall be used.

3.5.5 Medium-Voltage Insulated Cables

Medium-voltage cable messengers shall be attached to poles with clamps providing a strength exceeding the required messenger strength and with not less than 15.9 mm (5/8 inch) through-bolts. Messengers shall be dead-ended, grounded, and line-guyed at corners and dead-ends, and at intervals not exceeding 305 m along straight runs.

3.5.6 Low-Voltage Insulated Cables

Low-voltage cables shall be supported on clevis fittings using spool insulators. Dead-end clevis fittings and suspension insulators shall be provided where required for adequate strength. Dead-end construction shall provide a strength exceeding the rated breaking strength of the neutral messenger. Clevis attachments shall be provided with not less than 15.9 mm (5/8 inch) through-bolts. Secondary racks may be used when installed on wood poles and where the span length does not exceed 61 m. Secondary racks shall be two-, three-, or four-wire, complete with spool insulators. Racks shall meet strength and deflection requirements for heavy-duty steel racks, and shall be either galvanized steel or aluminum alloy. Tops of insulator saddles shall be rounded and smooth to avoid damage to conductor insulation. Each insulator shall be held in place with a 15.9 mm (5/8 inch) button-head bolt equipped with a nonferrous cotter pin, or equivalent, at the bottom. Racks for dead-ending four No. 4/0 AWG or four larger conductors shall be attached to poles with three 15.9 mm (5/8 inch) through-bolts. Other secondary racks shall be attached to poles with at least two 15.9 mm (5/8 inch) through-bolts. Minimum vertical spacing between conductors shall not be less than 200 mm.

3.6 CONNECTIONS TO UTILITY LINES

The Contractor shall coordinate the work with the Contracting Officer and shall provide for final connections to the installation electric lines.

3.7 CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS

Connections between aerial and underground systems shall be made as shown. Underground cables shall be extended up poles in conduit to cable terminations. Conduits shall be secured to poles by conduit supports spaced not more than 3 m apart and with one support not more than 300 mm from any bend or termination. Cables shall be supported by devices separate from the conduit or guard, near their point of exit from the riser conduit or guard. Cables guards shall be secured in accordance with the manufacturers published procedure. Risers shall be equipped with bushings to protect cables. Capnut potheads shall be used to terminate medium-voltage multiple-conductor cable.

3.8 CONNECTIONS TO BUILDINGS

3.8.1 Aerial Services

Connections to buildings shall be made at approximately the point indicated and shall be connected to the service entrance conductors. Supports at buildings shall be adequate to withstand required pulls; supports shall not be rated less than 4450 N (1000 pounds). Drip loops shall be formed on conductors at entrances to buildings, cabinets, or conduits. Service-entrance conduits with termination fittings and conductors within the building, including sufficient slack for connection to aerial service cables, shall conform to the requirements of Section 16415A ELECTRICAL WORK, INTERIOR.

3.8.2 Underground Services

Connections to buildings shall be made at the point indicated and shall be terminated at the service entrance equipment terminals. Cable pulling shall be in accordance with Section 16375A, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Service entrance conduits with termination fittings and conductors within the building shall conform to the requirements of Section 16415A ELECTRICAL WORK, INTERIOR.

3.9 GROUNDING

Noncurrent-carrying metal parts of equipment and conductor assemblies, such as luminaires, medium-voltage cable terminations and messengers, metal poles, operating mechanisms of pole top switches, panel enclosures, transformers, capacitors, recloser frames (cases) and other noncurrent-carrying metal items shall be grounded. Additional grounding of equipment, neutral, and surge arrester grounding systems shall be installed at poles where indicated.

3.9.1 Grounding Electrodes

Grounding electrodes shall be installed as follows:

- a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be located approximately 900 mm out from base of the pole and shall be driven into the earth until the tops of the rods are approximately 300 mm below finished grade. Multiple rods shall be evenly spaced at least 3 m apart and connected together 600 mm below grade with a minimum No. 6 bare copper conductor.
- b. Pole butt electrodes - Pole butt electrodes shall be installed where indicated, except that this method shall not be the sole grounding electrode at transformer locations. The pole butt electrode shall consist of a coil of at least 4 m of minimum No. 6 bare copper conductor stapled to the butt of the pole.
- c. Plate electrodes - Plate electrodes shall be installed in accordance with the manufacturer's instructions and IEEE C2 and NFPA 70.
- d. Ground Resistance - The maximum resistance of a driven ground rod shall not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes interconnected with grounding conductors, to achieve the specified ground resistance. The additional electrodes will be up to three, 2.4 m (8 feet) rods spaced a minimum of 3 m (10 feet) apart. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved connectors.

3.9.2 Grounding and Bonding Connections

Connections above grade shall be made by the fusion-welding process or with bolted solderless connectors in compliance with UL 467, and those below grade shall be made by a fusion-welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

3.9.3 Grounding Electrode Conductors

On multi-grounded circuits, as defined in IEEE C2, provide a single continuous vertical grounding electrode conductor. Neutrals, surge arresters, and equipment grounding conductors shall be bonded to this conductor. For single grounded or ungrounded systems, provide a grounding conductor for the surge arrester and equipment grounding conductors and a separate grounding conductor for the secondary neutrals. Grounding electrode conductors shall be sized as shown. Secondary system neutral conductors shall be connected directly to the transformer neutral bushings, then connected with a neutral bonding jumper between the transformer neutral bushing and the vertical grounding electrode conductor, as shown. Grounding electrode conductors shall be stapled to wood poles at intervals not exceeding 600 mm. On metal poles, a preformed galvanized steel strap, 15.9 mm (5/8 inch) wide by 0.853 (22 gauge) minimum by length, secured by a preformed locking method standard with the manufacturer, shall be used to support a grounding electrode conductor installation on the pole and spaced at intervals not exceeding 1.5 m with one band not more than 75 mm from each end of the vertical grounding electrode conductor. Bends greater than 45 degrees in grounding electrode conductor are not permitted.

3.10 FIELD TESTING

3.10.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 7 days prior to conducting tests.

The Contractor shall furnish materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

3.10.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.10.3 Ground-Resistance Tests

The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes shall be provided.

3.10.4 Medium-Voltage Preassembled Cable Test

After installation, prior to connection to an existing system, and before the operating test, the medium-voltage preassembled cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors at one terminal and connecting grounds or metallic shieldings or sheaths of the cable at the other terminal for each test. Prior to the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74 for the particular type of cable installed, and shall not exceed the recommendations of IEEE Std 404 for cable joints unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.10.5 Sag and Tension Test

The Contracting Officer shall be given prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits and reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

3.10.6 Low-Voltage Cable Test

For underground secondary or service laterals from overhead lines, the low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations of conductors in the same trench, duct, or cable, with other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

$$R \text{ in megohms} = (\text{rated voltage in kV} + 1) \times 304,800 / (\text{length of cable in meters})$$

Each cable failing this test shall be repaired or replaced. The repaired cable shall then be retested until failures have been eliminated.

3.10.7 Liquid-Filled Transformer Tests

The following field tests shall be performed on liquid-filled transformers. Pass-fail criteria shall be in accordance with the transformer manufacturer's specifications.

- a. Insulation resistance test phase-to-ground.
- b. Turns ratio test.
- c. Correct phase sequence.

3.10.8 Pre-Energization Services

The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the

detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment and to ensure that packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

Automatic circuit reclosers.

Capacitors.

Switches.

Transformers.

3.10.9 Operating Tests

After the installation is completed, and at such time as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with paragraph SUBMITTALS.

3.11 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

-- End of Section --

SECTION 16375A

ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND
02/02

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

| | |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ANSI C119.1 | (1986; R 1997) Sealed Insulated Underground Connector Systems Rated 600 Volts |
| ANSI C12.10 | (1997) Electromechanical Watthour Meters |
| ANSI C12.11 | (1987; R 1993) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV) |
| ANSI C12.4 | (1984; R 1996) Mechanical Demand Registers |
| ANSI C135.30 | (1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction |
| ANSI C29.1 | (1988; R 1996) Electrical Power Insulators - Test Methods |
| ANSI C37.121 | (1989; R 1995) Switchgear, Unit Substations Requirements |
| ANSI C37.16 | (2000) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations |
| ANSI C37.46 | (1981; R 1992) Power Fuses and Fuse Disconnecting Switches |
| ANSI C37.50 | (1989; R 1995) Switchgear, Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures |
| ANSI C37.72 | (1987) Manually-Operated, Dead-Front Padmounted Switchgear with Load Interrupting Switches and Separable Connectors for Alternating-Current Systems |
| ANSI C57.12.13 | (1982) Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations |
| ANSI C57.12.21 | (1995) Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with High-Voltage Bushings; (High-Voltage, 34 500 Grd Y/19 920 Volts and Below; Low-Voltage, 240/120; 167 kVA and Smaller) |

| | |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ANSI C57.12.26 | (1993) Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors, High-Voltage, 34 500 Grd Y/19 920 Volts and Below; 2500 kVA and Smaller |
| ANSI C57.12.27 | (1982) Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations |
| ANSI C57.12.28 | (1999) Switchgear and Transformers -Padmounted Equipment - Enclosure Integrity |
| ANSI C80.1 | (1995) Rigid Steel Conduit - Zinc Coated |
| ANSI O5.1 | (1992) Specifications and Dimensions for Wood Poles |

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|-------------------|---------------------------------------------------------------------------------------------------------------|
| ASTM A 123/A 123M | (2001) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products |
| ASTM A 153/A 153M | (2001) Zinc Coating (Hot-Dip) on Iron and Steel Hardware |
| ASTM A 48 | (1994ae1) Gray Iron Castings |
| ASTM A 48M | (1994e1) Gray Iron Castings (Metric) |
| ASTM B 117 | (1997) Operating Salt Spray (Fog) Apparatus |
| ASTM B 231/B 231M | (1999) Concentric-Lay-Stranded Aluminum 1350 Conductors |
| ASTM B 3 | (1995) Soft or Annealed Copper Wire |
| ASTM B 400 | (1994) Compact Round Concentric- Lay-Stranded Aluminum 1350 Conductor |
| ASTM B 496 | (1999) Compact Round Concentric-Lay-Stranded Copper Conductors |
| ASTM B 609/B 609M | (1999) Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes |
| ASTM B 8 | (1999) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft |
| ASTM B 800 | (2000) 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers |
| ASTM B 801 | (1999) Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation |
| ASTM C 478 | (1997) Precast Reinforced Concrete Manhole Sections |

ASTM C 478M (1997) Precast Reinforced Concrete Manhole Sections (Metric)

ASTM D 1654 (1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D 2472 (2000) Sulfur Hexafluoride

ASTM D 4059 (1996) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography

ASTM D 923 (1997) Sampling Electrical Insulating Liquids

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS5 (1994; CS5a-1995) Cross-Linked Polyethylene Insulated Shielded Power Cables Rated 5 Through 46 kV

AEIC CS6 (1996) Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69 kV

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a (1998) Approval Guide Fire Protection

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (1997) National Electrical Safety Code

IEEE C37.1 (1994) IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control

IEEE C37.13 (1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures

IEEE C37.2 (1996) Electrical Power System Device Function Numbers and Contact Designations

IEEE C37.20.1 (1993) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear

IEEE C37.20.2 (1993; C37.20.2b) Metal-Clad and Station-Type Cubicle Switchgear

IEEE C37.20.3 (1997) Metal-Enclosed Interrupter Switchgear

IEEE C37.23 (1987; R 1991) Guide for Metal-Enclosed Bus and Calculating Losses in Isolated-Phase Bus

IEEE C37.30 (1997) Requirements for High-Voltage Switches

IEEE C37.34 (1994) Test Code for High-Voltage Air Switches

IEEE C37.41 (1994; C37.41c) Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories

IEEE C37.63 (1997) Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizer for AC Systems

IEEE C37.90 (1989; R 1994) Relays and Relay Systems
Associated with Electric Power Apparatus

IEEE C37.90.1 (1989; R 1994) IEEE Standard Surge Withstand
Capability (SWC) Tests for Protective Relays and
Relay Systems

IEEE C37.98 (1987; R 1991) Seismic Testing of Relays

IEEE C57.12.00 (1993) Standard General Requirements for
Liquid-Immersed Distribution, Power, and
Regulating Transformers

IEEE C57.13 (1993) Instrument Transformers

IEEE C57.98 (1993) Guide for Transformer Impulse Tests
\\\$avail only as part of Distribution, Power, and
Regulating Transformers Stds Collection

IEEE C62.1 (1989; R 1994) Surge Arresters for AC Power
Circuits

IEEE C62.11 (1999) IEEE Standard Metal-Oxide Surge Arresters
for AC Power Circuits

IEEE C62.2 (1987; R 1994) Guide for the Application of
Gapped Silicon-Carbide Surge Arresters for
Alternating Current Systems

IEEE Std 100 (1997) IEEE Standard Dictionary of Electrical
and Electronics Terms

IEEE Std 242 (1986; R 1991) Recommended Practice for
Protection and Coordination of Industrial and
Commercial Power Systems

IEEE Std 386 (1995) Separable Insulated Connector Systems for
Power Distribution Systems Above 600V

IEEE Std 399 (1997) Recommended Practice for Industrial and
Commercial Power Systems Analysis

IEEE Std 404 (1993) Cable Joints for Use with Extruded
Dielectric Cable Rated 5000 V Through 138 000 V
and Cable Joints for Use with Laminated
Dielectric Cable Rated 2500 V Through 500 000 V

IEEE Std 48 (1998) Standard Test Procedures and Requirements
for Alternating-Current Cable Terminations 2.5
kV through 765 kV

IEEE Std 592 (1990; R 1996) Exposed Semiconducting Shields on
Premolded High Voltage Cable Joints and
Separable Insulated Connectors

IEEE Std 81 (1983) Guide for Measuring Earth Resistivity,
Ground Impedance, and Earth Surface Potentials
of a Ground System (Part 1) \\\$31.00\$\\F

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA AB 1 (1993) Molded Case Circuit Breakers and Molded

Case Switches

| | |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| NEMA BU 1 | (1994) Busways |
| NEMA FB 1 | (1993) Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies |
| NEMA FU 1 | (1986) Low Voltage Cartridge Fuses |
| NEMA LA 1 | (1992) Surge Arresters |
| NEMA PB 1 | (1995) Panelboards |
| NEMA PB 2 | (1995) Deadfront Distribution Switchboards |
| NEMA SG 2 | (1993) High Voltage Fuses |
| NEMA SG 3 | (1995) Power Switching Equipment |
| NEMA SG 5 | (1995) Power Switchgear Assemblies |
| NEMA TC 5 | (1990) Corrugated Polyolefin Coilable Plastic Utilities Duct |
| NEMA TC 6 | (1990) PVC and ABS Plastic Utilities Duct for Underground Installation |
| NEMA TC 7 | (1990) Smooth-Wall Coilable Polyethylene Electrical Plastic Duct |
| <u>NEMA TP 1</u> | <u>(2002) Guide for Determining Energy Efficiency for Distribution Transformers</u> |
| NEMA WC 7 | (1988; Rev 3 1996) Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy |
| NEMA WC 8 | (1988; Rev 3 1996) Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy |

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

| | |
|---------|---------------------------------|
| NFPA 70 | (2002) National Electrical Code |
|---------|---------------------------------|

UNDERWRITERS LABORATORIES (UL)

| | |
|---------|---------------------------------------------------------------------------------------|
| UL 1072 | (1995; Rev Mar 1998) Medium Voltage Power Cables |
| UL 1242 | (1996; Rev Mar 1998) Intermediate Metal Conduit |
| UL 1684 | (2000) Reinforced Thermosetting Resin Conduit (RTRC) and Fittings |
| UL 198C | (1986; Rev thru Feb 1998) High-Interrupting-Capacity Fuses, Current-Limiting Types |
| UL 198D | (1995) Class K Fuses |
| UL 198E | (1988; Rev Jul 1988) Class R Fuses |

| | |
|---------|--------------------------------------------------------------------------------------------------------------|
| UL 198H | (1988; Rev thru Nov 1993) Class T Fuses |
| UL 467 | (1993; Rev thru Apr 1999) Grounding and Bonding Equipment |
| UL 486A | (1997; Rev thru Dec 1998) Wire Connectors and Soldering Lugs for Use with Copper Conductors |
| UL 486B | (1997; Rev Jun 1997) Wire Connectors for Use with Aluminum Conductors |
| UL 489 | (1996; Rev thru Dec 1998) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures |
| UL 510 | (1994; Rev thru Apr 1998) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape |
| UL 514A | (1996; Rev Dec 1999) Metallic Outlet Boxes |
| UL 6 | (1997) Rigid Metal Conduit |
| UL 651 | (1995; Rev thru Oct 1998) Schedule 40 and 80 Rigid PVC Conduit |
| UL 854 | (1996; Rev Oct 1999) Service-Entrance Cables |
| UL 857 | (1994; Rev thru Dec 1999) Busways and Associated Fittings |

1.2 GENERAL REQUIREMENTS

1.2.1 Terminology

Terminology used in this specification is as defined in IEEE Std 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Electrical Distribution System; G, RE.

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams manufacturers standard installation drawings and other information necessary to define the installation and enable the Government to check conformity with the requirements of the contract drawings.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures shall be included with the detail drawings. Approved departures shall be made at no additional cost to the Government.

Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated

and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall consist of the following:

a. Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. All optional items shall be clearly identified as included or excluded.

b. Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

Detail drawings shall as a minimum depict the installation of the following items:

a. Medium-voltage cables and accessories including cable installation plan.

b. Transformers.

c. Substations.

d. Switchgear.

e. Pad-mounted loadbreak switches.

f. Busways.

g. Surge arresters.

As-Built Drawings; G, RE.

The as-built drawings shall be a record of the construction as installed. The drawings shall include the information shown on the contract drawings as well as deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be a full sized set of prints marked to reflect deviations, modifications, and changes. The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall provide three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within 10 calendar days from the time the drawings are returned to the Contractor.

SD-03 Product Data

Nameplates; G, RE.

Catalog cuts, brochures, circulars, specifications, product data, and

printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material and Equipment; G, RE.

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each such item.

General Installation Requirements; G, RE.

As a minimum, installation procedures for transformers, substations, switchgear, and medium-voltage cable terminations and splices.

Procedures shall include cable pulling plans, diagrams, instructions, and precautions required to install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Factory Tests; G, RE.

Certified factory test reports shall be submitted when the manufacturer performs routine factory tests, including tests required by standards listed in paragraph REFERENCES. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory, and submitted within 7 days following successful completion of the tests. The manufacturer's pass-fail criteria for tests specified in paragraph FIELD TESTING shall be included.

Field Testing; G, RE.

A proposed field test plan, 30 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Operating Tests; G, RE.

Six copies of the information described below in 215.9 by 279.4 mm (8-1/2 by 11 inch) binders having a minimum of three rings, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

- a. A list of equipment used, with calibration certifications.
- b. A copy of measurements taken.
- c. The dates of testing.
- d. The equipment and values to be verified.
- e. The condition specified for the test.
- f. The test results, signed and dated.
- g. A description of adjustments made.

Cable Installation; G, RE.

Six copies of the information described below in 215.9 by 279.4 mm

(8-1/2 by 11 inch) binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Sections shall be separated by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

- a. Site layout drawing with cable pulls numerically identified.
- b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.
- c. The cable manufacturer and type of cable.
- d. The dates of cable pulls, time of day, and ambient temperature.
- e. The length of cable pull and calculated cable pulling tensions.
- f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Material and Equipment; G, RE.

Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories (UL) or to be constructed or tested, or both, in accordance with the standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), or the National Electrical Manufacturers Association (NEMA), the Contractor shall submit proof that the items provided conform to such requirements. The label of, or listing by, UL will be acceptable as evidence that the items conform. Either a certification or a published catalog specification data statement, to the effect that the item is in accordance with the referenced ANSI or IEEE standard, will be acceptable as evidence that the item conforms. A similar certification or published catalog specification data statement to the effect that the item is in accordance with the referenced NEMA standard, by a company listed as a member company of NEMA, will be acceptable as evidence that the item conforms. In lieu of such certification or published data, the Contractor may submit a certificate from a recognized testing agency equipped and competent to perform such services, stating that the items have been tested and that they conform to the requirements listed, including methods of testing of the specified agencies. Compliance with above-named requirements does not relieve the Contractor from compliance with any other requirements of the specifications.

Cable Joints; G, RE.

A certification that contains the names and the qualifications of people recommended to perform the splicing and termination of medium-voltage cables approved for installation under this contract. The certification shall indicate that any person recommended to perform actual splicing and terminations has been adequately trained in the proper techniques and have had at least three recent years of experience in splicing and terminating the same or similar types of cables approved for installation. In addition, any person recommended by the Contractor may be required to perform a practice splice and termination, in the presence of the Contracting Officer, before being approved as a qualified installer of medium-voltage cables. If that additional requirement is imposed, the Contractor shall provide short sections of the approved types of cables along with the approved type of splice and termination kits, and detailed manufacturer's instruction for the proper splicing and termination of the approved cable types.

Cable Installer Qualifications; G, RERE.

The Contractor shall provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. A resume shall be provided showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers.

SD-10 Operation and Maintenance Data

Electrical Distribution System; G, RE.

Six copies of operation and maintenance manuals, within 7 calendar days following the completion of tests and including assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked. Manuals shall also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements shall also be included. Documents shall be bound in a binder marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers.

Three additional copies of the instructions manual shall be provided within 30 calendar days following the manuals.

1.4 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements. Wood poles held in storage for more than 2 weeks shall be stored in accordance with ANSI O5.1. Handling of wood poles shall be in accordance with ANSI O5.1, except that pointed tools capable of producing indentations more than 25 mm in depth shall not be used. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

1.5 EXTRA MATERIALS

One additional spare fuse or fuse element for each furnished fuse or fuse element shall be delivered to the contracting officer when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.2 NAMEPLATES

2.2.1 General

Each major component of this specification shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Nameplates shall be made of noncorrosive metal. Equipment containing liquid dielectrics shall have the type of dielectric on the nameplate. Sectionalizer switch nameplates shall have a schematic with all switch positions shown and labeled. As a minimum, nameplates shall be provided for transformers, circuit breakers, meters, switches, and switchgear.

2.2.2 Liquid-Filled Transformer Nameplates

Power transformers shall be provided with nameplate information in accordance with IEEE C57.12.00. Nameplates shall indicate the number of liters and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. If transformer nameplate is not so marked, the Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 50 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 50 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

2.3 CORROSION PROTECTION

2.3.1 Aluminum Materials

Aluminum shall not be used.

2.3.2 Ferrous Metal Materials

2.3.2.1 Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M and ASTM A 123/A 123M.

2.3.2.2 Equipment

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaries not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm (1/16 inch) from the test mark. The scribed test mark and test evaluation shall be in accordance with ASTM D 1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.3.3 Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as specified in Section 09900 PAINTS AND COATINGS.

2.4 CABLES

Cables shall be single conductor type unless otherwise indicated.

2.4.1 Medium-Voltage Cables

2.4.1.1 General

Cable construction shall be Type MV, conforming to NFPA 70 and UL 1072. Cables shall be manufactured for use in duct applications as indicated.

2.4.1.2 Ratings

Cables shall be rated for a circuit voltage of 15 kV.

2.4.1.3 Conductor Material

Underground cables shall be soft drawn copper complying with ASTM B 3 and ASTM B 8 for regular concentric and compressed stranding or ASTM B 496 for compact stranding.

2.4.1.4 Insulation

Cable insulation shall be ethylene-propylene-rubber (EPR) insulation conforming to the requirements of NEMA WC 8 and AEIC CS6. A 133 percent insulation level shall be used on 5 kV, 15 kV and 25 kV rated cables. The Contractor shall comply with EPA requirements in accordance with Section 01670 RECYCLED / RECOVERED MATERIALS.

2.4.1.5 Shielding

Cables rated for 2 kV and above shall have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape shield for each phase.

2.4.1.6 Neutrals

Concentric neutrals conductors shall be tinned copper, having a combined ampacity equal to the phase conductor ampacity rating.

2.4.1.7 Jackets

Cables shall be provided with a PVC jacket. Direct buried cables shall be rated for direct burial.

2.4.2 Low-Voltage Cables

Cables shall be rated 600 volts and shall conform to the requirements of NFPA 70, and must be UL listed for the application or meet the applicable section of either ICEA or NEMA standards.

2.4.2.1 Conductor Material

Underground cables shall be annealed copper complying with ASTM B 3 and ASTM B 8. Intermixing of copper and aluminum conductors is not permitted.

2.4.2.2 Insulation

Insulation must be in accordance with NFPA 70, and must be UL listed for the application or meet the applicable sections of either ICEA, or NEMA standards.

2.4.2.3 Jackets

Multiconductor cables shall have an overall PVC outer jacket.

2.4.2.4 Direct Buried

Single and multi-conductor cables shall of a type identified for direct burial. Service entrance cables shall conform to UL 854 for Type USE service entrance cable.

2.4.2.5 In Duct

Cables shall be single-conductor cable, in accordance with NFPA 70.

2.5 CABLE JOINTS, TERMINATIONS, AND CONNECTORS

2.5.1 Medium-Voltage Cable Joints

Medium-voltage cable joints shall comply with IEEE Std 404 and IEEE Std 592. Medium-voltage cable terminations shall comply with IEEE Std 48. Joints shall be the standard products of a manufacturer and shall be either of the factory preformed type or of the kit type containing tapes and other required parts. Joints shall have ratings not less than the ratings of the cables on which they are installed. Splice kits may be of the heat-shrinkable type for voltages up to 15 kV, of the premolded splice and connector type, the conventional taped type, or the resin pressure-filled overcast taped type for voltages up to 35 kV; except that for voltages of 7.5 kV or less a resin pressure-filled type utilizing a plastic-tape mold is acceptable. Joints used in manholes, handholes, vaults and pull boxes shall be certified by the manufacturer for waterproof, submersible applications.

2.5.2 Low-Voltage Cable Splices

Low-voltage cable splices and terminations shall be rated at not less than 600 Volts. Splices in conductors No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A. Splices in conductors No. 8 AWG and larger shall be made with noninsulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A and UL 486B. Splices shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket. Splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

2.5.3 Terminations

Terminations shall be in accordance with IEEE Std 48, Class 1 or Class 2; of the molded elastomer, wet-process porcelain, prestretched elastomer, heat-shrinkable elastomer, or taped type. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations shall be of the outdoor type, except that where installed inside outdoor equipment housings which are sealed against normal infiltration of moisture and outside air, indoor, Class 2 terminations are acceptable. Class 3 terminations are not acceptable. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, and armor.

2.5.3.1 Factory Preformed Type

Molded elastomer, wet-process porcelain, prestretched, and heat-shrinkable terminations shall utilize factory preformed components to the maximum extent practicable rather than tape build-up. Terminations shall have basic impulse levels as required for the system voltage level. Leakage distances shall comply

with wet withstand voltage test requirements of IEEE Std 48 for the next higher Basic Insulation Level (BIL) level.

2.5.3.2 Taped Terminations

Taped terminations shall use standard termination kits providing terminal connectors, field-fabricated stress cones, and rain hoods. Terminations shall be at least 510mm long from the end of the tapered cable jacket to the start of the terminal connector, or not less than the kit manufacturer's recommendations, whichever is greater.

2.6 CONDUIT AND DUCTS

Ducts shall be as indicated on the drawings.

2.6.1 Metallic Conduit

Intermediate metal conduit shall comply with UL 1242. Rigid galvanized steel conduit shall comply with UL 6 and ANSI C80.1. Metallic conduit fittings and outlets shall comply with UL 514A and NEMA FB 1.

2.6.2 Nonmetallic Ducts

2.6.2.1 Concrete Encased Ducts

UL 651 Schedule 40 or NEMA TC 6 Type EB.

2.6.2.2 Direct Burial

UL 651 Schedule 40, or NEMA TC 6 Type DB.

2.6.3 Conduit Sealing Compound

Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 2 degrees C (35 degrees F), shall neither slump at a temperature of 150 degrees C (300 degrees F), nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials.

2.7 MANHOLES, HANDHOLES, AND PULLBOXES

Manholes, handholes, and pullboxes shall be as indicated. Strength of manholes, handholes, and pullboxes and their frames and covers shall conform to the requirements of IEEE C2. Precast-concrete manholes shall have the required strength established by ASTM C 478, ASTM C 478M. Frames and covers shall be made of gray cast iron and a machine-finished seat shall be provided to ensure a matching joint between frame and cover. Cast iron shall comply with ASTM A 48M, Class 30B, minimum. Handholes for low voltage cables installed in parking lots, sidewalks, and turfed areas shall be fabricated from an aggregate consisting of sand and with continuous woven glass strands having an overall compressive strength of at least 69 MPa (10,000 psi) and a flexural strength of at least 34.5 MPa (5000 psi). Pullbox and handhole covers in sidewalks, and turfed areas shall be of the same material as the box. Concrete pullboxes shall consist of precast reinforced concrete boxes, extensions, bases, and covers.

2.8 POLES AND HARDWARE

Poles and hardware shall be in accordance with Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL.

2.9 TRANSFORMERS, SUBSTATIONS, AND SWITCHGEAR

Transformers, substations, and switchgear shall be of the outdoor type having the ratings and arrangements indicated. Medium-voltage ratings of cable terminations shall be 15 kV between phases for 133 percent insulation level.

2.9.1 Pad-Mounted Transformers

Pad-mounted transformers shall comply with ANSI C57.12.26 and shall be of the loop feed type. Pad-mounted transformer stations shall be assembled and coordinated by one manufacturer and each transformer station shall be shipped as a complete unit so that field installation requirements are limited to mounting each unit on a concrete pad and connecting it to primary and secondary lines. Stainless steel pins and hinges shall be provided. Barriers shall be provided between high- and low-voltage compartments. High-voltage compartment doors shall be interlocked with low-voltage compartment doors to prevent access to any high-voltage section unless its associated low-voltage section door has first been opened. Compartments shall be sized to meet the specific dimensional requirements of ANSI C57.12.26. Pentahead locking bolts shall be provided with provisions for a padlock.

2.9.1.1 High-Voltage Compartments

The high-voltage compartment shall be dead-front construction. Primary switching and protective devices shall include loadbreak switching, oil-immersed, current-limiting, bayonet-type fuses, medium-voltage separable loadbreak connectors, universal bushing wells and inserts or integral one piece bushings and surge arresters. Fuses shall comply with the requirements of paragraph METERING AND PROTECTIVE DEVICES. The switch shall be mounted inside transformer tank with switch operating handle located in high-voltage compartment and equipped with metal loop for hook stick operation. Fuses shall be interlocked with switches so that fuses can be removed only when the associated switch is in the "OPEN" position. Adjacent to medium-voltage cable connections, a nameplate or equivalent stencilled inscription shall be provided inscribed "DO NOT OPEN CABLE CONNECTORS UNLESS SWITCH IS OPEN." Surge arresters shall be fully insulated and configured to terminate on the same bushing as the primary cable by means of a loadbreak, feed-through bushing insert or a second set of high voltage bushings when there is no loop feed.

2.9.1.2 Load-Break Switch

Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Each switch shall be rated at 15 kV, 95 kV BIL, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 10,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment. Operation of switches shall be as follows:

| ARRANGEMENT # | DESCRIPTION OF SWITCH ARRANGEMENT | SWITCH POSITION | | | | | |
|---------------|--------------------------------------------------------------------|-----------------|-----------------|----------------|-----------------|--------------|---------------|
| | | LINE A SW OPEN | LINE A SW CLOSE | LINE B SW OPEN | LINE B SW CLOSE | XFMR SW OPEN | XFMR SW CLOSE |
| 1 | Line A connected to Line B and both lines connected to transformer | | X | | X | | X |
| 2 | Transformer connected to Line A only | | X | | X | | X |

| ARRANGEMENT # | DESCRIPTION OF SWITCH ARRANGEMENT | SWITCH POSITION | | | |
|---------------|--------------------------------------|-----------------|-----------------|----------------------|--------------------|
| | | LINE A SW OPEN | LINE A SW CLOSE | LINE B SW OPEN CLOSE | XFMR SW OPEN CLOSE |
| 3 | Transformer connected to Line B only | X | | X | X |
| 4 | Transformer open and loop closed | | X | X | X |
| 5 | Transformer open and loop open | X | | X | X |

2.9.1.3 Transformer Tank Sections

Transformers shall comply with IEEE C57.12.00, ANSI C57.12.21, and ANSI C57.12.26 and shall be of the mineral oil-insulated type. Transformers shall be suitable for outdoor use and shall have 2 separate windings per phase. All transformer windings shall be copper. Standard NEMA primary taps shall be provided. Where primary taps are not specified, 4, 2-1/2 percent rated kVA high-voltage taps shall be provided 2 above and 2 below rated, primary voltage. Operating handles for primary tap changers for de-energized operation shall be located within high-voltage compartments, externally to transformer tanks. Adjacent to the tap changer operating handle, a nameplate or equivalent stenciled inscription shall be provided and inscribed "DO NOT OPERATE UNDER LOAD." Transformer ratings at 60 Hz shall be as follows:

Three-phase capacity.....as indicated___ kVA.
 Impedance.....5.75%___.
 Temperature Rise.....65 degrees C.
 High-voltage winding.....12470___ volts.
 High-voltage winding connections.....Delta___.
 Low-voltage winding.....as indicated___ volts.
 Low-voltage winding connections..... Wye___
Winding material primary and secondary copper___.

2.9.1.4 Low-Voltage Cable Compartments

Neutrals shall be provided with fully-insulated bushings. Clamp type cable terminations, suitable for copper conductors entering from below, shall be provided as necessary.

2.9.1.5 Accessories

High-voltage warning signs shall be permanently attached to each side of transformer stations. Voltage warning signs shall comply with IEEE C2. Copper-faced steel or stainless steel ground connection pads shall be provided in both the high- and low-voltage compartments. Dial-type thermometer, liquid-level gauge, and drain valve with built-in sampling device shall be provided for each transformer station. Insulated-bushing-type parking stands shall be provided adjacent to each separable load-break elbow to provide for cable isolation during

sectionalizing operations.

2.9.2 Pad-Mounted Sectionalizers

Pad-mounted, sectionalizing switches shall conform to the requirements of IEEE C37.63. The switchgear shall be configured with 2 incoming compartments for loop-feed arrangement one incoming compartment for radial-feed equipped with SF6-insulated load-interrupter switches, as indicated. The outgoing compartments shall be provided with non-reclosing sectionalizers.

2.9.2.1 Ratings

Ratings at 60 Hz shall be:

Nominal voltage (kV).....14.4.

Rated maximum voltage (kV).....17.

Rated continuous current (A).....600.

Three-second short-time current-carrying capacity (kA).....14.

Contractor shall verify with user and/or COR available short circuit current at connection point to existing utility. Contact COR for discrepancies.

BIL (kV).....95.

2.9.2.2 Enclosures

Switchgear enclosures shall be of freestanding, self-supporting construction provided with separate incoming and outgoing compartments configured for bottom cable entry. Enclosures shall be of deadfront construction, provided with a hinged door for access to each compartment, and conform to the requirements of ANSI C57.12.28, ANSI C37.72, and IEEE C37.20.3, Category A.

2.9.3 Cable Terminating Cabinets

Cable terminating cabinets shall be hook-stick operable, deadfront construction conforming to the requirements of IEEE C37.20.3, Category A. Cabinets shall be provided with with 200 A. loadbreak junctions and elbow-type separable loadbreak connectors, cable parking stands, and grounding lugs. The cable terminating equipments shall conform to IEEE Std 386.

Ratings at 60 Hz shall be:

Nominal voltage (kV).....12470.

Rated maximum voltage (kV).....15000.

Rated continuous current (A).....200 A.

BIL (kV).....95.

2.10 METERING AND PROTECTIVE DEVICES

2.10.1 Fuses, Medium-Voltage, Including Current-Limiting

2.10.1.1 Construction

Units shall be suitable for outdoor use. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.10.1.2 Ratings

Expulsion-type power fuses shall have ratings in accordance with ANSI C37.46 and as follows:

Nominal voltage....._12470_.

Rated maximum voltage....._15000_.

Maximum symmetrical interrupting capacity....._14000_.

Rated continuous current....._as indicated_.

BIL....._95_.

2.10.1.3 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to ANSI C37.46.

2.10.2 Watthour Meters

Watthour meters shall conform to ANSI C12.10, except numbered terminal wiring sequence and case size may be the manufacturer's standard. Watthour meters shall be of the socket mounted outdoor type having a 60 minute, cumulative form, demand register meeting ANSI C12.4 and provided with not less than 2-1/2 stators. Watthour demand meters shall have factory-installed electronic pulse initiators. Pulse initiators shall be solid-state devices incorporating light-emitting diodes, phototransistors, and power transistors, except that mercury-wetted output contacts are acceptable. Initiators shall be totally contained within watthour demand meter enclosures, shall be capable of operating up to speeds of 500 pulses per minute with no false pulses, and shall require no field adjustments. Initiators shall be calibrated for a pulse rate output of 1 pulse per 1/4 disc revolution of the associated meter and shall be compatible with the indicated equipment.

2.11 SURGE ARRESTERS

Surge arresters shall comply with NEMA LA 1, IEEE C62.1, IEEE C62.2, and IEEE C62.11 and shall be provided where indicated. Arresters shall be distribution class, rated as shown. Arresters shall be equipped with mounting brackets suitable for the indicated installations. Arresters shall be of the metal-oxide varistor type.

2.12 GROUNDING AND BONDING

2.12.1 Driven Ground Rods

Ground rods shall be copper-clad steel conforming to UL 467 not less than 19 mm (3/4 inch) in diameter by 3.1 m (10 feet) in length. Sectional type rods may be used.

2.12.2 Grounding Conductors

Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be ASTM B 8 soft-drawn unless otherwise indicated. Aluminum is not acceptable.

2.13 CONCRETE AND REINFORCEMENT

Concrete work shall have minimum compressive strength and conform to the

requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Concrete reinforcing shall be as specified in Section 03200A CONCRETE REINFORCEMENT.

2.14 PADLOCKS

Padlocks shall comply with Section 08710 DOOR HARDWARE.

2.15 CABLE FIREPROOFING SYSTEMS

Cable fireproofing systems shall be listed in FM P7825a as a fire-protective coating or tape approved for grouped electrical conductors and shall be suitable for application on the type of medium-voltage cables provided. After being fully cured, materials shall be suitable for use where exposed to oil, water, gases, salt water, sewage, and fungus and shall not damage cable jackets or insulation. Asbestos materials are not acceptable.

2.15.1 Fireproof Coating

Cable fireproofing coatings shall be compounded of water-based thermoplastic resins, flame-retardant chemicals, and inorganic noncombustible fibers and shall be suitable for the application methods used. Coatings applied on bundled cables shall have a derating factor of less than 5 percent, and a dielectric strength of 95 volts per mil minimum after curing.

2.15.2 Fireproofing Tape

Fireproofing tape shall be at least 50 mm (2 inches) wide and shall be a flexible, conformable, polymeric, elastomer tape designed specifically for fireproofing cables.

2.15.3 Plastic Tape

Preapplication plastic tape shall be pressure sensitive, 0.254 mm (10 mil) thick, conforming to UL 510.

2.16 LIQUID DIELECTRICS

Liquid dielectrics for transformers, capacitors, reclosers, and other liquid-filled electrical equipment shall be non-polychlorinated biphenyl (PCB) mineral-oil or less-flammable liquid as specified. Nonflammable fluids shall not be used. Tetrachloroethylene (perchloroethylene) and 1, 2, 4 trichlorobenzene fluids shall not be used. Liquid dielectrics in retrofitted equipment shall be certified by the manufacturer as having less than 50 parts per million (ppm) PCB content. In lieu of the manufacturer's certification, the Contractor may submit a test sample of the dielectric in accordance with ASTM D 923 and have tests performed per ASTM D 4059 at a testing facility approved by the Contracting Officer. Equipment with test results indicating PCB level exceeding 50 ppm shall be replaced.

2.17 FACTORY TESTS

Factory tests shall be performed, as follows, in accordance with the applicable publications and with other requirements of these specifications. The Contracting Officer shall be notified at least 10 days before the equipment is ready for testing. The Contracting Officer reserves the right to witness the tests.

- a. Transformers: Manufacturer's standard routine tests in accordance with IEEE C57.12.00.
- b. Transformers rated 200 kVA and above: Reduced full-wave, chopped-wave, and full-wave impulse test on each line and neutral terminal, in accordance with IEEE C57.98.

- c. High-Voltage Air Switches: Manufacturer's standard tests in accordance with IEEE C37.34 and IEEE C37.41.
- d. Protective Relays: Seismic tests in accordance with IEEE C37.98. Surge withstand tests in accordance with IEEE C37.90.1.

- g. Factory Preformed Terminations: Wet withstand voltage tests in accordance with IEEE Std 48 for the next higher BIL level.
- h. Outdoor Switchgear: Manufacturer's standard tests in accordance with IEEE C37.20.1, IEEE C37.20.2, and IEEE C37.20.3.
- i. Electrical Power Insulators: Manufacturer's standard tests in accordance with ANSI C29.1.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Circuits installed aerially shall conform to the requirements of Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL. Steel conduits installed underground shall be installed and protected from corrosion in conformance with the requirements of Section 16415A ELECTRICAL WORK, INTERIOR. Except as covered herein, excavation, trenching, and backfilling shall conform to the requirements of Section 02316A EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS. Concrete work shall have minimum 20 MPa compressive strength and conform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.1.1 Conformance to Codes

The installation shall comply with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable.

3.1.2 Verification of Dimensions

The Contractor shall become familiar with details of the work, shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

3.1.3 Disposal of Liquid Dielectrics

PCB-contaminated dielectrics must be marked as PCB and transported to and incinerated by an approved EPA waste disposal facility. The Contractor shall furnish certification of proper disposal. Contaminated dielectrics shall not be diluted to lower the contamination level.

3.2 CABLE AND BUSWAY INSTALLATION

The Contractor shall obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, etc. The Contractor shall then perform pulling calculations and prepare a pulling plan which shall be submitted along with the

manufacturers instructions in accordance with SUBMITTALS.

3.2.1 Cable Installation Plan and Procedure

Cable shall be installed strictly in accordance with the cable manufacturer's recommendations. Each circuit shall be identified by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag shall contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

3.2.1.1 Cable Inspection

The cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed from cable in accordance with the cable manufacturer's recommendations.

3.2.1.2 Duct Cleaning

Duct shall be cleaned with an assembly that consists of a flexible mandrel (manufacturers standard product in lengths recommended for the specific size and type of duct) that is 6.4 mm (1/4 inch) less than inside diameter of duct, 2 wire brushes, and a rag. The cleaning assembly shall be pulled through conduit a minimum of 2 times or until less than a volume of 131 cubic centimeters (8 cubic inches) of debris is expelled from the duct.

3.2.1.3 Duct Lubrication

The cable lubricant shall be compatible with the cable jacket for cable that is being installed. Application of lubricant shall be in accordance with lubricant manufacturer's recommendations.

3.2.1.4 Cable Installation

The Contractor shall provide a cable feeding truck and a cable pulling winch as required. The Contractor shall provide a pulling grip or pulling eye in accordance with cable manufacturer's recommendations. The pulling grip or pulling eye apparatus shall be attached to polypropylene or manilla rope followed by lubricant front end packs and then by power cables. A dynamometer shall be used to monitor pulling tension. Pulling tension shall not exceed cable manufacturer's recommendations. The Contractor shall not allow cables to cross over while cables are being fed into duct. For cable installation in cold weather, cables shall be kept at 10 degrees C (50 degrees F) temperature for at least 24 hours before installation.

3.2.1.5 Cable Installation Plan

The Contractor shall submit a cable installation plan for all cable pulls in accordance with the detail drawings portion of paragraph SUBMITTALS. Cable installation plan shall include:

- a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.
- b. List of cable installation equipment.
- c. Lubricant manufacturer's application instructions.
- d. Procedure for resealing cable ends to prevent moisture from entering cable.
- e. Cable pulling tension calculations of all cable pulls.

- f. Cable percentage conduit fill.
- g. Cable sidewall thrust pressure.
- h. Cable minimum bend radius and minimum diameter of pulling wheels used.
- i. Cable jam ratio.
- j. Maximum allowable pulling tension on each different type and size of conductor.
- k. Maximum allowable pulling tension on pulling device.

3.2.2 Duct Line

Medium-voltage cables and Low-voltage cables shall be installed in duct lines where indicated. Neutral and grounding conductors shall be installed in the same duct with their associated phase conductors.

3.2.3 Electric Manholes

Cables shall be routed around the interior walls and securely supported from walls on cables racks. Cable routing shall minimize cable crossover, provide access space for maintenance and installation of additional cables, and maintain cable separation in accordance with IEEE C2.

3.3 CABLE JOINTS

Medium-voltage cable joints shall be made by qualified cable splicers only. Qualifications of cable splicers shall be submitted in accordance with paragraph SUBMITTALS. Shields shall be applied as required to continue the shielding system through each entire cable joint. Shields may be integrally molded parts of preformed joints. Shields shall be grounded at each joint or in accordance with manufacturer's recommended practice. Cable joints shall provide insulation and jacket equivalent to that of the associated cable. Armored cable joints shall be enclosed in compound-filled, cast-iron or alloy, splice boxes equipped with stuffing boxes and armor clamps of a suitable type and size for the cable being installed.

3.4 FIREPROOFING

Each medium-voltage cable and conductor in manholes shall be fire-proofed for their entire length within the manhole. Where cables and conductors have been lubricated to enhance pulling into ducts, the lubricant shall be removed from cables and conductors exposed in the manhole before fireproofing. Fire-stops shall be installed in each conduit entering or leaving a manhole.

3.4.1 Tape Method

Before application of fireproofing tape, plastic tape wrapping shall be applied over exposed metallic items such as the cable ground wire, metallic outer covering, or armor to minimize the possibility of corrosion from the fireproofing materials and moisture. Before applying fireproofing tape, irregularities of cables, such as at cable joints, shall be evened out with insulation putty. A flexible conformable polymeric elastomer fireproof tape shall be wrapped tightly around each cable spirally in 1/2 lapped wrapping or in 2 butt-jointed wrappings with the second wrapping covering the joints of the first.

3.4.2 Sprayable Method

Manholes shall be power ventilated until coatings are dry and dewatered and the coatings are cured. Ventilation requirements shall be in accordance with the manufacturer's instruction, but not less than 10 air changes per hour shall be

provided. Cable coatings shall be applied by spray, brush, or glove to a wet film thickness that reduces to the dry film thickness approved for fireproofing by FM P7825a. Application methods and necessary safety precautions shall be in accordance with the manufacturers instructions. After application, cable coatings shall be dry to the touch in 1 to 2 hours and fully cured in 48 hours, except where the manufacturer has stated that because of unusual humidity or temperature, longer periods may be necessary.

3.5 DUCT LINES

3.5.1 Requirements

Numbers and sizes of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of 100 mm per 30 m. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 450 mm (18 inches) for ducts of less than 80 mm (3 inch) diameter, and 900 mm (36 inches) for ducts 80 mm (3 inches) or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in manholes or handholes.

3.5.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.5.3 Concrete Encasement

Ducts requiring concrete encasements shall comply with NFPA 70, except that electrical duct bank configurations for ducts 150 mm (6 inches) in diameter shall be determined by calculation and as shown on the drawings. The separation between adjacent electric power and communication ducts shall conform to IEEE C2.

Duct line encasements shall be monolithic construction. Where a connection is made to a previously poured encasement, the new encasement shall be well bonded or doweled to the existing encasement. The Contractor shall submit proposed bonding method for approval in accordance with the detail drawing portion of paragraph SUBMITTALS. At any point, except railroad and airfield crossings, tops of concrete encasements shall be not less than the cover requirements listed in NFPA 70. At railroad and airfield crossings, duct lines shall be encased with concrete and reinforced as indicated to withstand specified surface loadings.

Tops of concrete encasements shall be not less than 1.5 m below tops of rails or airfield paving unless otherwise indicated. Where ducts are jacked under existing pavement, rigid steel conduit will be installed because of its strength.

To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 15 m in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 1.2 m on centers. Ducts shall be securely anchored to prevent movement during the placement of concrete and joints shall be staggered at least 150 mm vertically.

3.5.4 Nonencased Direct-Burial

Top of duct lines shall be not less than 914 mm (36 inches) below finished grade and shall be installed with a minimum of 75 mm of earth around each duct, except that between adjacent electric power and communication ducts, 300 mm of earth is required. Bottoms of trenches shall be graded toward manholes or handholes and shall be smooth and free of stones, soft spots, and sharp objects. Where bottoms of trenches comprise materials other than sand, a 75 mm layer of sand shall be laid first and compacted to approximate densities of surrounding firm soil before installing ducts. Joints in adjacent tiers of duct shall be vertically staggered at least 150 mm. The first 150 mm layer of backfill cover shall be sand compacted as previously specified. The rest of the excavation shall be backfilled and compacted in 75 to 150 mm layers. Duct banks may be held in alignment with earth. However, high-tiered banks shall use a wooden frame or equivalent form to hold ducts in alignment prior to backfilling.

3.5.5 Installation of Couplings

Joints in each type of duct shall be made up in accordance with the manufacturer's recommendations for the particular type of duct and coupling selected and as approved.

3.5.5.1 Plastic Duct

Duct joints shall be made by brushing a plastic solvent cement on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick 1/4-turn twist to set the joint tightly.

3.5.6 Duct Line Markers

Duct line markers shall be provided at the ends of long duct line stubouts or for other ducts whose locations are indeterminate because of duct curvature or terminations at completely below-grade structures. In addition to markers, a 0.127 mm (5 mil) brightly colored plastic tape, not less than 75 mm (3 inches) in width and suitably inscribed at not more than 3 m (10 feet) on centers with a continuous metallic backing and a corrosion-resistant 0.0254 mm (1 mil) metallic foil core to permit easy location of the duct line, shall be placed approximately 300 mm below finished grade levels of such lines.

3.6 MANHOLES, HANDHOLES, AND PULLBOXES

3.6.1 General

Manholes shall be constructed approximately where shown. The exact location of each manhole shall be determined after careful consideration has been given to the location of other utilities, grading, and paving. The location of each manhole shall be approved by the Contracting Officer before construction of the manhole is started. Manholes shall be the type noted on the drawings and shall be constructed in accordance with the applicable details as indicated. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. The Contractor may at his option utilize monolithically constructed precast-concrete manholes having the required strength and inside dimensions as required by the drawings or specifications. In paved areas, frames and covers for manhole and handhole entrances in vehicular traffic areas shall be flush with the finished surface of the paving. In unpaved areas, the top of manhole covers shall be approximately 15 mm above the finished grade. Where existing grades that are higher than finished grades are encountered, concrete assemblies designed for the purpose shall be installed to elevate temporarily the manhole cover to existing grade level. All duct lines entering manholes must be installed on compact soil or otherwise supported when entering a manhole to prevent shear stress on the duct at the point of entrance to the manhole. Duct lines entering cast-in-place concrete manholes shall be cast

in-place with the manhole. Duct lines entering precast concrete manholes through a precast knockout penetration shall be grouted tight with a portland cement mortar. PVC duct lines entering precast manholes through a PVC endbell shall be solvent welded to the endbell. A cast metal grille-type sump frame and cover shall be installed over the manhole sump. A cable-pulling iron shall be installed in the wall opposite each duct line entrance.

3.6.2 Electric Manholes

Cables shall be securely supported from walls by hot-dip galvanized cable racks with a plastic coating over the galvanizing and equipped with adjustable hooks and insulators. Cable racks shall be installed in each manhole and not less than 2 spare hooks shall be installed on each cable rack. Insulators shall be made of high-glazed porcelain. Insulators will not be required on spare hooks.

3.6.3 Communications Manholes

The number of hot-dip galvanized cable racks with a plastic coating over the galvanizing indicated shall be installed in each telephone manhole. Each cable rack shall be provided with 2 cable hooks. Cables for the telephone and communication systems will be installed by others.

3.6.4 Handholes

Handholes shall be located approximately as shown. Handholes shall be of the type noted on the drawings and shall be constructed in accordance with the details shown.

3.6.5 Pullboxes

Pullbox tops shall be flush with sidewalks or curbs or placed 15 mm above surrounding grades when remote from curbed roadways or sidewalks. Covers shall be marked "Low-Voltage" and provided with 2 lifting eyes and 2 hold-down bolts. Each box shall have a suitable opening for a ground rod. Conduit, cable, ground rod entrances, and unused openings shall be sealed with mortar.

3.6.6 Ground Rods

A ground rod shall be installed at the manholes, handholes and pullboxes. Ground rods shall be driven into the earth before the manhole floor is poured so that approximately 100 mm of the ground rod will extend above the manhole floor. When precast concrete manholes are used, the top of the ground rod may be below the manhole floor and a No. 1/0 AWG ground conductor brought into the manhole through a watertight sleeve in the manhole wall.

3.7 PAD-MOUNTED EQUIPMENT INSTALLATION

Pad-mounted equipment, shall be installed on concrete pads in accordance with the manufacturer's published, standard installation drawings and procedures, except that they shall be modified to meet the requirements of this document. Units shall be installed so that they do not damage equipment or scratch painted or coated surfaces. After installation, surfaces shall be inspected and scratches touched up with a paint or coating provided by the manufacturer especially for this purpose. Three-phase transformers shall be installed with phase sequence as per Ft. Riley Public Works. Primary taps shall be set at such that the output is 208 or 480 volts at 50% loading.

3.7.1 Concrete Pads

3.7.1.1 Construction

Concrete pads for pad-mounted electrical equipment may be either pre-fabricated or poured-in-place. Pads shall be constructed as indicated, except that exact pad

dimensions and mounting details are equipment specific and are the responsibility of the Contractor. Tops of concrete pads shall be level and shall project 100 mm above finished paving or grade and sloped to drain. Edges of concrete pads shall have 20 mm chamfer. Conduits for primary, secondary, and grounding conductors shall be set in place prior to placement of concrete pads. Where grounding electrode conductors are installed through concrete pads, PVC conduit sleeves shall be installed through the concrete to provide physical protection. To facilitate cable installation and termination, the concrete pad shall be provided with a rectangular hole below the primary and secondary compartments, sized in accordance with the manufacturer's recommended dimensions. Upon completion of equipment installation the rectangular hole shall be filled with masonry grout.

3.7.1.2 Concrete and Reinforcement

Concrete work shall have minimum 20 MPa compressive strength and conform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Concrete pad reinforcement shall be in accordance with Section 03200A CONCRETE REINFORCEMENT.

3.7.1.3 Sealing

When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.7.2 Padlocks

Padlocks shall be provided for pad-mounted equipment and for each fence gate. Padlocks shall be keyed as directed by the Contracting Officer.

3.8 CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS

Connections between aerial and underground systems shall be made as shown. Underground cables shall be extended up poles in conduit to cable terminations. Conduits shall be secured to the poles by 2-hole galvanized steel pipe straps spaced not more than 3 m apart and with 1 strap not more than 300 mm from any bend or termination. Cable guards shall be secured to poles in accordance with the manufacturer's published procedures. Conduits shall be equipped with bushings to protect cables and minimize water entry. Capnut potheads shall be used to terminate medium-voltage multiple-conductor cable. Cables shall be supported by devices separate from the conduit or guard, near their point of exit from the conduit or guard.

3.8.1 Pole Installation

Pole installation shall be in accordance with Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL.

3.9 CONNECTIONS TO BUILDINGS

Cables shall be extended into the various buildings as indicated, and shall be connected to the first applicable termination point in each building. Interfacing with building interior conduit systems shall be at conduit stubouts terminating 1.5 m outside of a building and 600 mm below finished grade as specified and provided under Section 16415A ELECTRICAL WORK, INTERIOR. After installation of cables, conduits shall be sealed with caulking compound to prevent entrance of moisture or gases into buildings.

3.10 GROUNDING

A ground ring consisting of the indicated configuration of bare copper conductors and driven ground rods shall be installed around pad-mounted equipment as shown. Equipment frames of metal-enclosed equipment, and other noncurrent-carrying metal

parts, such as cable shields, cable sheaths and armor, and metallic conduit shall be grounded. At least 2 connections shall be provided from a transformer, to the ground mat. Metallic frames and covers of handholes and pull boxes shall be grounded by use of a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.10.1 Grounding Electrodes

Grounding electrodes shall be installed as shown on the drawings and as follows:

- a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be driven into the earth until the tops of the rods are approximately 300 mm below finished grade.
- b. Ground mat - A ground mat shall be installed as shown.
- c. Ground ring - A ground ring shall be installed as shown consisting of bare copper conductors installed 600 mm, plus or minus 75 mm, below finished top of soil grade. Ground ring conductors shall be sized as shown.
- d. Additional electrodes - When the required ground resistance is not met, additional electrodes shall be provided interconnected with grounding conductors to achieve the specified ground resistance. The additional electrodes will be up to three, 3 m (10 feet) rods spaced a minimum of 3.7 m apart. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.10.2 Grounding and Bonding Connections

Connections above grade shall be made by the fusion-welding process or with bolted solderless connectors, in compliance with UL 467, and those below grade shall be made by a fusion-welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

3.10.3 Grounding and Bonding Conductors

Grounding and bonding conductors include conductors used to bond transformer enclosures and equipment frames to the grounding electrode system. Grounding and bonding conductors shall be sized as shown, and located to provide maximum physical protection. Bends greater than 45 degrees in ground conductors are not permitted. Routing of ground conductors through concrete shall be avoided. When concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit so as to provide an opening for the ground conductor, and the opening shall be sealed with a suitable compound after installation.

3.10.4 Surge Arrester Grounding

Surge arresters and neutrals shall be bonded directly to the transformer enclosure and then to the grounding electrode system with a bare copper conductor, sized as shown. Lead lengths shall be kept as short as practicable with no kinks or sharp bends.

3.10.5 Manhole, Handhole, or Concrete Pullbox Grounding

Ground rods installed in manholes, handholes, or concrete pullboxes shall be connected to cable racks, cable-pulling irons, the cable shielding, metallic sheath, and armor at each cable joint or splice by means of a No. 4 AWG braided tinned copper wire. Connections to metallic cable sheaths shall be by means of

tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 50 mm above and 150 mm below concrete penetrations. Grounding electrode conductors shall be neatly and firmly attached to manhole or handhole walls and the amount of exposed bare wire shall be held to a minimum.

3.10.6 Metal Splice Case Grounding

Metal splice cases for medium-voltage direct-burial cable shall be grounded by connection to a driven ground rod located within 600 mm of each splice box using a grounding electrode conductor having a current-carrying capacity of at least 20 percent of the individual phase conductors in the associated splice box, but not less than No. 6 AWG.

3.10.7 Riser Pole Grounding

A single continuous vertical grounding electrode conductor shall be installed on each riser pole and connected directly to the grounding electrodes indicated on the drawings or required by these specifications. All equipment, neutrals, surge arresters, and items required to be grounded shall be connected directly to this vertical conductor. The grounding electrode conductor shall be sized as shown. Grounding electrode conductors shall be stapled to wood poles at intervals not exceeding 600 mm.

3.11 FIELD TESTING

3.11.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 30 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field test reports shall be signed and dated by the Contractor.

3.11.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.11.3 Ground-Resistance Tests

The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

- a. Single rod electrode - 25 ohms.
- b. Multiple rod electrodes - 25 ohms.

- d. Ground ring - 25 ohms.

3.11.4 Medium-Voltage Cable Test

After installation and before the operating test or connection to an existing system, the medium-voltage cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors as one terminal and connecting grounds or metallic shieldings or sheaths of the cable as the other terminal for each test. Prior to making the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The test shall be conducted with all splices, connectors, and terminations in place. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 7 or NEMA WC 8 for the particular type of cable installed, except that 28 kV and 35 kV insulation test voltages shall be in accordance with either AEIC CS5 or AEIC CS6 as applicable, and shall not exceed the recommendations of IEEE Std 404 for cable joints and IEEE Std 48 for cable terminations unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.11.5 Low-Voltage Cable Test

Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

$$R \text{ in megohms} = (\text{rated voltage in kV} + 1) \times 304,800 / (\text{length of cable in meters})$$

Each cable failing this test shall be repaired or replaced. The repaired cable shall be retested until failures have been eliminated.

3.11.6 Liquid-Filled Transformer Tests

The following field tests shall be performed on all liquid-filled transformers. Pass-fail criteria shall be in accordance with transformer manufacturer's specifications.

- a. Insulation resistance test phase-to-ground.
- b. Turns ratio test.
- c. Correct phase sequence.
- d. Correct operation of tap changer.

3.11.7 Dry-Type Transformer Tests

The following field tests shall be performed on all dry-type transformers. Pass-fail criteria shall be in accordance with the transformer manufacturer's specifications.

- a. Insulation resistance test phase-to-ground.
- b. Turns ratio test.

3.11.8 Circuit Breaker Tests

The following field tests shall be performed on circuit breakers. Pass-fail criteria shall be in accordance with the circuit breaker manufacturer's specifications.

- a. Insulation resistance test phase-to-phase.
- b. Insulation resistance test phase-to-ground.
- c. Closed breaker contact resistance test.
- d. Power factor test.
- e. High-potential test.
- f. Manual operation of the breaker.

3.11.9 Pre-Energization Services

Calibration, testing, adjustment, and placing into service of the installation shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of 2 years of current product experience. The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment to ensure packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

- b. Pad-mounted transformers
- d. Switchboards

3.11.10 Operating Tests

After the installation is completed, and at such times as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the requirements herein. An operating test report shall be submitted in accordance with paragraph SUBMITTALS.

3.12 MANUFACTURER'S FIELD SERVICE

3.12.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as

designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, and servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations. A CD format video tape of the entire training session shall be submitted.

3.12.2 Installation Engineer

After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of the equipment, assist in the performance of the onsite tests, initial operation, and instruct personnel as to the operational and maintenance features of the equipment.

3.13 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

-- End of Section --

SECTION 16415A

ELECTRICAL WORK, INTERIOR
06/02

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

| | |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ANSI C12.1 | (1995) Code for Electricity Metering |
| ANSI C12.10 | (1997) Electromechanical Watthour Meters |
| ANSI C12.11 | (1987; R 1993) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV) |
| ANSI C12.4 | (1984; R 1996) Mechanical Demand Registers |
| ANSI C135.30 | (1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction |
| ANSI C37.16 | (2000) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations |
| ANSI C39.1 | (1981; R 1992) Requirements for Electrical Analog Indicating Instruments |
| ANSI C57.12.10 | (1988) Safety Requirements for Transformers 230 kV and Below 833/958 Through 8333/10417 kVA, Single-Phase, and 750/862 Through 60 000/80 000/100 000 kVA, Three-Phase Without Load Tap Charging; and 3750/4687 Through 60 000/80 000/100/000 kVA With Load Tap Charging |
| ANSI C57.12.13 | (1982) Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations |
| ANSI C57.12.27 | (1982) Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations |
| ANSI C57.12.50 | (1981; R 1989) Ventilated Dry-Type Distribution Transformers 1 to 500 kVA, Single-Phase; and 15 to 500 kVA, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts |
| ANSI C57.12.51 | (1981; R 1989) Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High-Voltage 601 to 34 500 Volts, |

| | |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | Low-Voltage 208Y/120 to 4160 Volts |
| ANSI C57.12.52 | (1981; R 1989) Sealed Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts |
| ANSI C57.12.70 | (1978; R 1993) Terminal Markings and Connections for Distribution and Power Transformers |
| ANSI C78.1 | (1991; C78.1a; R 1996) Fluorescent Lamps - Rapid-Start Types - Dimensional and Electrical Characteristics |
| ANSI C78.1350 | (1990) Electric Lamps - 400-Watt, 100-Volt, S51 Single-Ended High-Pressure Sodium Lamps |
| ANSI C78.1351 | (1989) Electric Lamps - 250-Watt, 100-Volt S50 Single-Ended High-Pressure Sodium Lamps |
| ANSI C78.1352 | (1990) Electric Lamps - 1000-Watt, 250-Volt, S52 Single-Ended High-Pressure Sodium Lamps |
| ANSI C78.1355 | (1989) Electric Lamps - 150-Watt, 55-Volt S55 High-Pressure Sodium Lamps |
| ANSI C78.1375 | (1996) 400-Watt, M59 Single-Ended Metal-Halide Lamps |
| ANSI C78.1376 | (1996) 1000-Watt, M47 Metal-Halide Lamps |
| ANSI C78.20 | (1995) Electric Lamps - Characteristics of Incandescent Lamps A, G, PS, and Similar Shapes with E26 Medium Screw Bases |
| ANSI C78.21 | (1995) Physical and Electrical Characteristics - Incandescent Lamps - PAR and R Shapes |
| ANSI C78.2A | (1991) 18 & 26- Watt, Compact Fluorescent Quad Tube Lamps ** |
| ANSI C78.2B | (1992) 9 & 13-Watt, Compact Fluorescent Quad Tube Lamps ** |
| ANSI C80.5 | (1995) Rigid Aluminum Conduit |
| ANSI C82.1 | (1997) Specifications for Fluorescent Lamp Ballasts \ \$18.00\$ \ F \ X Addenda D & E |
| ANSI C82.4 | (1992) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type) |

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|-------------|------------------------------------------------------------------------------------------|
| ASTM B 1 | (1995) Hard-Drawn Copper Wire |
| ASTM B 8 | (1999) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft |
| ASTM D 4059 | (1996) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography |
| ASTM D 709 | (2000) Laminated Thermosetting Materials |

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (1997) National Electrical Safety Code

IEEE C37.13 (1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures

IEEE C37.20.1 (1993) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear

IEEE C57.100 (1999) Test Procedure for Thermal Evaluation of Oil-Immersed Distribution Transformers \savail only as part of Distribution, Power, and Regulating Transformers Stds Collection

IEEE C57.12.00 (1993) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.12.80 (1996) Terminology for Power and Distribution Transformers \savail only as part of Distribution, Power, and Regulating Transformer Stds Collection

IEEE C57.12.90 (1999) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers \savail only as part of Distribution, Power, and Regulating Transformers Stds Collection

IEEE C57.13 (1993) Instrument Transformers

IEEE C57.98 (1993) Guide for Transformer Impulse Tests \savail only as part of Distribution, Power, and Regulating Transformers Stds Collection

IEEE C62.41 (1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits

IEEE Std 242 (1986; R 1991) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

IEEE Std 399 (1997) Recommended Practice for Industrial and Commercial Power Systems Analysis

IEEE Std 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1) \F31.00\F

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (1997) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA AB 1 (1993) Molded Case Circuit Breakers and Molded Case Switches

NEMA BU 1 (1994) Busways

NEMA FU 1 (1986) Low Voltage Cartridge Fuses

NEMA ICS 1 (1993) Industrial Control and Systems

NEMA ICS 2 (1993) Industrial Controls and Systems
Controllers, Contactors, and Overload Relays
Rated Not More Than 2,000 Volts AC or 750 Volts
DC

NEMA ICS 3 (1993) Industrial Control and Systems Factory
Built Assemblies

NEMA ICS 6 (1993) Industrial Control and Systems, Enclosures

NEMA LE 4 (1987) Recessed Luminaires, Ceiling Compatibility

NEMA MG 1 (1998) Motors and Generators

NEMA MG 10 (1994) Energy Management Guide for Selection and
Use of Polyphase Motors

NEMA OS 1 (1996) Sheet-Steel Outlet Boxes, Device Boxes,
Covers, and Box Supports

NEMA OS 2 (1998) Nonmetallic Outlet Boxes, Device Boxes,
Covers and Box Supports

NEMA PB 1 (1995) Panelboards

NEMA PB 2 (1995) Deadfront Distribution Switchboards

NEMA PE 5 (1996) Utility Type Battery Chargers

NEMA RN 1 (1998) Polyvinyl-Chloride (PVC) Externally
Coated Galvanized Rigid Steel Conduit and
Intermediate Metal Conduit

NEMA SG 3 (1995) Power Switching Equipment

NEMA ST 20 (1992) Dry-Type Transformers for General
Applications

NEMA TC 13 (1993) Electrical Nonmetallic Tubing (ENT)

NEMA TC 2 (1998) Electrical Polyvinyl Chloride (PVC)
Tubing (EPT) and Conduit (EPC-40 and EPC-80)

NEMA TP 1 (2002) Guide for Determining Energy Efficiency
for Distribution Transformers

NEMA VE 1 (1996) Metal Cable Tray Systems

NEMA WD 1 (1999) General Requirements for Wiring Devices

NEMA WD 6 (1997) Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101 (2000) Life Safety Code

NFPA 70 (2002) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 18 Industrial, Scientific, and Medical Equipment

UNDERWRITERS LABORATORIES (UL)

UL 1 (2000) Flexible Metal Conduit

UL 1004 (1994; Rev thru Nov 1999) Electric Motors

UL 1010 (1995; Rev thru Mar 1999) Receptical-Plug Combinations for Use in Hazardous (Classified) Locations

UL 1022 (1998) Line Isolation Monitors

UL 1029 (1994; Rev thru Dec 1997) High-Intensity-Discharge Lamp Ballasts

UL 1047 (1995; Rev Jul 1998) Isolated Power Systems Equipment

UL 1236 (1994; Rev thru Mar 1999) Battery Chargers for Charging Engine-Starter Batteries

UL 1242 (1996; Rev Mar 1998) Intermediate Metal Conduit

UL 1449 (1996; Rev thru Dec 1999) Transient Voltage Surge Suppressors

UL 1564 (1993; R Sep 1998) Industrial Battery Chargers

UL 1569 (1999; Rev thru Jan 2000) Metal-Clad Cables

UL 1570 (1995; Rev thru Nov 1999) Fluorescent Lighting Fixtures

UL 1571 (1995; Rev thru Nov 1999) Incandescent Lighting Fixtures

UL 1572 (1995; Rev thru Nov 1999) High Intensity Discharge Lighting Fixtures

UL 1660 (2000) Liquid-Tight Flexible Nonmetallic Conduit

UL 198B (1995) Class H Fuses

UL 198C (1986; Rev thru Feb 1998) High-Interrupting-Capacity Fuses, Current-Limiting Types

UL 198D (1995) Class K Fuses

UL 198E (1988; Rev Jul 1988) Class R Fuses

UL 198G (1988; Rev May 1988) Fuses for Supplementary Overcurrent Protection

UL 198H (1988; Rev thru Nov 1993) Class T Fuses

UL 198L (1995; Rev May 1995) D-C Fuses for Industrial Use

UL 20 (1995; Rev thru Oct 1998) General-Use Snap Switches

UL 360 (1996; Rev thru Oct 1997) Liquid-Tight Flexible Steel Conduit

UL 4 (1996) Armored Cable

UL 44 (1999) Thermoset-Insulated Wires and Cables

UL 467 (1993; Rev thru Apr 1999) Grounding and Bonding Equipment

UL 486A (1997; Rev thru Dec 1998) Wire Connectors and Soldering Lugs for Use with Copper Conductors

UL 486B (1997; Rev Jun 1997) Wire Connectors for Use with Aluminum Conductors

UL 486C (1997; Rev thru Aug 1998) Splicing Wire Connectors

UL 486E (1994; Rev thru Feb 1997) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors

UL 489 (1996; Rev thru Dec 1998) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

UL 498 (1996; Rev thru Jan 1999) Attachment Plugs and Receptacles

UL 5 (1996) Surface Metal Raceways and Fittings

UL 50 (1995; Rev thru Nov 1999) Enclosures for Electrical Equipment

UL 506 (1994; R Oct 1997) Specialty Transformers

UL 508 (1999) Industrial Control Equipment

UL 510 (1994; Rev thru Apr 1998) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape

UL 512 (1993; Rev thru Mar 1999) Fuseholders

UL 514A (1996; Rev Dec 1999) Metallic Outlet Boxes

UL 514B (1997; Rev Oct 1998) Fittings for Cable and Conduit

UL 514C (1996; Rev thru Dec 1999) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers

UL 542 (1999) Lampholders, Starters, and Starter Holders for Fluorescent Lamps

UL 6 (1997) Rigid Metal Conduit

UL 651 (1995; Rev thru Oct 1998) Schedule 40 and 80 Rigid PVC Conduit

UL 651A (1995; Rev thru Apr 1998) Type EB and A Rigid PVC Conduit and HDPE Conduit

| | |
|-------------------|-----------------------------------------------------------------------------------------------------------------------|
| UL 67 | (1993; Rev thru Oct 1999) Panelboards |
| UL 674 | (1994; Rev thru Oct 1998) Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations |
| UL 698 | (1995; Rev thru Mar 1999) Industrial Control Equipment for Use in Hazardous (Classified) Locations |
| UL 719 | (1996; Rev Jul 1999) Nonmetallic-Sheathed Cables |
| UL 797 | (1993; Rev thru Mar 1997) Electrical Metallic Tubing |
| UL 817 | (1994; Rev thru May 1999) Cord Sets and Power- |
| UL 83 | (1998; Rev thru Sep 1999) Thermoplastic-Insulated Wires and Cables |
| UL 844 | (1995; Rev thru Mar 1999) Electric Lighting Fixtures for Use in Hazardous (Classified) Locations |
| UL 845 | (1995; Rev thru Nov 1999) Motor Control Centers |
| UL 854 | (1996; Rev Oct 1999) Service-Entrance Cables |
| UL 857 | (1994; Rev thru Dec 1999) Busways and Associated Fittings |
| UL 869A | (1998) Reference Standard for Service Equipment |
| UL 877 | (1993; Rev thru Nov 1999) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations |
| UL 886 | (1994; Rev thru Apr 1999) Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations |
| UL 891 | (1994; Rev thru Jan 1995) Dead-Front Switchboards |
| UL 916 | (1998) Energy Management Equipment |
| UL 924 | (1995; Rev thru Oct 97) Emergency Lighting and Power Equipment |
| UL 935 | (1995; Rev thru Oct 1998) Fluorescent-Lamp Ballasts |
| UL 943 | (1993; Rev thru May 1998) Ground-Fault Circuit-Interrupters |
| UL 98 | (1994; Rev thru Jun 1998) Enclosed and Dead-Front Switches |
| UL Elec Const Dir | (1999) Electrical Construction Equipment Directory |

1.2 GENERAL

1.2.1 Rules

The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated or shown.

1.2.2 Coordination

The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that the outlets and equipment shall be properly located and readily accessible. Lighting fixtures, outlets, and other equipment and materials shall be carefully coordinated with mechanical or structural features prior to installation and positioned according to architectural reflected ceiling plans; otherwise, lighting fixtures shall be symmetrically located according to the room arrangement when uniform illumination is required, or asymmetrically located to suit conditions fixed by design and shown. Raceways, junction and outlet boxes, and lighting fixtures shall not be supported from sheet metal roof decks. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change. The Contractor shall coordinate the electrical requirements of the mechanical work and provide all power related circuits, wiring, hardware and structural support, even if not shown on the drawings.

1.2.3 Special Environments

1.2.3.1 Weatherproof Locations

Wiring, Fixtures, and equipment in designated locations shall conform to NFPA 70 requirements for installation in damp or wet locations.

1.2.3.2 Hazardous Locations

Wiring and equipment in locations indicated shall be of the classes, groups, divisions, and suitable for the operating temperature; as indicated.

1.2.3.3 Ducts, Plenums and Other Air-Handling Spaces

Wiring and equipment in ducts, plenums and other air-handling spaces shall be installed using materials and methods in conformance with NFPA 70 unless more stringent requirements are indicated in this specification or on the contract drawings.

1.2.4 Standard Products

Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.2.5 Nameplates

1.2.5.1 Identification Nameplates

Major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number as indicated. Designation of motors shall coincide with their designation in the motor control center or panel. Unless otherwise specified, identification nameplates shall be made of laminated plastic in accordance with ASTM D 709 with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with black-finished round-head drive screws, except motors, or approved nonadhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates. In all instances, the nameplate

shall be installed in a conspicuous location. At the option of the Contractor, the equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. The front of each panelboard, motor control center, switchgear, and switchboard shall have a nameplate to indicate the phase letter, corresponding color and arrangement of the phase conductors. The following equipment, as a minimum, shall be provided with identification nameplates:

| Minimum 6.4 mm High Letters | Minimum 3.2 mm High Letters |
|--------------------------------|--------------------------------|
| Panelboards | Control Power Transformers |
| Starters | Control Devices |
| Safety Switches | Instrument Transformers |
| Motor Control Centers | |
| Transformers | |
| Equipment Enclosures | |
| Switchgear | |
| Switchboards | |
| Motors | |

Each panel, section, or unit in motor control centers, switchgear or similar assemblies shall be provided with a nameplate in addition to nameplates listed above, which shall be provided for individual compartments in the respective assembly, including nameplates which identify "future," "spare," and "dedicated" or "equipped spaces."

1.2.5.2 Liquid-Filled Transformer Nameplates

Power transformers shall be provided with Nameplate C information in accordance with IEEE C57.12.00. Nameplates shall indicate percent impedance, voltage, kVA, frequency, number of phases, cooling class, insulation class, temperature rise, the number of gallons and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. The Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 50 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 50 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

1.2.6 As-Built Drawings

Following the project completion or turnover, within 30 days the Contractor shall furnish 2 sets of as-built drawings to the Contracting Officer.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Interior Electrical Equipment; G, RE.

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams, and other information necessary to define the installation. Detail drawings shall show the rating of items and systems and how the components of an item and system are assembled,

related portions of the project and the reasons why, shall be submitted with the detail drawings. Approved departures shall be made at no additional cost to the Government.

SD-03 Product Data

Fault Current and Protective Device Coordination Study; G, DF.

The study shall be submitted along with protective device equipment submittals. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study, The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Manufacturer's Catalog; G, RE.

Data composed of catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material, Equipment, and Fixture Lists; G, RE.

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each item.

Installation Procedures; G, RE.

Installation procedures for rotating equipment, transformers, switchgear, battery systems, voltage regulators, and grounding resistors. Procedures shall include diagrams, instructions, and precautions required to install, adjust, calibrate, and test devices and equipment.

As-Built Drawings; G, RE.

The as-built drawings shall be a record of the construction as installed. The drawings shall include all the information shown on the contract drawings, deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be kept at the job site and updated daily. The as-built drawings shall be a full-sized set of prints marked to reflect all deviations, changes, and modifications. The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within ten calendar days from the time the drawings are returned to the Contractor.

Onsite Tests; G, RE.

A detailed description of the Contractor's proposed procedures for on-site tests.

SD-06 Test Reports

Factory Test Reports; G, RE.

Six copies of the information described below in binders having a minimum of 5 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

- a. A list of equipment used, with calibration certifications.
- b. A copy of measurements taken.
- c. The dates of testing.
- d. The equipment and values to be verified.
- e. The conditions specified for the test.
- f. The test results, signed and dated.
- g. A description of adjustments made.

Field Test Plan; G, RE.

A detailed description of the Contractor's proposed procedures for onsite test submitted 30 days prior to testing the installed system. No field test will be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Field Test Reports; G, RE.

Six copies of the information described below in 216 x 280 mm binders having a minimum of 5 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

- a. A list of equipment used, with calibration certifications.
- b. A copy of measurements taken.
- c. The dates of testing.
- d. The equipment and values to be verified.
- e. The conditions specified for the test.
- f. The test results, signed and dated.
- g. A description of adjustments made.
- h. Final position of controls and device settings.

SD-07 Certificates

Materials and Equipment; G, RE.

The label or listing of the Underwriters Laboratories, Inc., will be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this label or listing, a statement from a nationally recognized, adequately equipped testing

agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements will be accepted. However, materials and equipment installed in hazardous locations must bear the UL label unless the data submitted from other testing agency is specifically approved in writing by the Contracting Officer. Items which are required to be listed and labeled in accordance with Underwriters Laboratories must be affixed with a UL label that states that it is UL listed. No exceptions or waivers will be granted to this requirement. Materials and equipment will be approved based on the manufacturer's published data.

For other than equipment and materials specified to conform to UL publications, a manufacturer's statement indicating complete compliance with the applicable standard of the American Society for Testing and Materials, National Electrical Manufacturers Association, or other commercial standard, is acceptable.

1.4 WORKMANSHIP

Materials and equipment shall be installed in accordance with NFPA 70, recommendations of the manufacturer, and as shown.

1.5 SEISMIC REQUIREMENTS

Seismic details shall conform to Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 16070A SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT

PART 2 PRODUCTS

Products shall conform to the respective publications and other requirements specified below. Materials and equipment not listed below shall be as specified elsewhere in this section. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.1 CABLES AND WIRES

Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and ampacities shown are based on copper, unless indicated otherwise. All conductors shall be copper.

2.1.1 Equipment Manufacturer Requirements

When manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to meet manufacturer's requirements.

2.1.2 Aluminum Conductors

Aluminum conductors shall not be used.

2.1.3 Insulation

Unless indicated otherwise, or required by NFPA 70, power and lighting wires shall be 600-volt, Type THWN, THHN, or THW conforming to UL 83, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits shall be Type TW, THW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.1.4 Bonding Conductors

ASTM B 1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B 8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.1.5 Service Entrance Cables

Service entrance (SE) and underground service entrance (USE) cables, UL 854.

2.1.6 TEXT DELETED

TEXT DELETED.

2.1.7 TEXT DELETED

TEXT DELETED.

2.1.8 TEXT DELETED

TEXT DELETED.

2.1.9 TEXT DELETED

TEXT DELETED.

2.1.10 TEXT DELETED

TEXT DELETED.

2.1.11 Tray Cable or Power Limited Tray Cable

UL listed; Type TC or PLTC.

2.1.12 Cord Sets and Power-Supply Cords

UL 817.

2.2 CABLE TRAYS

Cable tray shall conform to NEMA VE 1, shall form a wireway system, and shall be as indicated in the drawings. Cable trays shall be constructed of zinc-coated steel. Trays shall include splice and end plates, dropouts, and miscellaneous hardware. Edges, fittings, and hardware shall be finished free from burrs and sharp edges. Fittings shall have not less than the load-carrying ability of straight tray sections and shall have manufacturer's minimum standard radius. Radius of bends shall be 610 mm.

2.2.1 Trough

Trough-type cable trays shall be of a nominal 300 mm width.

2.2.2 Ladder

Ladder-type cable trays shall be of nominal 300 mm width. Rung spacing shall be on 230 mm maximum centers.

2.2.3 Solid Bottom

Solid bottom-type cable trays shall be of a nominal 300 mm width.

2.3 TRANSIENT VOLTAGE SURGE PROTECTION

Transient voltage surge suppressors shall be provided as indicated. Surge suppressors shall meet the requirements of IEEE C62.41 and be UL listed and

labeled as having been tested in accordance with UL 1449. Surge suppressor ratings shall be 480 OR 208 as indicated volts rms, operating voltage; 60 Hz; 3-phase; 4 wire with ground; transient suppression voltage (peak let-through voltage) of 400 volts for IEEE Category C1, 470 volts for IEEE Category C3 and 150 volts for IEEE B3 waves. Fuses shall not be used as surge suppression.

2.4 CIRCUIT BREAKERS

2.4.1 MOLDED-CASE CIRCUIT BREAKERS

Molded-case circuit breakers shall conform to NEMA AB 1 and UL 489 and UL 877 for circuit breakers and circuit breaker enclosures located in hazardous (classified) locations. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers.

2.4.1.1 Construction

Circuit breakers shall be suitable for mounting and operating in any position. Lug shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.4.1.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with NEMA AB 1. Ratings shall be coordinated with system X/R ratio.

2.4.1.3 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 150 amperes.

2.4.2 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where

indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

- a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.
- b. Adjustable long-time delay.
- c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.
- d. Adjustable short-time delay.
- e. Short-time $I^2 t$ switch.
- f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.
- j. Overload and short-time trip indicators shall be provided.

2.4.3 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through $I^2 t$ to a value less than the $I^2 t$ of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.4.4 SWD Circuit Breakers

Circuit breakers rated 15 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.4.5 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.4.6 Ground Fault Circuit Interrupters

UL 943. Breakers equipped with ground fault circuit interrupters shall have ground fault class, interrupting capacity, and voltage and current ratings as indicated.

2.5 CONDUIT AND TUBING

2.5.1 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797

2.5.2 Electrical Nonmetallic Tubing (ENT)

NEMA TC 13.

2.5.3 Electrical Plastic Tubing and Conduit

NEMA TC 2.

2.5.4 Flexible Conduit, Steel and Plastic

General-purpose type, UL 1; liquid tight, UL 360, and UL 1660.

2.5.5 Intermediate Metal Conduit

UL 1242.

2.5.6 PVC Coated Rigid Steel Conduit

NEMA RN 1.

2.5.7 Rigid Aluminum Conduit

ANSI C80.5 and UL 6.

2.5.8 Rigid Metal Conduit

UL 6.

2.5.9 Rigid Plastic Conduit

NEMA TC 2, UL 651 and UL 651A.

2.5.10 Surface Metal Electrical Raceways and Fittings

UL 5.

2.6 CONDUIT AND DEVICE BOXES AND FITTINGS

2.6.1 Boxes, Metallic Outlet

NEMA OS 1 and UL 514A.

2.6.2 Boxes, Nonmetallic, Outlet and Flush-Device Boxes and Covers

NEMA OS 2 and UL 514C.

2.6.3 Boxes, Outlet for Use in Hazardous (Classified) Locations

UL 886.

2.6.4 Boxes, Switch (Enclosed), Surface-Mounted

UL 98.

2.6.5 Fittings for Conduit and Outlet Boxes

UL 514B.

2.6.6 Fittings For Use in Hazardous (Classified) Locations

UL 886.

2.6.7 Fittings, PVC, for Use with Rigid PVC Conduit and Tubing

UL 514B.

2.7 CONDUIT COATINGS PLASTIC RESIN SYSTEM

NEMA RN 1, Type A-40.

2.8 CONNECTORS, WIRE PRESSURE

2.8.1 For Use With Copper Conductors

UL 486A.

2.9 ELECTRICAL GROUNDING AND BONDING EQUIPMENT

UL 467.

2.9.1 Ground Rods

Ground rods shall be of copper-clad steel conforming to UL 467 zinc-coated steel conforming to ANSI C135.30 solid stainless steel not less than 19.1 mm in diameter by 3.1 meter in length of the sectional type driven full length into the earth.

2.9.2 Ground Bus

The ground bus shall be bare conductor or flat copper in one piece, if practicable.

2.10 ENCLOSURES

NEMA ICS 6 or NEMA 250 unless otherwise specified.

2.10.1 Cabinets and Boxes

Cabinets and boxes with volume greater than 0.0164 cubic meters shall be in accordance with UL 50, hot-dip, zinc-coated, if sheet steel.

2.10.2 Circuit Breaker Enclosures

UL 489.

2.11 LIGHTING FIXTURES, LAMPS, BALLASTS, EMERGENCY EQUIPMENT, CONTROLS AND ACCESSORIES

The following specifications are supported and supplemented by information and details on the drawings. Additional fixtures, if shown, shall conform to this specification. Lighting equipment installed in classified hazardous locations shall conform to UL 844. Lamps, lampholders, ballasts, transformers, electronic circuitry and other lighting system components shall be constructed according to industry standards. Equipment shall be tested and listed by a recognized independent testing laboratory for the expected installation conditions. Equipment shall conform to the standards listed below.

2.11.1 Lamps

Lamps shall be constructed to operate in the specified fixture, and shall function without derating life or output as listed in published data. Lamps shall meet the requirements of the Energy Policy Act of 1992.

- b. Fluorescent lamps shall have color temperature of 3,500. They shall be designed to operate with the ballasts and circuitry of the fixtures in which they will be used. Fluorescent lamps, including spares, shall be manufactured by one manufacturer to provide for color and performance consistency. Fluorescent lamps shall comply with ANSI C78.1. Fluorescent tube lamp efficiencies shall meet or exceed the following requirements.

T8, 32 watts

(4' lamp)

2800 lumens

| | | |
|--------------|-----------|-------------|
| T12,34 watts | (4' lamp) | 2800 lumens |
| T8,59 watts | (8' lamp) | 5700 lumens |
| T12,60 watts | (8' lamp) | 5600 lumens |

(1) Linear fluorescent lamps, unless otherwise indicated, shall be 1219 mm long 32 watt T8, 265 mA, with minimum CRI of 75. Lamps of other lengths or types shall be used only where specified or shown. Lamps shall deliver rated life when operated on rapid start ballasts.

- c. High intensity discharge lamps, including spares, shall be manufactured by one manufacturer in order to provide color and performance consistency. High intensity discharge lamps shall be designed to operate with the ballasts and circuitry of the fixtures in which they will be used and shall have wattage, shape and base as shown. High intensity discharge lamps, unless otherwise shown, shall have medium or mogul screw base and minimum starting temperature of -29 degrees C . Metal halide lamps, unless otherwise shown, shall have minimum CRI of 65; color temperature of 4,300 degrees Kelvin; shall be -BU configuration if used in base-up position; and shall be -H or high output configuration if used in horizontal position. Lamps shall comply with all applicable ANSI C78.1350, ANSI C78.1351, ANSI C78.1352, ANSI C78.1355,ANSI C78.1375, and ANSI C78.1376.

2.11.2 Ballasts and Transformers

Ballasts or transformers shall be designed to operate the designated lamps within their optimum specifications, without derating the lamps. Lamp and ballast combinations shall be certified as acceptable by the lamp manufacturer.

- b. Fluorescent ballasts shall comply with ANSI C82.1 and shall be mounted integrally within fluorescent fixture housing unless otherwise shown. Ballasts shall have maximum current crest factor of 1.7; high power factor; Class A sound rating; maximum operating case temperature of 25 degrees C above ambient; and shall be rated Class P. Unless otherwise indicated, the minimum number of ballasts shall be used to serve each individual fixture. A single ballast may be used to serve multiple fixtures if they are continuously mounted, identically controlled and factory manufactured for that installation with an integral wireway.

(2) Electronic fluorescent ballasts shall comply with 47 CFR 18 for electromagnetic interference. Ballasts shall withstand line transients per IEEE C62.41, Category A. Ballasts shall have total harmonic distortion between 10 and 20%; minimum frequency of 20,000Hz; filament voltage between 2.5 and 4.5 volts; maximum starting inrush current of 20 amperes; and shall comply with the minimum Ballast Efficacy Factors shown in the table below. Minimum starting temperature shall be 10 degrees C . Ballasts shall carry a manufacturer's full warranty of three years, including a minimum \$10 labor allowance per ballast.

ELECTRONIC FLUORESCENT BALLAST EFFICACY FACTORS

| LAMP TYPE | TYPE OF STARTER | NOMINAL OPERATIONAL | NUMBER OF | MINIMUM BALLAST |
|-----------|-----------------|---------------------|-----------|-----------------|
|-----------|-----------------|---------------------|-----------|-----------------|

| | ELECTRONIC & LAMP | FLUORESCENT VOLTAGE | BALLAST LAMPS | EFFICACY FACTORS EFFICACY FACTOR |
|---------|----------------------|------------------------|------------------|-------------------------------------------|
| 32W T8 | rapid | 120 or 277 V | 1 | 2.54 |
| | start | | 2 | 1.44 |
| | linear & | | 3 | 0.93 |
| | U-tubes | | 4 | 0.73 |
| 34W T12 | rapid | 120 or 277 V | 1 | 2.64 |
| | start | | 2 | 1.41 |
| | linear & | | 3 | 0.93 |
| | U-tubes | | | |
| 59W T8 | rapid | 120 or 277 V | 2 | 0.80 |
| | start | | | |
| | linear | | | |
| 60W T12 | rapid | 120 or 277 V | 2 | 0.80 |
| | start | | | |
| | linear | | | |

2.11.3 Fixtures

Fixtures shall be in accordance with the size, shape, appearance, finish, and performance shown. Unless otherwise indicated, lighting fixtures shall be provided with housings, junction boxes, wiring, lampholders, mounting supports, trim, hardware and accessories for a complete and operable installation. Recessed housings shall be minimum 20 gauge cold rolled or galvanized steel as shown. Extruded aluminum fixtures shall have minimum wall thickness of 3 mm . Plastic lenses shall be 100% virgin acrylic or as shown. Glass lenses shall be tempered. Heat resistant glass shall be borosilicate type. Conoid recessed reflector cones shall be Alzak with clear specular low iridescent finish.

- a. Incandescent fixtures shall comply with UL 1571. Incandescent fixture specular reflector cone trims shall be integral to the cone and shall be finished to match. Painted trim finishes shall be white with minimum reflectance of 88%. Low voltage incandescent fixtures shall have integral step-down transformers.
- b. Fluorescent fixtures shall comply with UL 1570. Recessed ceiling fixtures shall comply with NEMA LE 4. Fixtures shall be plainly marked for proper lamp and ballast type to identify lamp diameter, wattage, color and start type. Marking shall be readily visible to service personnel, but not visible from normal viewing angles. Fluorescent fixture lens frames on recessed and surface mounted troffers shall be one assembly with mitered corners. Parabolic louvers shall have a low

iridescent finish and 45 degree cut-off. Louver intersection joints shall be hairline type and shall conceal mounting tabs or other assembly methods. Louvers shall be free from blemishes, lines or defects which distort the visual surface. Integral ballast and wireway compartments shall be easily accessible without the use of special tools. Housings shall be constructed to include grounding necessary to start the lamps. Open fixtures shall be equipped with a sleeve, wire guard, or other positive means to prevent lamps from falling. Medium bi-pin lampholders shall be twist-in type with positive locking position. Long compact fluorescent fixtures and fixtures utilizing U-bend lamps shall have clamps or secondary lampholders to support the free ends of the lamps.

- d. Emergency lighting fixtures and accessories shall be constructed and independently tested to meet the requirements of applicable codes. Batteries shall be Nicad or equal with no required maintenance, and shall have a minimum life expectancy of five years and warranty period of three years.

e. Exit Signs

Exit signs shall be ENERGY STAR compliant, thereby meeting the following requirements. Input power shall be less than 5 watts per face. Letter size and spacing shall adhere to NFPA 101. Luminance contrast shall be greater than 0.8. Average luminance shall be greater than 15 cd/m^2 measured at normal (0 degree) and 45 degree viewing angles. Minimum luminance shall be greater than 8.6 cd/m^2 measured at normal and 45 degree viewing angles. Maximum to minimum luminance shall be less than 20:1 measured at normal and 45 degree viewing angles. The manufacturer warranty for defective parts shall be at least 5 years. Exit signs shall flash when a general evacuation alarm is initiated by the fire alarm system

2.11.4 Lampholders, Starters, and Starter Holders

UL 542

2.11.5 Ultrasonic, and Passive Infrared Occupancy Sensors

UL 916

2.12 INSTRUMENTS, ELECTRICAL INDICATING

ANSI C39.1.

2.13 MOTORS, AC, FRACTIONAL AND INTEGRAL

Motors, ac, fractional and integral kilowatt, 373.0 kW and smaller shall conform to NEMA MG 1 and UL 1004 for motors; NEMA MG 10 for energy management selection of polyphase motors; and UL 674 for use of motors in hazardous (classified) locations. In addition to the standards listed above, motors shall be provided with efficiencies as specified in the table "MINIMUM NOMINAL EFFICIENCIES" below.

2.13.1 Rating

The kilowatt rating of motors should be limited to no more than 125 percent of the maximum load being served unless a NEMA standard size does not fall within this range. In this case, the next larger NEMA standard motor size should be used.

2.13.2 Motor Efficiencies

All permanently wired polyphase motors of 746 W or more shall meet the minimum full-load efficiencies as indicated in the following table, and as specified in this specification. Motors of 746 W or more with open, drip proof or totally enclosed fan cooled enclosures shall be high efficiency type, unless otherwise indicated. Motor efficiencies indicated in the tables apply to general-purpose, single-speed, polyphase induction motors. Applications which require definite purpose, special purpose, special frame, or special mounted polyphase induction motors are excluded from these efficiency requirements. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.

MINIMUM NOMINAL MOTOR EFFICIENCIES
OPEN DRIP PROOF MOTORS

| kW | 1200 RPM | 1800 RPM | 3600 RPM |
|-------|----------|----------|----------|
| 0.746 | 82.5 | 85.5 | 80.0 |
| 1.12 | 86.5 | 86.5 | 85.5 |
| 1.49 | 87.5 | 86.5 | 86.5 |
| 2.24 | 89.5 | 89.5 | 86.5 |
| 3.73 | 89.5 | 89.5 | 89.5 |
| 5.60 | 91.7 | 91.0 | 89.5 |
| 7.46 | 91.7 | 91.7 | 90.2 |
| 11.2 | 92.4 | 93.0 | 91.0 |
| 14.9 | 92.4 | 93.0 | 92.4 |
| 18.7 | 93.0 | 93.6 | 93.0 |
| 22.4 | 93.6 | 93.6 | 93.0 |
| 29.8 | 94.1 | 94.1 | 93.6 |
| 37.3 | 94.1 | 94.5 | 93.6 |
| 44.8 | 95.0 | 95.0 | 94.1 |
| 56.9 | 95.0 | 95.0 | 94.5 |
| 74.6 | 95.0 | 95.4 | 94.5 |
| 93.3 | 95.4 | 95.4 | 95.0 |
| 112.0 | 95.8 | 95.8 | 95.4 |
| 149.0 | 95.4 | 95.8 | 95.4 |
| 187.0 | 95.4 | 96.2 | 95.8 |
| 224.0 | 95.4 | 95.0 | 95.4 |
| 261.0 | 94.5 | 95.4 | 95.0 |
| 298.0 | 94.1 | 95.8 | 95.0 |
| 336.0 | 94.5 | 95.4 | 95.4 |
| 373.0 | 94.5 | 94.5 | 94.5 |

TOTALLY ENCLOSED FAN-COOLED MOTORS

| kW | 1200 RPM | 1800 RPM | 3600 RPM |
|-------|----------|----------|----------|
| 0.746 | 82.5 | 85.5 | 78.5 |
| 1.12 | 87.5 | 86.5 | 85.5 |
| 1.49 | 88.5 | 86.5 | 86.5 |
| 2.24 | 89.5 | 89.5 | 88.5 |
| 3.73 | 89.5 | 89.5 | 89.5 |
| 5.60 | 91.7 | 91.7 | 91.0 |
| 7.46 | 91.7 | 91.7 | 91.7 |
| 11.2 | 92.4 | 92.4 | 91.7 |
| 14.9 | 92.4 | 93.0 | 92.4 |
| 18.7 | 93.0 | 93.6 | 93.0 |
| 22.4 | 93.6 | 93.6 | 93.0 |
| 29.8 | 94.1 | 94.1 | 93.6 |
| 37.3 | 94.1 | 94.5 | 94.1 |
| 44.8 | 94.5 | 95.0 | 94.1 |
| 56.9 | 95.0 | 95.4 | 94.5 |
| 74.6 | 95.4 | 95.4 | 95.0 |

TOTALLY ENCLOSED FAN-COOLED MOTORS

| | | | |
|-------|------|------|------|
| 93.3 | 95.4 | 95.4 | 95.4 |
| 112.0 | 95.8 | 95.8 | 95.4 |
| 149.0 | 95.8 | 96.2 | 95.8 |
| 187.0 | 95.6 | 96.2 | 95.9 |
| 224.0 | 95.4 | 96.1 | 95.8 |
| 261.0 | 94.5 | 96.2 | 94.8 |
| 298.0 | 94.5 | 95.8 | 94.5 |
| 336.0 | 94.5 | 94.5 | 94.5 |
| 373.0 | 94.5 | 94.5 | 94.5 |

MINIMUM NOMINAL MOTOR EFFICIENCIES
OPEN DRIP PROOF MOTORS

| HP | 1200 RPM | 1800 RPM | 3600 RPM |
|-----|----------|----------|----------|
| 1 | 82.5 | 85.5 | 80.0 |
| 1.5 | 86.5 | 86.5 | 85.5 |
| 2 | 87.5 | 86.5 | 86.5 |
| 3 | 89.5 | 89.5 | 86.5 |
| 5 | 89.5 | 89.5 | 89.5 |
| 7.5 | 91.7 | 91.0 | 89.5 |
| 10 | 91.7 | 91.7 | 90.2 |
| 15 | 92.4 | 93.0 | 91.0 |
| 20 | 92.4 | 93.0 | 92.4 |
| 25 | 93.0 | 93.6 | 93.0 |
| 30 | 93.6 | 93.6 | 93.0 |
| 40 | 94.1 | 94.1 | 93.6 |
| 50 | 94.1 | 94.5 | 93.6 |
| 60 | 95.0 | 95.0 | 94.1 |
| 75 | 95.0 | 95.0 | 94.5 |
| 100 | 95.0 | 95.4 | 94.5 |
| 125 | 95.4 | 95.4 | 95.0 |
| 150 | 95.8 | 95.8 | 95.4 |
| 200 | 95.4 | 95.8 | 95.4 |
| 250 | 95.4 | 96.2 | 95.8 |
| 300 | 95.4 | 95.0 | 95.4 |
| 350 | 94.5 | 95.4 | 95.0 |
| 400 | 94.1 | 95.8 | 95.0 |
| 450 | 94.5 | 95.4 | 95.4 |
| 500 | 94.5 | 94.5 | 94.5 |

TOTALLY ENCLOSED FAN-COOLED MOTORS

| HP | 1200 RPM | 1800 RPM | 3600 RPM |
|-----|----------|----------|----------|
| 1 | 82.5 | 85.5 | 78.5 |
| 1.5 | 87.5 | 86.5 | 85.5 |
| 2 | 88.5 | 86.5 | 86.5 |
| 3 | 89.5 | 89.5 | 88.5 |
| 5 | 89.5 | 89.5 | 89.5 |
| 7.5 | 91.7 | 91.7 | 91.0 |
| 10 | 91.7 | 91.7 | 91.7 |
| 15 | 92.4 | 92.4 | 91.7 |
| 20 | 92.4 | 93.0 | 92.4 |
| 25 | 93.0 | 93.6 | 93.0 |
| 30 | 93.6 | 93.6 | 93.0 |
| 40 | 94.1 | 94.1 | 93.6 |
| 50 | 94.1 | 94.5 | 94.1 |
| 60 | 94.5 | 95.0 | 94.1 |
| 75 | 95.0 | 95.4 | 94.5 |
| 100 | 95.4 | 95.4 | 95.0 |
| 125 | 95.4 | 95.4 | 95.4 |

| TOTALLY ENCLOSED FAN-COOLED MOTORS | | | |
|------------------------------------|------|------|------|
| 150 | 95.8 | 95.8 | 95.4 |
| 200 | 95.8 | 96.2 | 95.8 |
| 250 | 95.6 | 96.2 | 95.9 |
| 300 | 95.4 | 96.1 | 95.8 |
| 350 | 94.5 | 96.2 | 94.8 |
| 400 | 94.5 | 95.8 | 94.5 |
| 450 | 94.5 | 94.5 | 94.5 |
| 500 | 94.5 | 94.5 | 94.5 |

2.14 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

2.14.1 General

NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Panelboards supplying non-linear loads shall have neutrals sized for 200 percent of rated current.

2.14.2 Motor Starters

Combination starters shall be provided with circuit breakers.

2.14.3 Thermal-Overload Protection

Each motor of 93 W (1/8 hp) or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.14.4 Low-Voltage Motor Overload Relays

2.14.4.1 General

Thermal overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or motor controller, and shall be rated in accordance with the requirements of NFPA 70. Standard units shall be used for motor starting times up to 7 seconds.

2.14.4.2 Construction

Manual reset type thermal relay shall be bimetallic construction. Automatic reset type thermal relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.14.4.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than minus 10 degrees C, an ambient temperature-compensated overload relay shall be provided.

2.14.5 Automatic Control Devices

2.14.5.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate kilowatt rating.

2.14.5.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.14.5.3 Manual/Automatic Selection

- a. Where combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch (marked MANUAL-OFF-AUTOMATIC) shall be provided for the manual control.
- b. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.
- c. Connections to the selector switch shall be such that; only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.14.6 Motor Control Centers

Control centers shall conform to the requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2as shown. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Motor control centers shall be provided with a full-length ground bus bar.

2.15 PANELBOARDS

Dead-front construction, NEMA PB 1 and UL 67.

2.16 RECEPTACLES

2.16.1 Attachment Plugs and Receptacles

UL 498.

2.16.2 Standard Grade

UL 498.

2.16.3 Ground Fault Interrupters

UL 943, Class A or B.

2.16.4 NEMA Standard Receptacle Configurations

NEMA WD 6.

- a. Single and Duplex, 15-Ampere and 20-Ampere, 125 Volt

15-ampere, non-locking: NEMA type 5-15R, locking: NEMA type L5-15R, 20-ampere, non-locking: NEMA type 5-20R, locking: NEMA type L5-20R.

- b. 15-Ampere, 250 Volt

Two-pole, 3-wire grounding, non-locking: NEMA type 6-15R, locking: NEMA type L6-15R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-15R, locking: NEMA type L15-15R.

- c. 20-Ampere, 250 Volt

Two-pole, 3-wire grounding, non-locking: NEMA type 6-20R, locking: NEMA type L6-20R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-20R, locking: NEMA type L15-20R.

- d. 30-Ampere, 125/250 Volt

Three-pole, 3-wire, non-locking: NEMA type 10-30R, locking: NEMA type L10-30R. Three-pole, 4-wire grounding, non-locking: NEMA type 14-30R, locking: NEMA type L14-30R.

- e. 30-Ampere, 250 Volt

Two-pole, 3-wire grounding, non-locking: NEMA type 6-30R, locking: NEMA type L6-30R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-30R, locking: NEMA type L15-30R.

- f. 50-Ampere, 125/250 Volt

Three-pole, 3-wire: NEMA type 10-50R. Three-pole, 4-wire grounding: NEMA type 14-50R.

- g. 50-Ampere, 250 Volt

Two-pole, 3-wire grounding: NEMA type 6-50R. Three-pole, 4-wire grounding: NEMA type 15-50R.

2.17 Service Entrance Equipment

UL 869A.

2.18 SPLICE, CONDUCTOR

UL 486C.

2.19 POWER-SWITCHGEAR ASSEMBLIES INCLUDING SWITCHBOARDS

Assemblies shall be metal-enclosed, freestanding general-purpose type in accordance with NEMA PB 2, UL 891, and IEEE C37.20.1 and shall be installed to provide front and rear access. Busses shall be copper. Assembly shall be approximately 2.3 meters high; arrangement of circuit breakers and other items specified shall be as indicated. The withstand rating and interrupting capacity of the switchboards and circuit breakers shall be based on the maximum fault current available.

2.19.1 Circuit Breakers

Circuit breakers shall be molded-case circuit breakers.

2.19.2 Auxiliary Equipment

2.19.2.1 Instruments

Instruments shall be long scale, 173 mm minimum, semiflush rectangular, indicating or digital switchboard type, mounted at eye level.

- a. Ammeter, range 0 to 100% of switchboard circuit breaker rating of each building switchboard, complete with selector switch having off position and positions to read each phase current.
- b. Voltmeter, range 0 to system voltage of respective building, complete with selector switch having off position and positions to read each phase to phase and phase to neutral voltage.

2.19.2.2 Control Switch

2.20 SNAP SWITCHES

UL 20.

2.21 Dimmers

Incandescent NEMA WD-1; Dimmer switches shall be constructed such that the on-off function is independent of the brightness setting; shall be semiconductor phase control type.; and shall have voltage and wattage ratings suitable for the intended application. Dimmer switch shall be slide type.

2.22 Occupancy Sensors

Occupancy sensors shall meet the requirements of UL 916 and include both ultrasonic and infrared type sensors. The technical requirements of the sensors are indicated on the drawings. Sensor quantities and locations will vary by manufacturer. As part of submittal for occupancy sensors, the contractor shall provide a sensor layout provided by the sensor manufacturer. The layout shall indicate the location of the sensors and the coverage area in the room.

2.23 TAPES

2.23.1 Plastic Tape

UL 510.

2.23.2 Rubber Tape

UL 510.

2.24 TRANSFORMERS

Single- and three-phase transformers shall have two windings per phase. Full-capacity standard NEMA taps shall be provided in the primary windings of transformers unless otherwise indicated. Three-phase transformers shall be configured with delta-wye windings, except as indicated. "T" connections may be used for transformers rated 15 kVA or below.

2.24.1 Transformers, Dry-Type

Transformers shall have 220 degrees C insulation system for transformers 15 kVA and greater, and shall have 180 degrees C insulation system for transformers rated 10 kVA and less, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient temperature of 40 degrees C. Transformer of 150 degrees C temperature rise shall be capable of carrying continuously 100 percent of nameplate kVA without exceeding insulation rating. Transformers shall meet the energy efficiency standard of NEMA TP-1 and the DOE 'Energy Star' label. Transformer losses shall conform to NEMA TP-1.

a. 600 Volt or Less Primary:

NEMA ST 20, UL 506, general purpose, dry-type, self-cooled, ventilated. Transformers shall be provided in NEMA 1 enclosure. Transformers shall be quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.24.2 Average Sound Level

The average sound level in decibels (dB) of transformers shall not exceed the following dB level at 300 mm for the applicable kVA rating range listed unless otherwise indicated:

| kVA Range | dB Sound Level |
|--------------|----------------|
| 1-50 | 50 |
| 51-150 | 55 |
| 151-300 | 58 |
| 301-500 | 60 |
| 501-700 | 62 |
| 701-1000 | 64 |
| 1001-1500 | 65 |
| 1501 & above | 70 |

2.25 ISOLATED POWER SYSTEM EQUIPMENT

UL 1047, with monitor UL 1022.

2.26 WATTHOUR METERS, UTILITY REVENUE

Watthour meters shall conform to ANSI C12.1. Watthour demand meters shall have factory-installed electronic pulse initiators meeting the requirements of ANSI C12.1. Pulse initiators shall be solid-state devices incorporating light-emitting diodes, phototransistors, and power transistors, except that mercury-wetted output contacts are acceptable. Initiators shall be totally contained within watthour demand meter enclosures, shall be capable of operating up to speeds of 500 pulses per minute with no false pulses, and shall require no field adjustments. Initiators shall be calibrated for a pulse rate output of one pulse per 1/4 disc revolution of the associated meter and shall be compatible with the indicated equipment.

2.27 INSTRUMENT TRANSFORMERS

2.27.1 General

Instrument transformers shall comply with ANSI C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on drawings.

2.27.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are

acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Other thermal and mechanical ratings of current transformer and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.27.2.1 Voltage Transformers

Voltage transformers shall have indicated ratios. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.28 WIRING DEVICES

NEMA WD 1 for wiring devices, and NEMA WD 6 for dimensional requirements of wiring devices.

PART 3 EXECUTION

3.1 GROUNDING

Grounding shall be in conformance with NFPA 70, the contract drawings, and the following specifications.

3.1.1 Ground Rods

The resistance to ground shall be measured using the fall-of-potential method described in IEEE Std 81. The maximum resistance of a driven ground shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, additional rods not less than 1.8 meters on centers may be used. In high-ground-resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved connectors.

3.1.2 Ground Bus

Ground bus shall be provided in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment shall be effectively grounded by bonding to the ground bus. The ground bus shall be bonded to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 100 mm above the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure-connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, a minimum of 4, one at each corner, multiple grounding systems shall be furnished. Connections shall be bolted type in lieu of thermoweld, so they can be changed as required by additions and/or alterations.

3.1.3 Grounding Conductors

A green equipment grounding conductor, sized in accordance with NFPA 70 shall be

provided, regardless of the type of conduit. Equipment grounding bars shall be provided in all panelboards. The equipment grounding conductor shall be carried back to the service entrance grounding connection or separately derived grounding connection. All equipment grounding conductors, including metallic raceway systems used as such, shall be bonded or joined together in each wiring box or equipment enclosure. Metallic raceways and grounding conductors shall be checked to assure that they are wired or bonded into a common junction. Metallic boxes and enclosures, if used, shall also be bonded to these grounding conductors by an approved means per NFPA 70. When switches, or other utilization devices are installed, any designated grounding terminal on these devices shall also be bonded to the equipment grounding conductor junction with a short jumper.

3.2 WIRING METHODS

Wiring shall conform to NFPA 70, the contract drawings, and the following specifications. Unless otherwise indicated, wiring shall consist of insulated conductors installed in rigid zinc-coated steel conduit, electrical metallic tubing, electrical nonmetallic tubing, and intermediate metal conduit. TEXT DELETED. Wire fill in conduits shall be based on NFPA 70 for the type of conduit and wire insulations specified. Wire fill in conduits located in Class I or II hazardous areas shall be limited to 25 percent of the cross sectional area of the conduit.

3.2.1 Conduit and Tubing Systems

Conduit and tubing systems shall be installed as indicated. Conduit sizes shown are based on use of copper conductors with insulation types as described in paragraph WIRING METHODS. Minimum size of raceways shall be 15 mm. Only metal conduits will be permitted when conduits are required for shielding or other special purposes indicated, or when required by conformance to NFPA 70. Nonmetallic conduit and tubing may be used in damp, wet or corrosive locations when permitted by NFPA 70 and the conduit or tubing system is provided with appropriate boxes, covers, clamps, screws or other appropriate type of fittings. Electrical metallic tubing (EMT) may be installed only within buildings. EMT may be installed in concrete and grout in dry locations. EMT installed in concrete or grout shall be provided with concrete tight fittings. EMT shall not be installed in damp or wet locations, or the air space of exterior masonry cavity walls. Bushings, manufactured fittings or boxes providing equivalent means of protection shall be installed on the ends of all conduits and shall be of the insulating type, where required by NFPA 70. Only UL listed adapters shall be used to connect EMT to rigid metal conduit, cast boxes, and conduit bodies. Aluminum conduit may be used only where installed exposed in dry locations. Nonaluminum sleeves shall be used where aluminum conduit passes through concrete floors and firewalls. Penetrations of above grade floor slabs, time-rated partitions and fire walls shall be firestopped in accordance with Section 07840A FIRESTOPPING. Except as otherwise specified, IMC may be used as an option for rigid steel conduit in areas as permitted by NFPA 70. Raceways shall not be installed under the firepits of boilers and furnaces and shall be kept 150 mm away from parallel runs of flues, steam pipes and hot-water pipes. Raceways shall be concealed within finished walls, ceilings, and floors unless otherwise shown. Raceways crossing structural expansion joints or seismic joints shall be provided with suitable expansion fittings or other suitable means to compensate for the building expansion and contraction and to provide for continuity of grounding. Wiring installed in underfloor duct system shall be suitable for installation in wet locations.

3.2.1.1 Pull Wires

A pull wire shall be inserted in each empty raceway in which wiring is to be installed if the raceway is more than 15 meters in length and contains more than the equivalent of two 90-degree bends, or where the raceway is more than 45 meters in length. The pull wire shall be of No. 14 AWG zinc-coated steel, or of plastic having not less than 1.4 MPa (200 psi) tensile strength. Not less than

254 mm of slack shall be left at each end of the pull wire.

3.2.1.2 Conduit Stub-Ups

Where conduits are to be stubbed up through concrete floors, a short elbow shall be installed below grade to transition from the horizontal run of conduit to a vertical run. A conduit coupling fitting, threaded on the inside shall be installed, to allow terminating the conduit flush with the finished floor. Wiring shall be extended in rigid threaded conduit to equipment, except that where required, flexible conduit may be used 150 mm above the floor. Empty or spare conduit stub-ups shall be plugged flush with the finished floor with a threaded, recessed plug.

3.2.1.3 Below Slab-on-Grade or in the Ground

Electrical wiring below slab-on-grade shall be protected by a conduit system. Conduit passing vertically through slabs-on-grade shall be rigid steel or IMC. Rigid steel or IMC conduits installed below slab-on-grade or in the earth shall be field wrapped with 0.254 mm thick pipe-wrapping plastic tape applied with a 50 percent overlay, or shall have a factory-applied polyvinyl chloride, plastic resin, or epoxy coating system.

3.2.1.4 Installing in Slabs Including Slabs on Grade

Conduit installed in slabs-on-grade shall be rigid steel or IMC. Conduits shall be installed as close to the middle of concrete slabs as practicable without disturbing the reinforcement. Outside diameter shall not exceed 1/3 of the slab thickness and conduits shall be spaced not closer than 3 diameters on centers except at cabinet locations where the slab thickness shall be increased as approved by the Contracting Officer. Where conduit is run parallel to reinforcing steel, the conduit shall be spaced a minimum of one conduit diameter away but not less than 25.4 mm from the reinforcing steel.

3.2.1.5 Changes in Direction of Runs

Changes in direction of runs shall be made with symmetrical bends or cast-metal fittings. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment shall be prevented during the course of construction. Clogged raceways shall be cleared of obstructions or shall be replaced.

3.2.1.6 Supports

Metallic conduits and tubing, and the support system to which they are attached, shall be securely and rigidly fastened in place to prevent vertical and horizontal movement at intervals of not more than 3 meters and within 900 mm of boxes, cabinets, and fittings, with approved pipe straps, wall brackets, conduit clamps, conduit hangers, threaded C-clamps, beam clamps, or ceiling trapeze. Loads and supports shall be coordinated with supporting structure to prevent damage or deformation to the structure. Loads shall not be applied to joist bridging. Attachment shall be by wood screws or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws, welded threaded studs, heat-treated or spring-steel-tension clamps on steel work. Nail-type nylon anchors or threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine screws. Raceways or pipe straps shall not be welded to steel structures. Cutting the main reinforcing bars in reinforced concrete beams or joists shall be avoided when drilling holes for support anchors. Holes drilled for support anchors, but not used, shall be filled. In partitions of light steel construction, sheet-metal screws may be used. Raceways shall not be supported using wire or nylon ties. Raceways shall be independently supported

from the structure. Upper raceways shall not be used as a means of support for lower raceways. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Cables and raceways shall not be supported by ceiling grids. Except where permitted by NFPA 70, wiring shall not be supported by ceiling support systems. Conduits shall be fastened to sheet-metal boxes and cabinets with two locknuts where required by NFPA 70, where insulating bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, a single locknut and bushing may be used. Threadless fittings for electrical metallic tubing shall be of a type approved for the conditions encountered. Additional support for horizontal runs is not required when EMT rests on steel stud cutouts.

3.2.1.7 Exposed Raceways

Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Raceways under raised floors and above accessible ceilings shall be considered as exposed installations in accordance with NFPA 70 definitions.

3.2.1.8 Exposed Risers

Exposed risers in wire shafts of multistory buildings shall be supported by U-clamp hangers at each floor level, and at intervals not to exceed 3 meters.

3.2.1.9 Communications Raceways

Communications raceways indicated shall be installed in accordance with the previous requirements for conduit and tubing and with the additional requirement that the minimum conduit size shall be 1 inch, and shall not contain more than two 90-degree bends or the equivalent. Additional pull or junction boxes shall be installed to comply with these limitations whether or not indicated. Inside radii of bends in conduits of 25 mm (1 inch) size or larger shall not be less than ten times the nominal diameter.

3.2.2 Cable Trays

Cable trays shall be supported in accordance with the recommendations of the manufacturer but at no more than 1.8 meter intervals. Contact surfaces of aluminum connections shall be coated with an antioxidant compound prior to assembly. Adjacent cable tray sections shall be bonded together by connector plates of an identical type as the cable tray sections. The Contractor shall submit the manufacturer's certification that the cable tray system meets all requirements of Article 318 of NFPA 70. The cable tray shall be installed and grounded in accordance with the provisions of Article 318 of NFPA 70. Data submitted by the Contractor shall demonstrate that the completed cable tray systems will comply with the specified requirements. Cable trays shall terminate 250 mm from both sides of smoke and fire partitions. Conductors run through smoke and fire partitions shall be installed in 103 mm (4 inch) rigid steel conduits with grounding bushings, extending 300 mm beyond each side of the partitions. The installation shall be sealed to preserve the smoke and fire rating of the partitions. Penetrations shall be firestopped in accordance with Section 07840A FIRESTOPPING.

3.2.3 Cables and Conductors

Installation shall conform to the requirements of NFPA 70. Covered, bare or insulated conductors of circuits rated over 600 volts shall not occupy the same equipment wiring enclosure, cable, or raceway with conductors of circuits rated 600 volts or less.

3.2.3.1 Sizing

Unless otherwise noted, all sizes are based on copper conductors and the

insulation types indicated. Sizes shall be not less than indicated. Branch-circuit conductors shall be not smaller than No. 12 AWG. Conductors for branch circuits of 120 volts more than 30 meters long and of 277 volts more than 70 meters long, from panel to load center, shall be no smaller than No. 10 AWG. Class 1 remote control and signal circuit conductors shall be not less than No. 14 AWG. Class 2 remote control and signal circuit conductors shall be not less than No. 16 AWG. Class 3 low-energy, remote-control and signal circuits shall be not less than No. 22 AWG.

3.2.3.2 Use of Aluminum Conductors in Lieu of Copper

Aluminum conductors shall not be used.

3.2.3.3 Cable Systems

Cable systems shall be installed where indicated. Cables shall be installed concealed behind ceiling or wall finish where practicable. Cables shall be threaded through holes bored on the approximate centerline of wood members; notching of surfaces will not be permitted. Sleeves shall be provided through bond beams of masonry-block walls for threading cables through hollow spaces. Exposed cables shall be installed parallel or at right angles to walls or structural members. In rooms or areas not provided with ceiling or wall finish, cables and outlets shall be installed so that a room finish may be applied in the future without disturbing the cables or resetting the boxes. Exposed nonmetallic-sheathed cables less than 1.2 meters above floors shall be protected from mechanical injury by installation in conduit or tubing.

3.2.3.4 Cable Splicing

Splices shall be made in an accessible location. Crimping tools and dies shall be approved by the connector manufacturer for use with the type of connector and conductor.

- a. Copper Conductors, 600 Volt and Under: Splices in conductors No. 10 AWG and smaller diameter shall be made with an insulated, pressure-type connector. Splices in conductors No. 8 AWG and larger diameter shall be made with a solderless connector and insulated with tape or heat-shrink type insulating material equivalent to the conductor insulation.

3.2.3.5 Conductor Identification and Tagging

Power, control, and signal circuit conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Where several feeders pass through a common pull box, the feeders shall be tagged to indicate clearly the electrical characteristics, circuit number, and panel designation. Phase conductors of low voltage power circuits shall be identified by color coding. Phase identification by a particular color shall be maintained continuously for the length of a circuit, including junctions.

- a. Color coding shall be provided for service, feeder, branch, and ground conductors. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in the same raceway or box, other neutral shall be white with colored (not green) stripe. The color coding for 3-phase and single-phase low voltage systems shall be as follows:

120/208-volt, 3-phase: Black(A), red(B), and blue(C).
 277/480-volt, 3-phase: Brown(A), orange(B), and yellow(C).
 120/240-volt, 1-phase: Black and red.

- b. Conductor phase and voltage identification shall be made by color-coded insulation for all conductors smaller than No. 6 AWG. For conductors No. 6 AWG and larger, identification shall be made by color-coded insulation, or conductors with black insulation may be furnished and identified by the use of half-lapped bands of colored electrical tape wrapped around the insulation for a minimum of 75 mm of length near the end, or other method as submitted by the Contractor and approved by the Contracting Officer.
- c. Control and signal circuit conductor identification shall be made by color-coded insulated conductors, plastic-coated self-sticking printed markers, permanently attached stamped metal foil markers, or equivalent means as approved. Control circuit terminals of equipment shall be properly identified. Terminal and conductor identification shall match that shown on approved detail drawings. Hand lettering or marking is not acceptable.

3.3 BOXES AND SUPPORTS

Boxes shall be provided in the wiring or raceway systems where required by NFPA 70 for pulling of wires, making connections, and mounting of devices or fixtures. Pull boxes shall be furnished with screw-fastened covers. Indicated elevations are approximate, except where minimum mounting heights for hazardous areas are required by NFPA 70. Unless otherwise indicated, boxes for wall switches shall be mounted 1.2 meters above finished floors. Switch and outlet boxes located on opposite sides of fire rated walls shall be separated by a minimum horizontal distance of 600 mm. The total combined area of all box openings in fire rated walls shall not exceed 0.0645 square meters per 9.3 square meters. Maximum box areas for individual boxes in fire rated walls vary with the manufacturer and shall not exceed the maximum specified for that box in UL Elec Const Dir. Only boxes listed in UL Elec Const Dir shall be used in fire rated walls.

3.3.1 Box Applications

Each box shall have not less than the volume required by NFPA 70 for number of conductors enclosed in box. Boxes for metallic raceways shall be listed for the intended use when located in normally wet locations, when flush or surface mounted on outside of exterior surfaces, or when located in hazardous areas. Boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces shall be gasketed. Boxes for mounting lighting fixtures shall be not less than 102 mm square, or octagonal, except smaller boxes may be installed as required by fixture configuration, as approved. Cast-metal boxes with 2.4 mm wall thickness are acceptable. Large size boxes shall be NEMA 1 or as shown. Boxes in other locations shall be sheet steel except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit and tubing or nonmetallic sheathed cable system, when permitted by NFPA 70. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers.

3.3.2 Brackets and Fasteners

Boxes and supports shall be fastened to wood with wood screws or screw-type nails of equal holding strength, with bolts and metal expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screw or welded studs on steel work. Threaded studs driven in by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of expansion shields, or machine screws. Penetration of more than 38.1 mm (1-1/2 inches) into reinforced-concrete beams or more than 19.1 mm (3/4 inch) into reinforced-concrete joists shall avoid cutting any main reinforcing steel. The use of brackets which depend on gypsum wallboard or plasterboard for primary support will not be permitted. In partitions of light steel construction, bar

hangers with 25 mm long studs, mounted between metal wall studs or metal box mounting brackets shall be used to secure boxes to the building structure. When metal box mounting brackets are used, additional box support shall be provided on the side of the box opposite the brackets. This additional box support shall consist of a minimum 300 mm long section of wall stud, bracketed to the opposite side of the box and secured by two screws through the wallboard on each side of the stud. Metal screws may be used in lieu of the metal box mounting brackets.

3.3.3 Mounting in Walls, Ceilings, or Recessed Locations

In walls or ceilings of concrete, tile, or other non-combustible material, boxes shall be installed so that the edge of the box is not recessed more than 6 mm from the finished surface. Boxes mounted in combustible walls or ceiling material shall be mounted flush with the finished surface. The use of gypsum or plasterboard as a means of supporting boxes will not be permitted. Boxes installed for concealed wiring shall be provided with suitable extension rings or plaster covers, as required. The bottom of boxes installed in masonry-block walls for concealed wiring shall be mounted flush with the top of a block to minimize cutting of the blocks, and boxes shall be located horizontally to avoid cutting webs of block. Separate boxes shall be provided for flush or recessed fixtures when required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided.

3.3.4 Installation in Overhead Spaces

In open overhead spaces, cast-metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast-metal boxes having threadless connectors and sheet metal boxes shall be supported directly from the building structure or by bar hangers. Hangers shall not be fastened to or supported from joist bridging. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved type fastener not more than 600 mm from the box.

3.4 DEVICE PLATES

One-piece type device plates shall be provided for all outlets and fittings. Plates on unfinished walls and on fittings shall be of zinc-coated sheet steel, cast-metal, or impact resistant plastic having rounded or beveled edges. Plates on finished walls shall be of steel with baked enamel finish or impact-resistant plastic and shall be ivory. Screws shall be of metal with countersunk heads, in a color to match the finish of the plate. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1.6 mm. The use of sectional-type device plates will not be permitted. Plates installed in wet locations shall be gasketed and provided with a hinged, gasketed cover, unless otherwise specified.

3.5 RECEPTACLES

3.5.1 Single and Duplex, 15 or 20-ampere, 125 volt

Single and duplex receptacles shall be rated 20 amperes, 125 volts, two-pole, three-wire, grounding type with polarized parallel slots. Bodies shall be of ivory to match color of switch handles in the same room or to harmonize with the color of the respective wall, and supported by mounting strap having plaster ears. Contact arrangement shall be such that contact is made on two sides of an inserted blade. Receptacle shall be side- or back-wired with two screws per terminal. The third grounding pole shall be connected to the metal mounting yoke. Switched receptacles shall be the same as other receptacles specified except that the ungrounded pole of each suitable receptacle shall be provided with a separate terminal. Only the top receptacle of a duplex receptacle shall be wired for switching application. Receptacles with ground fault circuit

interrupters shall have the current rating as indicated, and shall be UL Class A type unless otherwise shown. Ground fault circuit protection shall be provided as required by NFPA 70 and as indicated on the drawings.

3.5.2 Weatherproof Applications

Weatherproof receptacles shall be suitable for the environment, damp or wet as applicable, and the housings shall be labeled to identify the allowable use. Receptacles shall be marked in accordance with UL 514A for the type of use indicated; "Damp locations", "Wet Locations", "Wet Location Only When Cover Closed". Assemblies shall be installed in accordance with the manufacturer's recommendations.

3.5.2.1 Damp Locations

Receptacles in damp locations shall be mounted in an outlet box with a gasketed, weatherproof, cast-metal cover plate (device plate, box cover) and a gasketed cap (hood, receptacle cover) over each receptacle opening. The cap shall be either a screw-on type permanently attached to the cover plate by a short length of bead chain or shall be a flap type attached to the cover with a spring loaded hinge.

3.5.2.2 Wet Locations

Receptacles in wet locations shall be installed in an assembly rated for such use whether the plug is inserted or withdrawn, unless otherwise indicated. In a duplex installation, the receptacle cover shall be configured to shield the connections whether one or both receptacles are in use.

3.5.3 Receptacles, 15-Ampere, 250-Volt

Receptacles, 15-ampere, 250-volt, shall be as indicated with bodies of ivory phenolic compound supported by mounting yoke having plaster ears. The third grounding pole shall be connected to the metal yoke. Each receptacle shall be provided with a mating cord-grip plug.

3.5.4 Receptacles, 20-Ampere, 250-Volt

Receptacles, single, 20-ampere, 250-volt, shall be ivory molded plastic, two-pole, three-wire or three-pole, four-wire, grounding type complete with appropriate mating cord-grip plug.

3.5.5 Special-Purpose or Heavy-Duty Receptacles

Special-purpose or heavy-duty receptacles shall be of the type and of ratings and number of poles indicated or required for the anticipated purpose. Contact surfaces may be either round or rectangular. One appropriate straight or angle-type plug shall be furnished with each receptacle. Locking type receptacles, rated 30 amperes or less, shall be locked by rotating the plug. Locking type receptacles, rated more than 50 amperes, shall utilize a locking ring.

3.6 WALL SWITCHES

Wall switches shall be of the totally enclosed tumbler type. The wall switch handle and switch plate color shall be ivory. Wiring terminals shall be of the screw type or of the solderless pressure type having suitable conductor-release arrangement. Not more than one switch shall be installed in a single-gang position. Switches shall be rated 20-ampere 120-volt for use on alternating current only. Dimming switches shall be solid-state flush mounted, sized for the loads.

3.7 SERVICE EQUIPMENT

Service provisions Service-disconnecting means shall be of the enclosed molded-case circuit breaker type with an external handle for manual operation. When service disconnecting means is a part of an assembly, the assembly shall be listed as suitable for service entrance equipment. Enclosures shall be sheet metal with hinged cover for surface mounting unless otherwise indicated.

3.8 PANELBOARDS AND LOADCENTERS

Circuit breakers and switches used as a motor disconnecting means shall be capable of being locked in the open position. Door locks shall be keyed alike. Nameplates shall be as approved. Directories shall be typed to indicate loads served by each circuit and mounted in a holder behind a clear protective covering. Busses shall be aluminum.

3.8.1 Loadcenters

Loadcenters shall be circuit breaker equipped.

3.8.2 Panelboards

Panelboards shall be circuit breaker or fusible switch equipped as indicated on the drawings.

3.9 UNDERGROUND SERVICE

Unless otherwise indicated, interior conduit systems shall be stubbed out 1.5 m beyond the building wall and 600 mm below finished grade, for interface with the exterior service lateral conduits and exterior communications conduits. Outside conduit ends shall be bushed when used for direct burial service lateral conductors. Outside conduit ends shall be capped or plugged until connected to exterior conduit systems. Underground service lateral conductors will be extended to building service entrance and terminated in accordance with the requirements of Section 16375A ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and NFPA 70.

3.10 MOTORS

Each motor shall conform to the kW and voltage ratings indicated, and shall have a service factor and other characteristics that are essential to the proper application and performance of the motors under conditions shown or specified. Three-phase motors for use on 3-phase 208-volt systems shall have a nameplate rating of 200 volts. Unless otherwise specified, all motors shall have open frames, and continuous-duty classification based on a 40 degree C ambient temperature reference. Polyphase motors shall be squirrel-cage type, having normal-starting-torque and low-starting-current characteristics, unless other characteristics are specified in other sections of these specifications or shown on contract drawings. The Contractor shall be responsible for selecting the actual kilowatt (horsepower) ratings and other motor requirements necessary for the applications indicated. When electrically driven equipment furnished under other sections of these specifications materially differs from the design, the Contractor shall make the necessary adjustments to the wiring, disconnect devices and branch-circuit protection to accommodate the equipment actually installed.

3.11 MOTOR CONTROL

Each motor or group of motors requiring a single control and not controlled from a motor-control center shall be provided under other sections of these specifications with a suitable controller and devices that will perform the functions as specified for the respective motors. Each motor of 93 W (1/8 hp) or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or

double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats, float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate kilowatt rating. When the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit. When combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch shall be provided for the manual control; when the automatic-control device actuates the pilot control circuit of a magnetic starter, the latter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low- or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

3.11.1 Motor Control Centers

Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Combination starters shall be provided with circuit breakers. Motor control centers shall be provided with a full-length ground bus bar.

3.11.2 Contacts

Unless otherwise indicated, contacts in miscellaneous control devices such as float switches, pressure switches, and auxiliary relays shall have current and voltage ratings in accordance with NEMA ICS 2 for rating designation B300.

3.11.3 Safety Controls

Safety controls for boilers shall be connected to a 2-wire, 120 volt grounded circuit supplied from the associated boiler-equipment circuit. Where the boiler circuit is more than 120 volts to ground, safety controls shall be energized through a two-winding transformer having its 120 volt secondary winding grounded. Overcurrent protection shall be provided in the ungrounded secondary conductor and shall be sized for the load encountered.

3.12 MOTOR-DISCONNECT MEANS

Each motor shall be provided with a disconnecting means when required by NFPA 70 even though not indicated. For single-phase motors, a single or double pole toggle switch, rated only for alternating current, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor rating. Switches shall disconnect all ungrounded conductors.

3.13 TRANSFORMER INSTALLATION

Three-phase transformers shall be connected only in a delta-wye or wye-delta configuration as indicated. "T" connections may be used for transformers rated at 15 kVA or below. Dry-type transformers shown located within 1.5 meters of the exterior wall shall be provided in a weatherproof enclosure. Transformers to

be located within the building may be provided in the manufacturer's standard, ventilated indoor enclosure designed for use in 40 degrees C ambient temperature, unless otherwise indicated.

3.14 LIGHTING FIXTURES, LAMPS AND BALLASTS

This paragraph shall cover the installation of lamps, lighting fixtures and ballasts in interior or building mounted applications.

3.14.1 Lamps

Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed just prior to project completion. Lamps installed and used for working light during construction shall be replaced prior to turnover to the Government if more than 15% of their rated life has been used. Lamps shall be tested for proper operation prior to turn-over and shall be replaced if necessary with new lamps from the original manufacturer. 10% spare lamps of each type, from the original manufacturer, shall be provided.

3.14.2 Lighting Fixtures

Fixtures shall be as shown and shall conform to the following specifications and shall be as detailed on the drawings. Illustrations shown on the drawings are indicative of the general type desired and are not intended to restrict selection to fixtures of any particular manufacturer. Fixtures of similar designs and equivalent energy efficiency, light distribution and brightness characteristics, and of equal finish and quality will be acceptable if approved. In suspended acoustical ceilings with fluorescent fixtures, the fluorescent emergency light fixtures shall be furnished with self-contained battery packs.

3.14.2.1 Accessories

Accessories such as straps, mounting plates, nipples, or brackets shall be provided for proper installation.

3.14.2.2 Ceiling Fixtures

Ceiling fixtures shall be coordinated with and suitable for installation in, on or from the ceiling as shown. Installation and support of fixtures shall be in accordance with NFPA 70 and manufacturer's recommendations. Where seismic requirements are specified herein, fixtures shall be supported as shown or specified. Recessed fixtures shall have adjustable fittings to permit alignment with ceiling panels. Recessed fixtures installed in fire-resistive ceiling construction shall have the same fire rating as the ceiling or shall be provided with fireproofing boxes having materials of the same fire rating as the ceiling, in conformance with UL Elec Const Dir. Surface-mounted fixtures shall be suitable for fastening to the ceiling panel structural supports.

3.14.2.3 Fixtures for Installation in Grid Type Ceilings

Fixtures for installation in grid type ceilings which are smaller than a full tile shall be centered in the tile. 305 by 1219 mm fixtures shall be mounted along the grid rail as shown. Work above the ceiling shall be coordinated among the trades to provide the lighting layout shown. Fixtures mounted to the grid shall have trim exactly compatible with the grid. Contractor shall coordinate trims with ceiling trades prior to ordering fixtures. Metric fixtures shall be designed to fit the metric grid specified. Fixtures in continuous rows shall be coordinated between trades prior to ordering. Fixtures shall be mounted using independent supports capable of supporting the entire weight of the fixture. No fixture shall rest solely on the ceiling grid. Recessed fixtures installed in seismic areas should be installed utilizing specially designed seismic clips. Junction boxes shall be supported at four points.

3.14.2.4 Suspended Fixtures

Suspended fixtures shall be provided with swivel hangers or hand-straightens so that they hang plumb. Pendants, rods, or chains 1.2 meters or longer excluding fixture shall be braced to prevent swaying using three cables at 120 degrees of separation. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and gloss specified. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown. Maximum distance between suspension points shall be 3.1 meters or as recommended by the manufacturer, whichever is less.

Suspended fixtures installed in seismic areas shall have 45% swivel hangers and shall be located with no obstructions within the 45% range in all directions. The stem, canopy and fixture shall be capable of 45% swing.

3.14.3 Ballasts

Remote type ballasts or transformers, where indicated, shall be mounted in a well ventilated, easily accessible location, within the maximum operating distance from the lamp as designated by the manufacturer.

3.14.4 Emergency Light Sets

Emergency light sets shall conform to UL 924 with the number of heads as indicated. Sets shall be permanently connected to the wiring system by conductors installed in short lengths of flexible conduit.

3.15 EQUIPMENT CONNECTIONS

Wiring not furnished and installed under other sections of the specifications for the connection of electrical equipment as indicated on the drawings shall be furnished and installed under this section of the specifications. Connections shall comply with the applicable requirements of paragraph WIRING METHODS. Flexible conduits 2 m or less in length shall be provided to all electrical equipment subject to periodic removal, vibration, or movement and for all motors. All motors shall be provided with separate grounding conductors. Liquid-tight conduits shall be used in damp or wet locations.

3.15.1 Motors and Motor Control

Motors, motor controls, and motor control centers shall be installed in accordance with NFPA 70, the manufacturer's recommendations, and as indicated. Wiring shall be extended to motors, motor controls, and motor control centers and terminated.

3.15.2 Installation of Government-Furnished Equipment

Wiring shall be extended to the equipment and terminated.

3.15.3 Food Service Equipment Provided Under Other Sections

Wiring shall be extended to the equipment and terminated.

3.16 CIRCUIT PROTECTIVE DEVICES

The Contractor shall calibrate, adjust, set and test each new adjustable circuit

protective device to ensure that they will function properly prior to the initial energization of the new power system under actual operating conditions.

3.17 PAINTING AND FINISHING

Field-applied paint on exposed surfaces shall be provided under Section 09900 PAINTS AND COATINGS.

3.18 REPAIR OF EXISTING WORK

The work shall be carefully laid out in advance, and where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, this work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to the Government.

3.19 FIELD TESTING

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 30 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspection recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. All field test reports will be signed and dated by the Contractor.

3.19.1 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.19.2 Ground-Resistance Tests

The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std 81. Soil resistivity in the area of the grid shall be measured concurrently with the grid measurements. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

- a. Single rod electrode - 25 ohms.

3.19.3 Ground-Grid Connection Inspection

All below-grade ground-grid connections will be visually inspected by the Contracting Officer before backfilling. The Contractor shall notify the Contracting Officer 32 hours before the site is ready for inspection.

3.19.4 Cable Tests

The Contractor shall be responsible for identifying all equipment and devices that could be damaged by application of the test voltage and ensuring that they have been properly disconnected prior to performing insulation resistance

testing. An insulation resistance test shall be performed on all low and medium voltage cables after the cables are installed in their final configuration and prior to energization. The test voltage shall be 500 volts DC applied for one minute between each conductor and ground and between all possible combinations of conductors. The minimum value of resistance shall be:

R in megohms = (rated voltage in kV + 1) x 304.8/(length of cable in meters)

Each cable failing this test shall be repaired or replaced. The repaired cable system shall then be retested until failures have been eliminated.

3.19.4.1 Medium Voltage Cable Tests

- a. Continuity test.
- b. Insulation resistance test.
- c. DC high-potential test.

3.19.4.2 Low Voltage Cable Tests

- a. Continuity test.
- b. Insulation resistance test.

3.19.5 Metal Enclosed Bus Duct Tests

- a. Insulation Resistance phase-to-phase, all combinations.
- b. Insulation resistance phase-to-ground, each phase.
- c. AC or DC high-potential test.
- d. Phase rotation test.

3.19.6 Motor Tests

- a. Phase rotation test to ensure proper directions.
- b. Operation and sequence of reduced voltage starters.
- c. High potential test on each winding to ground.
- d. Insulation resistance of each winding to ground.
- e. Vibration test.
- f. Dielectric absorption test on motor.

3.19.7 Dry-Type Transformer Tests

The following field tests shall be performed on all dry-type transformers 30 kVA and above.

- a. Insulation resistance test phase-to-ground, each phase.
- b. Turns ratio test.

3.19.8 Circuit Breaker Tests

The following field tests shall be performed on circuit breakers.

3.19.8.1 Circuit Breaker Tests, Medium Voltage

- a. Insulation resistance test phase-to-phase, all combinations.
- b. Insulation resistance tests phase-to-ground, each phase.
- c. Closed breaker contact resistance test.
- d. Power factor test.
- e. High-potential test.
- f. Manual and electrical operation of the breaker.

3.19.8.2 Circuit Breakers, Low Voltage

- a. Insulation resistance test phase-to-phase, all combinations.
- b. Insulation resistance test phase-to-ground, each phase.
- c. Closed breaker contact resistance test.
- d. Manual and electrical operation of the breaker.

3.19.8.3 Circuit Breakers, Molded Case

- a. Insulation resistance test phase-to-phase, all combinations.
- b. Insulation resistance test phase-to-ground, each phase.
- c. Closed breaker contact resistance test.
- d. Manual operation of the breaker.

3.19.9 Motor Control Centers

- a. Insulation resistance test phase-to-phase, all combinations.
- b. Insulation resistance test phase-to-ground, each phase.
- c. Manual and electrical operational tests.

3.20 OPERATING TESTS

After the installation is completed, and at such time as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with paragraph FIELD TEST REPORTS.

3.21 FIELD SERVICE

3.21.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation

and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations. A CD format video of the entire training shall be submitted.

3.21.2 Installation Engineer

After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of equipment, assist in the performance of the onsite tests, oversee initial operations, and instruct personnel as to the operational and maintenance features of the equipment.

3.22 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

-- End of Section --