

DIVISION 2

SITework

SECTION 02100

EXCAVATION, BACKFILL AND EMBANKMENT

PART 1 - GENERAL

1.01 SCOPE.

- A. The work covered by this section and required by this Contract includes the completion of all excavation, backfilling and embankment to the lines and grades indicated by the drawings, as further specified below, and necessary to the following operations:
 - 1. stripping, storing and replacing topsoil;
 - 2. excavation and backfill for pipe trenches;
 - 3. excavation and embankment for road, grading and drainage of the site;
 - 4. excavation and backfill for buildings and structures; and
 - 5. borrow excavation.

1.02 CHARACTER OF MATERIAL.

- A. The Contractor must satisfy himself regarding the character and amount of loam, clay, sand, quicksand, muck, gravel, rock, water and all other material to be encountered in the work to be performed.

1.03 DESCRIPTION

- A. The Contractor shall excavate, protect and backfill all foundations, trenches, tunnels and other excavations that may be necessary for completing the work to be done under this Contract. All excavation shall be in open cuts, except where and to such extent as the Engineer may authorize or direct that the same be done in tunnel, or where such is specified in the Special Requirements or Contract drawings. Trenches may, in general, be excavated and backfilled either by machinery, or by hand as the Contractor may elect; provided, however, that the Engineer shall be empowered, wherever he shall decide that such necessity exists, to direct that hand excavation be employed; and, provided, further that backfilling by hand shall be done to the extent hereinafter specified. The Contractor shall have no claim for extra compensation due to the fact that hand, instead of machine, excavation may be necessary from any cause whatever.
- B. The Contractor shall perform all excavation of every description and of whatever substances encountered, to the lines and grades or depths indicated by the drawings, as specified herein, or as directed by the Engineer. Embankments shall be prepared in accordance with the Specifications, and as necessary to bring the ground surface to the subgrade elevation for roads and to finished grade elevations for other areas as shown on the drawings, or directed by the Engineer. All excavated material not required for backfill or embankment shall be removed and wasted or otherwise disposed of as directed or specified.
- C. The term "subgrade" as used herein shall have the meaning given below:
 - (1) the bed of a trench prepared as specified to receive pipes or other conduits;
 - (2) the area upon which the lower surface of roadway paving, walks, gutters, or curb rests;

- (3) the surface of excavation or embankment areas prepared to receive topsoil; and
- (4) the areas upon which rest the planned bottom of footings, foundations, or slabs.

PART 2 - MATERIALS

2.01 TOPSOIL

- A. **Stripping.** The area from which topsoil is to be stripped and the locations where it is to be stored shall be as shown on the drawings or as specified below. The topsoil shall be stripped to a depth of not less than six (6) inches. On all areas where any type of grading is to be performed, including the areas within the lines of buildings and structures, the topsoil shall be carefully removed and spread either on areas already graded and prepared for topsoil, or in stockpiles conveniently located to the areas which are later to receive application of topsoil.
- B. **Spreading.** On areas intended to receive topsoil, the compacted subgrade shall be scarified to a depth of two (2) inches for bonding topsoil with subsoil. The topsoil shall then be evenly spread, compacted and graded to the finished elevations shown on the drawings or as specified by the Engineer. Compaction shall be effected by a single pass of an approved roller.

2.02 REMOVAL AND STORAGE OF MATERIAL

- A. In locations where the working space is limited, the material excavated from the first one hundred (100) feet of any trench, or from such additional length as may be required, shall upon order of the Engineer, be removed at the Contractor's own cost and expense, as soon as excavated. The materials subsequently excavated shall be used to refill the trench. In no case will the Contractor be allowed to cast excavated material beyond curb of right-of-way lines, or on sidewalks or lawns, and the failure or refusal of the Contractor to comply with this requirement shall be sufficient cause for the Engineer to stop all work under the Contract.
- B. In case more material is excavated from any trench than can be backfilled over the completed sewer or can be stored within the limits of the right-of-way, leaving space for the traffic and drainage as herein provided, the excess material shall be removed to some convenient place, provided by the Contractor. The Contractor shall at his own cost and expense bring back as much of the material so removed, as may be required to properly backfill the trench, if of the proper kind; or, if so directed by the Engineer, the Contractor shall, at his own cost and expense, furnish such other suitable material as may be necessary.
- C. When it is necessary to haul soft or wet material over the streets, the Contractor shall provide suitable tight vehicles, or a pattern approved by the Engineer for this purpose.

2.03 SHEETING, BRACING AND SHORING

- A. The Contractor shall furnish the material for, and do all timber shoring, bracing and sheeting necessary to perform and protect the excavation, and as required by the Engineer to protect the work, other structures, the public, and the Contractor's employees. If trench protection is necessary, per OSHA requirements, the Contractor shall account for the anticipated expense in the appropriate bid item, or in the unit cost for pipe installed, or a combination of both. If the Engineer deems that sheeting, bracing, or shoring is necessary, it shall be supplied by the Contractor at no additional expense to the Owner. Such sheeting, etc. may be removed as the work progresses, but where, in the opinion of

the Engineer, damage may result through removal, it shall be left in place with payment therefor made as hereinafter provided. The right of the Engineer to order sheeting, etc. left in place shall not render the issuance of such order obligatory on the part of the Engineer.

- B. All sheeting, etc. shall be arranged so that it may be withdrawn, as the trenches are backfilled, without injury to the pipe and its appurtenances, and without injury to or settlement of adjacent structures and pavements. All voids caused by withdrawal shall be immediately filled with sand or other satisfactory material and compacted by ramming or other method satisfactory to the Engineer.
- C. No timber sheeting, bracing or shoring shall be left within eighteen (18) inches of any natural ground surfaces or within twelve (12) inches of the subgrade of any rigid or flexible type pavement, or railroad roadbed. In any trench shoring system no vertical member shall remain directly over the pipe, and no horizontal member shall remain within twelve (12) inches of any pipe. After backfilling is started, no sheeting shall extend below the horizontal diameter of the pipe without the Engineer's approval. Sheeting left in place shall be cut off at such point as the Engineer may order, and the portions cut off shall be removed from the work.
- D. If the Engineer determines that the material furnished is not of proper size or quality, or not properly placed, the Contractor shall furnish and place other and satisfactory material in an acceptable manner, and shall not be entitled to additional compensation for such corrective work.

PART III - EXECUTION

3.01 ORDER OF WORK

- A. The Contractor shall submit a progress schedule, Microsoft Project or approved equal, and shall carry on his work in strict accordance therewith. Deviations from the progress schedule may be made only with the approval of the Engineer.
- B. Manholes shall be constructed either at the same time as the main sewer or immediately after its completion.

3.02 SEWER LINES AND GRADES. Sewer lines and grades shall be laid out and maintained during construction in the following manner.

- A. Prior to the commencement of trench excavation, the Contractor shall prepare and submit to the Engineer for approval, detailed cut sheets provided by the Contractor's surveyor. The surveyor shall be registered in the State of Florida. Cut sheet shall show; the beginning and ending of manholes; the distance between manholes; the grade, size and type of line, the depth of cut; etc.. The form of cut sheets shall be satisfactory to the Engineer. All expense for the preparation of cut sheets shall be borne by the contractor and be included in the unit price per foot of pipe. Cut sheets must be approved by the Engineer in writing before pipe laying operations may be permitted. It shall be the responsibility of the Contractor to prepare cut sheets far enough in advance of his anticipated trenching schedule so that avoidable delay in the work will not occur.
- B. Before beginning the excavation for any run of main sewer, the Contractor's forces, under the direction of the Engineer, shall:
 - 1. Set control points for line and grade as given on the Drawings or as otherwise determined by the Engineer. In unpaved or unsurfaced areas, these points shall be placed on the top of stakes securely driven into the ground. In paved areas, there

may be spikes driven into the paving or crosses cut into the paving, and in either case, enclosed in a painted circle. Stakes or points shall be sufficiently offset from the centerline so as to be undisturbed during the excavation and pipe laying operations. The offset shall be on the side of the centerline opposite to that on which excavation will be thrown.

2. As the rough excavation is completed, the Contractor's surveyor shall place grade or batter boards of finished, straight lumber across the trench opposite each stake or point. The grade boards shall be securely supported so as not to be subject to accidental displacement. The top of each board shall be leveled and set at the same distance above the sewer invert. A nail shall then be driven into the top of each board on the centerline of the sewer and each nail connected by a string line pulled taut.
3. The preparation of the final subgrade and the pipe laying shall then proceed in the manner specified herein, beginning at the manhole having the lower invert and working upgrade and using the string line as control for maintaining sewer grade and horizontal alignment. A straight wooden pole, suitably marked and with a right-angled offset at the bottom to project past the bell of the pipe and rest upon the pipe invert, shall be used to check the vertical distance from string line to invert.

- C. The use of laser beams shall be acceptable as a method of controlling pipe alignment and grade.

3.03 WIDTH AND DEPTH OF TRENCHES

- A. From the subgrade elevation to an elevation at least twelve (12) inches above the top of the outside barrel of the pipe, the banks of trenches in all cases shall be excavated to vertical lines, and the trenches shall be not less than twelve (12) inches nor more than sixteen (16) inches wider nor more than eight (8) inches in width is provided on each side of the barrel of the pipe. If sheeting is required, the foregoing dimensions shall be applicable to the inside faces of the sheeting.
- B. From a point twelve (12) inches above the top of the outside barrel of the pipe to the surface, the banks of trenches in all streets, roads or highways, paved or unpaved, shall be kept as nearly vertical as possible, and in no case shall the width of trench at the top exceed the outside diameter of the pipe plus forty (40) inches. If the specified maximum width of trench cannot otherwise be maintained, the Contractor shall install temporary sheeting at his own cost and expense. Where sewers are to be constructed on rights-of-way or easements in open country, the specified maximum width of trench at the top may be exceeded only if the construction is kept entirely within the limits of the easements or rights-of-way and can be carried on without damage to adjoining property.
- C. Except at locations where excavation of rock or unsuitable material is required, care shall be taken not to excavate below the depths specified, when rock is encountered, it shall be removed to a depth six (6) inches below the outside bottom of the pipe at the barrel. When the material encountered at subgrade is unstable, it shall be removed from under the pipe and on each side of the pipe for a distance of one (1) diameter of the pipe. such rock or unsuitable material excavation below subgrade shall be backfilled with moist clay, sand, bankrun gravel, or other suitable material compacted to the satisfaction of the Engineer, and the bed thus formed shaped as required above. In rock excavation, if trenches are shattered by blasting below the lines of excavation specified herein, the trench shall be refilled to subgrade with sand, well tamped earth, or concrete, if required by the Engineer, at the Contractor's expense. If earth trenches are excavated beyond the

specified depths, they shall be backfilled to the proper grade with suitable, thoroughly tamped material at the expense of the Contractor.

3.04 PREPARATION OF FOUNDATION

- A. In earth trenches, the bottom thereof shall be carefully rounded to fit the lower ninety degrees (90°) of the circumference of the pipe, i.e., so that one-fourth of the external circumference of the pipe will rest firmly on the undisturbed soil. Bell-holes shall be excavated to insure that the barrel of the pipe will rest for its entire length upon the trench bottom.
- B. Bell-holes shall be properly cut to provide free support of the pipe barrel and shall be directed by the Engineer. All irregularities and cavities, either in earth or rock excavation, in the bottom of trenches or tunnels, shall be filled up to a level which will support ninety degrees (90°) of the lower pipe circumference with selected material free from large gravel, rocks and stones, firmly compacted before pipe lines are laid therein.
- C. Where, in the opinion of the Engineer, the ground does not afford a sufficiently firm foundation, the Contractor shall construct a timber foundation, or shall excavate the trench to such increased depth as may be directed, and then shall bring up the bottom of the trench to the required level and form with such material and in such manner as the Engineer may direct.

3.05 CONCRETE CRADLE AND ENCASEMENT

- A. The profiles generally indicate the approximate vertical limits where concrete cradle and encasement are necessary to support the anticipated loads on completed sewers for the widths of trench as required for each size and class of pipe, based on the crushing strength of the pipe.
- B. The Contractor is warned that if the trench widths or clearances between pipe and trench walls or face of sheeting, as specified above, are exceeded, he will be required to furnish in all locations at his own expense either concrete cradle or encasement as directed by the Engineer.
- C. It is anticipated that subsurface conditions may require a cradle for a portion of the project to provide an adequate foundation, even though the ultimate anticipated load on the pipe is less than the minimum crushing strength for sand bearing. The Contractor shall place the cradle or encasement at the location, and of the materials, as directed and required by the Engineer. The Contractor will not be paid for any cradle beyond the required widths of trench.
- D. All excavation made beyond the required limits shall be at the Contractor's expense.

3.06 LENGTH OF OPEN TRENCH

- A. The Engineer shall have the right to limit the amount of trench opened in advance of pipe laying and the amount of pipe laid in advance of backfilling, but in no case, except when leakage tests are required by the Engineer, shall these amounts exceed three hundred (300) feet and one hundred (100) feet, respectively. Trench excavation shall be fully completed, except for the shaping of the bottom of the trench, at least twenty (20) feet in advance of the pipe placement and shall be kept free from obstructions, except that at the close of work at night, or at the discontinuance of work, the pipe laying may be completed to within five (5) feet of the end of the open trench.

- B. The Engineer shall be empowered, at any time, to require the refilling of open trenches over completed pipe lines, if, in his judgement, such action is necessary, and the Contractor shall thereby have no claim for extra compensation even though to accomplish said refilling, he is compelled temporarily to stop excavation or other work at any place.
- C. If the work is stopped on any trench, for any reason except by order of the Engineer, and the excavation is left open for an unreasonable length of time (in the opinion of the Engineer) in advance of construction, the Contractor shall, if so directed, refill such trench at his own cost and shall not again open said trench until he is ready to complete the structure therein.

3.07 ACCOMMODATION OF TRAFFIC

- A. Streets shall not be unnecessarily obstructed and, unless the Engineer, in writing, shall authorize the complete closing of the street, the Contractor shall take such measures at his own expense as may be necessary to keep the street or road open and safe for traffic.
- B. The Contractor shall construct and maintain without extra compensation such adequate and proper bridges over excavations as may be necessary or as directed for the safe accommodation of pedestrians or vehicles. The Contractor shall furnish and erect without cost to the Owner substantial barricades at crossings of trenches, or along the trench, to protect the traveling public.
- C. The Contractor shall not obstruct fire hydrants.
- D. The roadway on one side of the line of work shall be kept open at all times.
- E. The streets, crosswalks and sidewalks shall be kept clean, clear and free for the passage of vehicles or pedestrians, unless otherwise authorized in writing by the Engineer. A straight and continuous passageway on sidewalks and over crosswalks, at least three (3) feet in width, shall be preserved free from all obstruction.
- F. Where deemed necessary, such additional passageway as may be directed shall be maintained free from obstructions.
- G. In narrow or congested streets or alleys, when so directed, the Contractor shall complete his work up to a point designated by the Engineer before opening the work ahead, in order to give access to garages and other places. The Contractor shall in all cases so arrange his work as to cause the least inconvenience to property owners consistent with the proper precaution of the work as determined by the Engineer.

3.08 ACCOMMODATION OF DRAINAGE

- A. Gutters, sewers, drains and ditches shall be kept open at all times for surface drainage. No damming or ponding of water in gutters or other waterways will be permitted, except where stream crossings are necessary and then only to an extent which the engineer shall consider necessary. The Contractor will be responsible for all clean-up to existing utilities caused by their activities.
- B. The Contractor shall not direct any flow of water across or over pavements except through approved pipes or properly constructed troughs and he shall, when so required at his own expense and cost, provide pipes or troughs of such sizes and lengths as may be required and place the same as directed.

- C. The grading in the vicinity of sewer trenches shall be controlled so that the ground surface is properly pitched to prevent water running into trenches.

3.09 PUMPING

- A. The Contractor shall keep all excavations free from water, at his own expense, while structural work is in progress, and to such extent as may be necessary while excavation work along is being carried on.
- B. The Contractor shall build all dams and other devices necessary for this purpose, including lowering the water table below trench bottom by well points and pumping, and provide and operate pumps of sufficient capacity for dewatering the excavations.
- C. He shall provide for the disposal of the water removed from excavation in such manner as shall not cause injury to the public health, to public or private property, to the work of other Contractors, to any portion of the work completed or in progress, or produce any impediment to the use of the highways, roads, lanes, and streets by the public.
- D. Any dewatering required shall be performed at the Contractor's expense. Payment for dewatering shall be included in the Contractor's bid prices for pipe or other structures requiring dewatering for installation. If holes made for installation of well points are installed in a roadway, shoulder, or under a structure, these holes shall be filled with lean grout prior to backfill and compaction. Any permits needed for dewatering shall be obtained and paid for by the contractor.

3.10 EMBANKMENT

- A. Where embankment is necessary to support the foundations of the pipe or structure, it shall be made to the height, width and slopes shown on the drawings, or as directed. The entire embankment, or such portion thereof as may be deemed necessary by the Engineer, shall be made prior to the construction of the sewer, structure, or the foundation thereof, at such time and in such order as the Engineer may direct; and the embankment, sewer, or structure, and appurtenances, which may be laid thereon or therein, shall be maintained by the Contractor, at his own cost and expense, until the completion of the period of one (1) year from and after the date of the Certificate of Completion and Acceptance.
- B. After carefully grubbing and clearing the ground, removing all loose rock and stone, and all muck and improper material, to such a depth as the Engineer may determine, the embankment shall be built up of good loam, gravel or sand, or other selected and approved material, free from all stone above four (4) inches diameter, and not containing in any place a proportion of stones exceeding one (1) part stone to three (3) parts earth.
- C. In cast material which is unsatisfactory for the foundation of any embankment is encountered, said material shall be removed to such depth, and for such length and width as may be directed by the Engineer. Payment for the removal of material unfit for the foundation of an embankment will be made at the price bid or stipulated per cubic yard for excavation below subgrade.
- D. The material for embankment shall be deposited in layers of not more than nine (9) inches in thickness; each layer shall be separately compacted by heavy, grooved iron rollers, or where such rollers cannot be used, by heavy paver's rammers. The embankment shall be watered during rolling, if so required. No breaks or irregularities in the distribution of the material or the formation of the layers will be allowed. The whole embankment shall be carried up evenly to the height given by the Engineer in such a manner as to make a compact and solid foundation. When pipe is to be laid in a fill, the embankment shall be

brought to a height of at least one (1) foot above the proposed top of the pipe before the trench is excavated. The embankment shall then be excavated to the proper form and grade, and the sewer placed thereon; after which the embankment shall be carried up to a height of not less than three (3) feet above the top of the sewer, the material being placed and rolled or rammed in layers as above described.

3.11 BACKFILLING TRENCHES

- A. It is the intent of the following requirements for the backfilling of trenches to specify materials and methods which will:
1. result in thorough compaction of the backfilled material without the displacement of the grade or alignment of the sewer line and its appurtenances, and
 2. eliminate settlement of the backfilled material.
- B. If displacement of the sewer or settlement of the backfilled material does occur, it will be considered as conclusive evidence of improper workmanship or the inclusion of unsuitable materials or both, and it shall be the Contractor's responsibility, at his own expense, to remove and recompact the settled material and regrade and realign the sewer. During the course of the backfilling operation, the Engineer may, at any location of depth of trench, make tests to determine whether the Contractor's compaction operations are sufficient to meet the requirements specified below.
- C. The procedure of backfilling shall be as follows:
1. After the structure, pipe, or conduit and its appurtenances have been installed or constructed, the excavation, to a height of at least two (2) feet above the top of pipe or conduit, shall be refilled with clean earth deposited in four (4) inch layers and solidly rammed down and tamped around the pipe, or conduit and under it, with mechanical tampers and proper tools made for this purpose. The operation shall be done in such manner as not to disturb the structure. The area around the pipe shall be hand-tamped.
 2. The earth, to the height specified above, shall be carefully thrown in with hand shovels; under no condition shall any other means than hand shoveling, such as pushing in with heavy equipment, be used.
 3. The remainder of the trench, except as described below, shall then be refilled evenly to the required height in layers, each layer not to exceed six (6) inches in thickness after compaction. Mechanical tampers shall be used so as to produce a density of backfill (as determined by weight) at the bottom of each layer of not less than ninety-five percent (95%) of the optimum density of that material based upon the AASHTO T-180 modified proctor. The earth shall be properly rammed as directed, and wetted as required as the work progresses.
 4. Care shall be taken to carry the fill up evenly on opposite side of the sewer, other trench excavations, and around the sides of all structures.
- D. If, in the opinion of the Engineer, the material being used for backfilling is of such character that satisfactory results cannot be obtained by tamping and ramming, the Contractor shall backfill and puddle the excavations in such manner and at such times as the Engineer may direct.

- E. If the material excavated is not clean earth, as above specified, the best of the materials excavated shall be used in backfilling, in position and manner as directed by the Engineer.
- F. In rock trenches, selected earth, sand or gravel shall be provided and used as backfill in the manner hereinbefore described to a height of two (2) feet above the top of the sewer. The backfill for the balance of the trench in all cases shall be of good earth, sand or gravel, which may contain stones not more than six (6) inches in largest dimensions, but not in proportion exceeding twenty percent (20%) of the total volume of backfill.
- G. No bulkheads, or retaining walls for the backfilling, will be allowed in the trenches over the sewer, except for temporary use.
- H. Should there be a deficiency of proper material for refilling, the Contractor shall furnish acceptable material at his own cost and expense.
- I. No house ashes, putrescible refuse or other material of unsatisfactory character shall be used in refilling, and the Contractor shall not permit the trench to be used as a dumping ground for refuse.
- J. Testing of backfill in trenches shall be performed as deemed necessary by the Engineer of his representatives. The Contractor will supply and pay for test laboratory.

3.12 BORROW EXCAVATION

- A. In cases where the amount of embankment exceeds the amount of excavation within the limits of the site as indicated by the Drawings, and where material is not available from other sources of contracts, the Contractor shall obtain sufficient, suitable material from borrow pits located entirely beyond the limits of the site unless the Engineer gives written permission to obtain such material from an area within the site.
- B. The Contractor shall notify the Engineer sufficiently in advance of borrow excavation requirements to permit the Engineer to determine necessity, and to view the proposed borrow pit.
- C. Borrow obtained from within the site shall be removed to uniform lines and grades satisfactory to the Engineer, and in such a manner as will not detract from the general appearance of the improvement and shall not create unsatisfactory conditions.
- D. All borrow pits shall be stripped of brush, roots, grass and other vegetation prior to removal of material for embankment purposes.

3.13 BUILDINGS AND STRUCTURES

A. Excavation.

1. All excavation for buildings and structures shall be performed in the dimensions indicated on the Drawings. If suitable bearing is not encountered at the planned footing or foundation elevations, the excavation shall be carried to such elevations as are approved by the Engineer.
2. Prior to construction of foundations, the excavation shall be inspected by the Engineer and no foundation work shall be started prior to the Engineer's approval of the excavation. Care shall be exercised to avoid excavation below the depths indicated on the Drawings or as directed by the Engineer.
3. Where excavation is made below plan elevation or below elevations directed by the Engineer. Where excavation is made below plan elevation or below elevations directed by the Engineer, through the fault of the Contractor, the excavation shall be restored to the proper elevation in the manner described for backfill below, or the heights of walls or footings shall be increased, as may be directed by the Engineer, at the expense of the Contractor.

B. Drainage.

1. Grading in the vicinity of structures shall be controlled to prevent water running into excavated areas. Any accumulation of water in excavations shall be removed by pumping or other means at the Contractor's expense.

C. Backfill.

1. After completion of footings and walls, and the removal of forms, and prior to backfilling, the excavation shall be cleaned of all trash and debris.
2. Backfill material shall consist of the excavation or other materials free from trash, lumbar or other debris. It shall be placed in horizontal layers not exceeding six (6) inches in depth, moistened if required, and compacted by hand or mechanical tampers to a density to prevent excessive settlement.

3.14 RESPONSIBILITY FOR CONDITION OF EXCAVATION

- A. The Contractor shall be responsible for the condition of all excavations made by him. All slides and cave-ins shall be removed without extra compensation, at whatever time and under whatever circumstances they may occur.
- B. The failure of the Engineer to order the use of bracing or sheeting or a better quality, grade or section, or larger sizes of steel or timber, or to order sheeting, bracing, struts, or shoring to be left in place, or the failure to give orders or directions as to the manner or methods of placing or driving sheeting,,, bracing jacks, wales, rangers, or other members, shall not in any way or to any extent relieve the Contractor of any responsibility concerning the condition of excavation or of any of his obligations under the Contract; nor shall any delay, whether caused by any action or want of action on the part of the Contractor, or by any act of the Owner, or his agents, or employees, resulting in the keeping of an excavation open longer than would otherwise have been necessary, relieve the Contractor or from the necessity of properly and adequately protecting the excavation from caving or slipping, nor from any of his obligations under the Contract relating to injury of persons or property, nor entitle him to any claim for extra compensation.

3.15 PROTECTION OF PROPERTY AND STRUCTURES

- A. The Contractor shall, at his own expense, sustain in their places, and protect from direct or indirect injury, all pipes, tracks, walls, buildings, and other structures or property in the vicinity of his work, whether above or below the ground, or that may appear in the excavation. He shall at all times have a sufficient quantity of timber and plank, chains, ropes, trench boxes, and other material and equipment, on the ground and shall use them as necessary for sheeting his excavations and for sustaining or supporting any structures that are uncovered, undermined, endangered, threatened or weakened.
- B. The Contractor shall take all risks attending the presence of proximity of pipes, poles, tracks, walls, buildings, and other structures and property, of every kind and description, in or over his excavation, or in the vicinity of his work, whether above or below the surface of the ground; and he shall be responsible for all damages and assume all expense for direct or indirect injury, caused by his work, to any of time, or to any person or property by reason of injury to them, whether such structures are not shown on the Drawings.
- C. Where necessary, in order to keep one side of the street or roadway free from any obstruction or to keep the material piled alongside the excavation from falling on private property outside the right of way, a safe and suitable fence shall be placed alongside the excavation.
- D. In the event of encountering quicksand, subsurface streams or similar dangerous contingencies, or where passing especially heavy building or any structures which by their construction or position might bring a great pressure upon the excavations the right is reserved by the Engineer to direct that such buildings, or structures, shall be underpinned, or supported and protected, or that special sheeting shall be driven in such a manner and to such depth, as may be directed, or that only a short length of excavation shall be opened at one time; and furthermore, if necessary, that the excavation shall be securely sheeted and braced on all sides, after the manner of a shaft, and that the permanent work shall be constructed in the same manner and the shaft backfilled before another opening is made. Any work done as above directed shall be at the cost and expense of the Contractor.
- E. The Engineer reserves the right under such conditions to stop the excavation or any other part of the work, and to require the Contractor to complete the structure and the backfilling up to such a point as the Engineer may direct before proceeding further with the excavation; and the Contractor shall not thereby become entitled to demand or to receive any allowance or compensation, other than an extension of the contract time for as many days as the Engineer may determine that the work was delayed by such stoppage.

3.16 OBSTRUCTION SHOWN ON DRAWINGS

- A. Certain information regarding the reputed presence, size, character, and location of existing underground structures, pipes and conduits has been shown on the Contract Drawings. There is no certainty of the accuracy of this information and the location of underground structures shown may be inaccurate and other obstructions than those shown be encountered.
- B. The Contractor hereby distinctly agrees that the Owner is not responsible for the correctness or sufficiency of the information given; that in no event is this information to be considered as a part of the Contract; that he shall have no claim for delay or extra compensation on account of incorrectness of information given, or on account of the insufficiency or absence of information regarding obstructions either revealed or not

revealed by the Drawings; and that he shall have no claim for relief from an obligation of responsibility under the Contract, in case the location, size or character of any pipe or other underground structure is not as indicated on the Drawings; or in case any pipe or other underground structure is encountered that is not shown on the Drawings.

- C. The Contractor is solely and completely responsible for contacting utility providers and locating services to field locate existing utilities 48 hours in advance of his activities. If inadequate locations are made, or if hand-digging of "test holes" is deemed necessary, this shall be accomplished and affected by the Contractor at no additional expense to the Owner.

3.17 REMOVAL OF OBSTRUCTIONS

- A. Should the position of any pipe, conduits, pole, or other structures, above or below the ground be such as, in the opinion of the Engineer, to require its removal, realignment, or change due to work to be done under the Contract, the work of removal, realignment, or change will be done as extra work, or will be done by the Owner of the obstructions, without cost to the Contractor; but the Contractor shall uncover and sustain the structures, at his own expense, before such removal and before and after such realignment or change as constituting part of the Contract; and the Contractor shall not be entitled to any claim for damage or extra compensation on account of the presence of said structure, or on account of any delay in the removal or rearrangement of the same.
- B. The Contractor shall, without extra compensation, break through and reconstruct, if necessary, the invert or arch of any sewer, culver, or conduit that may be encountered, if the said structure is in such a position that in the judgement of the Engineer, as not to require its removal, realignment or complete reconstruction.
- C. The Contractor shall not interfere with any persons, firms or corporations, or with the Owner in protecting, removing, changing, or replacing their pipes, conduits, poles, or other structures; but he shall suffer said persons, firms, or corporations, or the Owner to take all such measures as they may deem necessary or advisable for the purpose aforesaid, and the Contractor shall thereby be in no way relieved of any of his responsibilities under this Contract. At railway or railroad track crossings or paralleling, any expense to which the Owner of the trackage is put in shoring up tracks, or in maintaining traffic, shall be borne by the Contractor, whether the same is billed directly to him, or the Owner. Should any such bill be unpaid by the Contractor, before final payment under the Contract is made, the Owner shall be empowered to pay said bill and retain the amount thereof, from any monies due, or to become due the Contractor.
- D. Except where trees are in rights-of-way, in immediate proximity to the excavation, they shall not be cut down except by authorization of the Engineer,, and the Contractor shall have no claim for the extra compensation owing to the fact that he may be required to excavate by hand, or tunnel in the vicinity of trees that may be left standing.

3.18 CHANGE OF EXCAVATION LOCATION

- A. In case the Engineer shall direct that the location of a trench or other excavation be changed from that shown on the Drawings, on account of the presence of an obstruction, or from other cause, or if a changed location shall be authorized upon the Contractor's request, the Contractor shall not be entitled to extra compensation, or to a claim for damage, provided that the change is made before the excavation is begun. If, however, such change, made at the direction of the Engineer, involves the abandonment of excavation already made, such abandoned excavation, together with the necessary refill, will be classed as miscellaneous excavation. In the event that the excavation is

abandoned in favor of a new location, at the Contractor's request, the abandoned excavation and refill shall be at the Contractor's expense.

- B. Minor changes in alignment of pipe or other structures to accommodate the actual location of existing facilities shall be considered typical of construction activities and no additional compensation will be made for changes of this nature.

3.19 CLEANUP

- A. As the trenches are filled in and the work completed, the Contractor shall immediately and at his own cost and expense remove and dispose of all surplus earth, stone or other material from the work, in such manner and at such point or points, as he may select or provide, subject to the approval of the Engineer; or he may deposit the same, either with or without rehandling, at any point or points on the line of the work covered by the Contract, if so directed by the Engineer; and shall leave all roads, sidewalks and other places free, clear and in good order. In case the Contractor shall fail or neglect to do so, or to make satisfactory progress in doing so within twenty-four (24) hours after the receipt of a written notice from the Engineer, the Owner may remove such surplus material and clear the roadways, sidewalks and other places, and the cost of said work shall be charged to the Contractor and deducted from any monies due or to become due him under the Contract.
- B. All surplus earth or other material wasted on public property shall be evenly spread and left in a neat and smooth condition. All removed materials shall become the property of the Owner, if they so desire. If the Owner does not want the removed materials, surplus materials will be removed by the Contractor at no extra cost to the Owner.
- C. As soon as the trenches are refilled, all surplus earth, sand or rubbish shall be removed and kept removed to a point not more than two hundred (200) feet from the head of the open trench, unless otherwise authorized by the Engineer.

3.20 MAINTENANCE OF BACKFILLED TRENCH SURFACES

- A. The Contractor shall crown to such height, as directed by the Engineer, the top of all backfilled trench excavations. The Contractor shall also maintain these crowned surfaces to the satisfaction of the Engineer, without additional compensation, from the time of crowning operation to and including a period of eight (8) months beyond date of a Certificate of Completion of the work under this contract.
- B. The Contractor shall be responsible for any injury or damage resulting from lack of required trench maintenance during the prescribed maintenance period. If the Contractor does not satisfactorily provide specified maintained surfaces or begin repairs of such surfaces when needed, within twenty-four (24) hours after written notice from the Engineer, such work may be done by the Owner and the cost thereof charged against the Contractor.

END OF SECTION

SECTION 02200
SITE GRADING

PART 1 - GENERAL

1.01 Work Includes

- A. Excavation and embankment necessary for grading the site shall be considered to include that required for roads, walks, culvert installations, and drainage ditches and channels.

PART 2 - EXECUTION

2.01 Preparation

- A. After the removal of topsoil, the then existing surface is to be excavated or filled to the elevations and slopes indicated on the Drawings, or as directed by the Engineer. Additional fill, if required, and is not available elsewhere, shall be excavated from borrow areas selected by the Contractor, but subject to the approval of the Engineer. Unless otherwise provided, all borrow pits shall be located entirely outside the limits of the site.
- B. On areas where roadway pavement is to be placed, the subgrade therefore shall be no more than 0.10 foot above or below the established grade; in other areas, the finished grade shall be not more than 0.15 foot above or below the established grade.
- C. Where rock is encountered at road subgrade or finished grade in areas other than roads, it shall be removed for a depth of six (6) inches below such subgrade or finished grade elevation.
- D. Subgrades and shoulders for the access and service roads shall be constructed to the lines and grades indicated, and in conformance with the applicable requirements of the "Standard Specifications" for the Florida State Department of Transportation.

2.02 Embankment

- A. On hillsides in which the existing slope is steeper than four to one, the Engineer may require the surface to be plowed to provide binding of the embankment with the original ground. When, in the opinion of the Engineer, existing slopes are excessive, the Engineer may require the original ground to be cut into the steps or berms.
- B. All materials removed from classes of excavation, which are determined as suitable by the Engineer, shall be used in the formation of embankments. Excavated material, which is not required for embankments, shall be disposed of by the Contractor, at his responsibility and expense, outside the limits of the site, unless the Engineer gives

notice of some point of disposal within the site. No material shall be disposed of in any flood channel area.

- C. Earth or other friable materials shall be placed in successive horizontal layers of loose material not more than nine (9) inches in depth, spread uniformly by use of graders or other approved devices, and rolled until thoroughly compacted with an approved three (3) wheel power roller weighing not less than ten (10) tons. The Engineer may permit the Contractor to use approved sheep-foot tamping rollers. Embankments at points inaccessible to the roller shall be made in horizontal layers of loose material not exceeding six (6) inches in depth and thoroughly compacted by mechanical tampers.
- D. Where rock only is available, it shall be placed in loose layers not exceeding two (2) feet in depth and rolled as provided above. Rock fills shall only be considered as such where the earth or other finer materials is uniformly distributed and is considerably less than sufficient to fill the voids and interstices; otherwise it shall be considered and placed as earth fill. The top layer of rock fills shall not exceed eight (8) inches in depth, and the interstices shall be thoroughly filled with small spall, shale, gravel, or other similar approved material and thoroughly compacted. This top layer of rock shall be kept at least eight (8) inches below the elevation of subgrade for payments, and finished grade elsewhere, with the balance of the fill formed by topsoil or other approved material, as required.
- E. No roots, leaves, grass, or any form of vegetation shall be placed [or allowed to remain in filled or graded areas.](#)
- F. The Contractor shall be responsible for the stability of all embankments and shall replace all sections which, in the opinion of the Engineer, have been damaged or displaced due to carelessness or neglect on the part of the Contractor due to natural causes, such as storms.
- G. During grading operations, cuts and fills shall be kept shaped and drained at all times.

END OF SECTION

SECTION 02900
GRASSING, MULCHING AND SODDING

PART I - GENERAL

1.01 WORK INCLUDED

- A. The work specified in this section consists of grassing, or of grassing and mulching, on slopes, shoulders and other areas. The work of grassing shall include seeding and fertilizing; also watering as required. Any of the items of work covered by this section may be eliminated from the contract, at the discretion of the Engineer. Sodding is included herewith and shall conform to the lines and grades as shown on the plans.

PART II - MATERIALS AND EQUIPMENT

2.01 MATERIALS AND EQUIPMENT

- A. The materials used for the work in this section shall conform to the requirements hereinafter specified.

2.02 SOD

- A. Sod shall be of St. Augustine grass and shall be well matted with roots. St. Augustine shall be used in residential areas. Bahia shall be used in the right-of-way areas, not covered by St. Augustine grass.
- B. The sod shall be taken up in commercial-size rectangles, preferably 12-inch by 12-inch, except where 6-inch strip sodding is called for.
- C. The sod shall be sufficiently thick to secure a dense stand of live grass. The sod shall be live, fresh and uninjured, at the time of planting. It shall be planted as soon as possible after being dug and shall be shaded and kept moist from the time it is dug until it is planted. The sod shall be approved by the Engineer before placing.
- D. Source Requirements for Sod and Mulch. No mulch material or sod shall be used which is not certified as being free of the imported fire ant, and before any mulch or sod is brought to the project, the Contractor will be required to furnish the Engineer a written certification and clearance, from pest control officials of either the State or the Federal Department of Agriculture, verifying that the materials are being obtained from an area outside of the zone of quarantine of the imported fire ant, or that they are free of the imported fire ant.

2.03 WATER

- A. The water used in the grassing operations may be obtained from the reclaimed water system.
- B. The water shall be free of excess and harmful chemicals, acids, alkalis, or any substance which might be harmful to plant growth or obnoxious to traffic.
- C. Salt water shall not be used.

2.04 EQUIPMENT

A. Fertilizer Spreader.

1. The device for spreading dry fertilizer or for spraying liquid fertilizer shall meet the approval of the Engineer.

B. Seed Spreader.

1. The seed spreader shall be an approved mechanical head spreader or other approved type of spreader and may be integral with the cultipacker roller equipment specified below.

C. Equipment for Cutting Mulch into Soil.

1. The mulching equipment shall be a rotovator, or other equipment determined by the Engineer to be equally suitable for cutting the specified materials uniformly into the soil and to the required controlled depth.
2. Harrows will not be allowed.

D. Rollers.

1. A cultipacker, traffic roller, or other roller approved by the Engineer, will be required for rolling the grassed and mulched areas.

E. Water-Metering Devices.

1. The vehicle used for applying the water to the grassed areas shall be equipped with an approved metering device installed at such point on the vehicle as to measure the water at the time of its being applied to the grassed areas.

PART III - EXECUTION

3.01 TIME OF BEGINNING OPERATIONS

- A. Whenever a suitable length of roadway is completed and ready for planting the Contractor shall, if directed by the Engineer, proceed at once with the planting of the available shoulder or embankment areas.

3.02 WEATHER AND SOIL LIMITATIONS

- A. Fertilizing, seeding or mulching operations will not be permitted when wind velocities exceed 15 miles per hour.
- B. Seed shall be sowed only when the soil is moist and in proper condition to induce growth.

3.03 SOIL MANIPULATION

- A. All soil manipulation shall be done at right angles to the direction of slope.

3.04 WATERING

- A. The soil shall be maintained in a moist condition for a period of at least two weeks after the planting.

3.05 APPLYING AND MIXING FERTILIZER

A. Rate of Application.

1. At the Contractor's option either dry or liquid commercial grade fertilizer may be used.
2. The rate of application for dry fertilizer shall be 800 to 1000 pounds per acre, with application in the upper range for sandy soils in the lower range for loamy soils. The exact rate will be set by the Engineer.
3. Liquid fertilizer shall be applied at an equivalent rate which will provide the same amount of plant food as required for dry fertilizer (or at approximately 74 to 92 gallons per acre).

B. Application.

1. The fertilizer shall be spread or sprayed uniformly over the area to be grassed by use of the approved distributing device, except that on steep slopes or other areas where machine-spreading may not be practicable, spreading may be done by hand or by hose if the Engineer so directs.
2. Immediately after dry fertilizer is spread, it shall be harrowed in and mixed with the soil to a depth of approximately four inches.
3. When liquid fertilizer is sprayed, the soil, if dry, shall be moistened by sprinkling before the liquid fertilizer is applied not later than seven days after the seed is in place.

3.06 MULCHING

A. When Dry Mulch is Used.

1. When mulching is called for, approximately two inches, loose thickness, of the straw or hay material shall then be applied uniformly over the grassing area, and the mulch material cut into the soil with the equipment specified, so as to produce a loose mulch thickness of three to four inches.
2. Care shall be exercised so that the materials are not cut too deeply into the soil.

B. When Green Mulch is Used.

1. When green mulch is used, the green mulch shall be incorporated into the soil not later than two days after being cut, and not artificial watering shall be done before the mulch is applied.
2. It shall be spread in a layer of approximately two inches loose thickness, and cut into the soil with the equipment specified.
3. The material shall not be cut too deeply into the soil.

3.07 SEEDING

- A. Soon after the mulch material has been cut into the soil, and while the soil is still loose and moist, the seed shall be scattered uniformly over the grassing area.

The rate of spread for the seed shall be as follows:

1. Where mulching is not called for, or where dry mulch is used, the rate shall be 60 pounds per acre. In the period from March 15 to October 15 the seed mixture shall be 30 pounds of Bahia and 30 pounds of Bermuda. In the remainder of the year, the mixture shall be 20 pounds each of Bahia, Bermuda and rye seed.
2. When green mulch is used, the required rate of spread shall be reduced to 45 pounds per acre, because of the faster growing rate of the green mulch as compared with that of the seeds. The seed mixture shall be 22-1/2 pounds of Bahia and 22-1/2 pound of Bermuda, except that in the period October 15 to March 15 the mixture shall be 15 pounds each of Bahia, Bermuda and rye grass seed.
3. Seeding may be done in conjunction with the rolling if the equipment used is designed for that purpose.
4. Rolling. Immediately after completion of the seeding, the entire grassed or mulched area shall be rolled thoroughly with the equipment specified. At least two trips over the entire area will be required.

3.08 SODDING

- A. Wherever sodding is indicated on the plans, it shall include all of the requirements of this section except "Mulching".

3.09 MAINTENANCE

- A. The Contractor shall be responsible for keeping the ground moist by watering until an acceptable stand of grass is grown. He will also be required to repair at his own expense any damage due to washouts, erosion or other causes which might occur prior to final acceptance of this work.

END OF SECTION

DIVISION 3
CONCRETE

SECTION 03300

CAST IN-PLACE AND POURED CONCRETE

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. The work included under this section consists of furnishing all materials, forms, transportation and equipment, and performing all necessary labor to do all the plain and reinforced concrete work shown on the Drawings, or incidental to the proper execution of the work, or as herein specified.
- B. Composition: Concrete shall be composed of cement, fine aggregate, coarse aggregate, and water so proportioned and mixed as to produce a plastic workable mixture in accordance with all requirements under this section suitable to the specific conditions of placement.

1.02 SUBMITTALS

- A. All materials specified shall be certified by the producer or manufacturer that the furnished material meets the specific requirements of the specifications. Concrete mix designs shall be submitted for approval prior to placement.

1.03 CODES AND STANDARDS: ACI 301 "Specifications for Structural Concrete for Buildings", ACI 347 "Recommended Practice for Concrete Formwork"; ACI 304 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete"; comply with applicable provisions except as otherwise indicated.

1.04 TESTING

- A. Air content shall be in accordance with American Society for Testing Materials Standard Methods C 173, one for each set of compressive strength specimens.
- B. Sampling of freshly mixed concrete shall be in accordance with ASTM C172.
- C. Slump: ASTM C-143
- D. Test results will be reported in writing to Engineer, Contractor, Owner and Concrete producer on same day tests are made.
- E. Laboratory Reports: Submit 2 copies of laboratory test or evaluation reports for concrete materials and mix designs.
- F. Test cylinders shall be pulled for each days pour and each 50cy thereafter.

PART 2 - MATERIALS AND EQUIPMENT

2.01 PORTLAND CEMENT. Shall comply with the standard specifications for Portland Cement, A.S.T.M. designation C-150, Type II, or Type III (high-early), where indicated on drawings.

2.02 CONCRETE AGGREGATE. Shall conform to standard specifications for concrete aggregate, A.S.T.M. Designation C-33 or to ASTM C-330. Maximum size of aggregate shall not exceed one-fifth of the narrowest dimension between reinforcing bars.

A. Fine Aggregate. Fine aggregate shall be clean, hard, strong, durable, uncoated particles of natural sand known as Lake Wales, Interlachen, or approved equal. The source, composition, quality and gradation of the fine aggregate shall be subject aid the approval of the Engineer. Samples of the sand shall be furnished, together with certified copies of the gradation and analysis from the recognized testing laboratory.

1. The weight of extraneous or deleterious substances shall not exceed the following percentages:

Loss by Decantation	3%
Shale	1%
Clay Lumps	1%
Coal and Lignite	1%

2. The fine aggregate shall be reasonable well graded from coarse to fine and when tested by means of laboratory sieves shall meet the following requirements in percent of total weight:

<u>Total Retained On</u>	<u>Percent Retained</u>
No. 4 Sieve	0 - 5
No. 10 Sieve	3 - 30
No. 30 Sieve	30 - 70
No. 50 Sieve	65 - 95
No. 100 Sieve	95 - 100

Deficiencies in the percentages of the fine aggregates passing the No. 50 and No. 100 Sieves may be remedied by the addition of pozzolanic or cementitious materials excepting Portland cement. Such materials must meet the approval of the Engineer.

B. Coarse Aggregate.

1. Coarse aggregate shall consist of hard, tough, durable components, free from adherent coatings and vegetable matter, and shall not contain soft, friable, thin or elongated particles in quantities considered deleterious by the Engineer. Coarse aggregate shall be properly graded from fine to coarse to produce concrete of desired strength, density, and workability. The source, composition, quality and

gradation of the coarse aggregate shall be subject to the approval of the Engineers. Samples of the coarse aggregate shall be furnished together with certified copies of the gradation and analysis from a recognized testing laboratory.

2. All coarse aggregate shall be washed and shall be free from disintegrated pieces, salt, alkali, vegetable matter and adherent coatings. The total percentage of all deleterious substances shall not exceed 5 percent by weight. The substances designated shall not be present in excess of the following amounts.

Loss by Decantation	1%
Clay Lumps or Other Soluble Materials	3%
Soft Fragments	5%

3. Where the cover over reinforcing is 2 inches or more, the maximum size of aggregate shall be 12 inches. Where the cover over reinforcing is less than 2 inches, the maximum size of aggregate shall be 3/4 inch. The maximum size of aggregate shall not exceed one-fifth of the narrowest dimension between forms nor three-fourths of the minimum clear spacing between reinforcing bars. The grading of the coarse aggregate in the concrete shall be within the following limits.

	<u>Percent Passing</u>
Maximum Size Square Mesh Screen	97 - 100%
2 Maximum Size Square Mesh Screen	40 - 70%
No. 4 Sieve	0 - 6%

2.03 WATER. Water shall be clean and free from oil, acids, alkalies, organic materials or other injurious substances.

2.04 REINFORCEMENT

- A. Reinforcing Bars: ASTM A615, Grade 60, deformed bars of USA manufacture.
- B. Welded Wire Fabric: ASTM A185, gauges, spacing and dimensions as indicated.
- C. Metal Bar Supports: CRSI MSP-1, Chapter 3, Class 2, Type B, Stainless Steel Protected Bar Supports, or otherwise approved by the Engineer. Use concrete supports for reinforcement in concrete placed on grade.
- D. Tie Wire: 16 gauge minimum, black, soft annealed.
- E. Coupler Splice Devices: Cadweld tensions couplers, capable of developing the ultimate strength of the bar as manufactured by Erico Products, Incorporated, Solon, Ohio, or equal.

2.05 FORM WORK

- A. Lumber: Douglas Fir or Larch, No. 2 grade, seasoned and surfaced on four sides.
- B. Plywood: Plyform, Class 1, BB-Exterior type, mill oiled and edge sealed, with thickness not less than 3/4 inch.
- C. Medium Density Overlay (MDO) Plywood Forms: PS-1, B-B High Density Concrete Form Overlay, Class I, unoiled.
 - 1. Butt form panels, make contact surface fully flush and seal butting holes with sponge form tape. Chamfer edges of beams and ceilings.
 - 2. Where MDO plywood is used to form beams, do not use MDO plywood that has been patched or damaged.
- D. Drip Forms: Varnished ponderosa pine or equally rigid non-staining plastic, 2 inch wide on each leg.
- E. Steel Forms. Uncoated steel, 3/16 inch minimum thickness, fabricated to close tolerances, protected only by the specified release agent, braced so as not to bend dent or dimple under wet concrete load, vibrator impact, and tool impact. maintain steel form in rust-free condition by use of steel wood and light grinding, followed by coats of specified release agent. Use forms that can be adjusted into true alignment without stops or ridges.
- F. Glass Fiber Reinforced Plastic (FRP) Forms: Smooth coated forms, braced so as not to bend, dent or dimple under wet concrete loads, vibrator impact and tool impact, and at least 0.11 inch thick. Design forms for external bracing at piers and columns, without use of form ties.
- G. Plugged Cone Form Ties: Rod type, with ends or end fasteners which can be removed without spalling the concrete and which leave a hole equal in depth to the required reinforcement clearance. Form ties shall be of a design in which the hole left by the removed end or end fastener is easily filled to match the surface of the hardened concrete. Provide removable cones 13 inches in diameter by 12 inches deep. Provide preformed mortar plugs to match the color of the concrete, recessed 3 inch, adhered with an approved two part epoxy.
- H. Weep Hole Forms: PVC polyethylene, or ABS pipe, matching color of the concrete, 4 inch inside diameter, with outlet projecting 12 inches from wall and cutoff in a plane parallel to it.
- I. Circular and Elliptical Column Forms: Fabricate of two pieces, clamped watertight using gaskets and without horizontal joints. Install horizontal construction joints only where indicated or as directed by the Engineer.

- J. Beam Forms: Provide in one length without form joints and suitable for cambering up to 1/160 of span without distortion of profile or opening of seams.
- K. Forms of Hammerhead Pier Caps: Provide in one length with adjustable soffits, bulkheads and screens as necessary to accommodate different hammerhead beam configurations. Provide no construction joints in hammerhead pier caps. Where three or fewer identical hammerhead pier caps occur within a line section, steel braced HDO plywood forms may be substituted for steel forms if:
 - 1. Working drawings of formwork are submitted.
 - 2. Internal form ties are regularly spaced no less than 48 inches each way, and are made watertight.
 - 3. Form ties have removable cones, which are filled to match concrete.
 - 4. Joints in panels are fully watertight.
 - 5. The resulting surface matches the appearance of steel formed hammerhead caps, with no visible discoloration due to form leakage.
- L. Styrofoam Board: Expanded polystyrene extruded into board form, closed cell, moisture resistant, capable of maintaining indicated clear space between concrete structures.
- M. Control Joint Filler: Use epoxy joint filler equal to BurkEpoxy Joint Filler to fill voids left by saw cuts and to resist against spalling caused by vehicle traffic in concrete slabs.
- N. Inserts: Galvanized cast steel or galvanized welded steel, complete with anchors to concrete and fittings such as bolts, wedges and straps. Provide hanger inserts spaced to match grid of suspended ceilings.
- O. Shoring: As designed and executed by Contractor to support all loads.
- P. Chamfer Strips: Polyvinyl strips designed to be nailed in the forms to provide a 3/4 inch chamfer at exposed edges of concrete members.
- Q. Form Release Agent: A blend of natural and synthetic chemicals that employs a chemical reaction to provide quick, easy and clean release of concrete from forms, and equal to Eucoslip, by the Euclid Chemical Company, or Release #1, by The Burke Company. Use a non-staining release agent that leaves the concrete with a paintable surface.

2.06 ADMIXTURES

- A. Air Entraining Admixture: ASTM C260.
- B. Water Reducing and Retarding Admixture:

1. Concrete Without Superplasticizer:
 - a. Water Reducing Admixtures: ASTM C494, Type A, equal to Eucon WR-75 by the Euclid Company, Pozzolith 200N by Master Builders, Plastocrete 161 by Sika Chemical Corporation, and containing no calcium chloride.
 - b. Water Reducing and Retarding Admixtures: ASTM C494, Type D, equal to Eucon Retarder-75 by the Euclid Company, Pozzolith 100 XR by Master Builders, Plastiment by Sika Chemical Corporation, and containing no calcium chloride.
 - c. Accelerating Admixtures: ASTM C494, Type C or E, equal to Accelguard 80 by the Euclid Company, Darex Set Accelerator by W.R. Grace, and containing no calcium chloride.
2. Concrete with Superplasticizer:
 - a. Water Reducing, High Range Admixtures: ASTM C494, Type F or G, equal to Eucon 37 by the Euclid Company, Rheobild 716 by Master Builders, Daracem 100 by W.R. Grace, Sikament by Sika Chemical Corporation, and consisting of a second generation admixture, free of chlorides and alkalis (except for those attributable to water) composed of a synthesized sulfonated complex polymer, enabling the concrete to maintain its reoplastic state in excess of two hours if necessary.
 - b. Manufacturer's Job Site Representation: Provide the services of a competent field service representative from the manufacturer of each of the admixtures selected for use to provide at the job site advice and consultation on the use of the admixture materials, including the effect on the concrete in place, including recommending maximum discharge time for superplasticizer method and procedure to induce superplasticizer into mixer, quantities of admixtures to be used if variations are required because of temperature/humidity, wind or other environmental considerations, and to be available on short call at any time requested by the Owner, Contractor, or concrete producer.

2.07 GROUT

- A. Nonshrink, Nonmetallic Grout: The Burke Company's Non-Ferrous, Non-Shrink Grout, Sauereisen F-100 Level Fill, Master Builders Masterflow 713, Euclid NS Grout, or equal pre-mixed type.
- B. Nonshrink Metallic Grout: The Burke Company's Metallic Spec Grout, Master Builders Embeco 636 Grout pre-mixed type, or equal.
- C. Epoxy Grout: Sikadur 42 Grout-Pak, or equal, for grouting sleeves for anchor bolts, etc.

- D. Clarifier Basin Grout: Class B concrete of coarse aggregate shall pass the 3/4 inch sieve.
- 2.08 MEMBRANE CURING COMPOUND. Membrane curing compound shall be wax-free, pigmented, 100 percent resin base compound such as A.C. Horn's "Horncure 30 C", Hunt Process Corporation; Southern's "All-Resin", or equal.
- 2.09 BONDING AGENT. Bonding agent shall be Colma Fix, as manufactured by Sika Chemical Corporation, of Passaic, New Jersey or equal. To be considered equal, the material must be a two-component epoxy-polysulphide resin system, and it must have a demonstrated record of strong adhesion to both wet and dry concrete in either the hardened or the plastic state. It must also be of equal strength.
- 2.10 ACCESSORIES
- A. Precast Concrete Block Supports for Reinforcing Bars: Comply with ACI 315. Provide blocks with No. 4 dowels bent 90° to support top bars.
 - B. Membrane: 6 mil polyethylene film.
 - C. Water Stops: Polyvinyl chloride meeting all requirements of U.S. Army Corps of Engineer's Specification CRD-C-572 and equal to Burke Water Stops as manufactured by The Burke Company. Provide flat dumbbell type and center bulb type, 9 inches x 3/8 inch at wall thickness of 12 inches or greater, and 6 inches x 3/8 inches at wall thickness less than 12 inches. Provide 6 inch split-ribbed with center bulb type at connections of new concrete structures with existing concrete. Provide water stops as indicated on the Drawings.
 - D. Preformed Expansion Joint Filler:
 - 1. Bituminous type conforming to the requirements of ASTM D994.
 - 2. Nonextruding type, self expanding cork, 3/4 inch thick or as otherwise shown on the Drawings, conforming to the requirements of ASTM D1752, Type III, and compatible with the specified joint sealant compound.
 - E. Joint Sealant: A multipart, gray polyurethane sealant meeting U.S. Federal Specification TT-S-00227E (3) Type 1, Class A self-leveling for horizontal joints, and Type II, Class A, non-sag for vertical joints, and recommended by the manufacturer for continuous immersion in water. Provide sealants as manufactured by Products Research and Chemical Corporation, Mameco International, The Burke Company, W.R. Meadows, or equal.
 - F. Tongue and Groove Joint Forms: 24 gauge steel forms complete with steel stakes and splice plates, designed for joints not to receive a poured seal, and equal to Burke Keyed Kold Joint as manufactured by The Burke Company.

- G. Inserts: Galvanized steel to fit the proposed hanger or support.
- H. Mortar for Repair of Concrete: Same materials as used for concrete, except omit coarse aggregate and use not more than one part cement to two and on-half parts sand by damp loose volume. Use no more mixing water than is necessary for handling and placing.
- I. Burlap Mats: Conform to AASHTO Specification M182.
- J. Epoxy Bonding Agent: Euco #452, BurkEpoxy MV, Sikadur Hi Mod, Concsive 1001-LPL, or equal.
- K. Powered Epoxy Coating for Anchor Bolts: Powdered epoxy resin as manufactured by the 3M Company, Scotchkote No. 213, Armstrong No. R349.

2.11 CONDUITS AND PIPES EMBEDDED IN CONCRETE

- A. Conduits, pipes and sleeves of any material not harmful to concrete shall be permitted to be embedded in concrete with approval of the engineer, provided they are not considered to replace structurally the displaced concrete.
- B. Conduits and pipes of aluminum shall not be embedded in structural concrete unless effectively coated or covered to prevent electrolytic action between aluminum and steel.
- C. Conduits and pipes, with their fittings, embedded within a column shall not displace more than 4% of the area of cross section on which strength is calculated or which is required for fire protections.
- D. Conduits, pipes, sleeves passing through a slab, wall or beam shall not impair significantly the strength of the construction.
- E. Except when plans for conduits and pipes are approved by the engineer, conduits and pipes embedded within a slab, wall, or beam shall satisfy the following:
 - 1. They shall not be larger in outside dimension than one-third overall thickness of slab, wall, or beam in which they are embedded.
 - 2. They shall not be spaced closer than three diameters or widths on center.

2.12 PIPES CONTAINING LIQUID, GAS, OR VAPOR

- A. Pipes that will contain liquid, gas or vapor may be embedded in structural concrete under the following conditions:
 - 1. Pipes and fittings shall be designed to resist effects of the material, pressure, and temperature to which they will be subjected.

2. No liquid, gas, or vapor, except water not exceeding 90°F (32C) nor 50 psi (345 kPa) pressure, shall be placed in the pipes until the concrete has attained its design strength.
3. Concrete cover for pipes, conduits and fittings shall be not less than 12 inches (38 mm) for concrete exposed to earth or weather or in contact with ground.
4. Reinforcement with an area of not less than 0.002 times area of concrete section shall be provided normal to piping.
5. Piping and conduit shall be so fabricated and installed that cutting, bending or displacement of reinforced from its proper location will not be required.

PART 3 - EXECUTION

3.01 PROPORTIONING.

- A. The proportions of aggregate to cement shall be such as to produce a thoroughly plastic mixture which will work readily into the corners and angles of the forms and around the reinforcement but without permitting the materials to segregate or excess free water to collect on the surface. The percentage of sand shall not be less than thirty (30) nor more than fifty (50) percent of the total weight of the aggregate.
- B. The total content, including the surface water contained in the aggregate, shall not exceed 5.7 gallons per sack of cement. The slump shall not exceed four (4) inches. Air-entraining admixture shall be Darex AEA as manufactured by the Dewey and Almy Chemical Company.
- C. The amount of air entrained in the freshly mixed concrete shall not be less than three (3) percent nor more than six (6) percent. The minimum cement content in sacks per cubic yard of concrete shall not be less than six (6) sacks per cubic yard for Class "A" concrete.
- D. Concrete materials shall be accurately measured by weight. Measurement of materials for ready-mixed concrete shall conform to the "Standard Specifications for Ready-Mixed Concrete", (A.S.T.M. designation C-94).
 1. Class "A" concrete for all structures shall have minimum compressive strength of 4000 psi at 28 days.
 2. Class "B" concrete for sidewalks shall have minimum compressive strength of 3000 psi at 28 days.
 3. All concrete shall be Class "A" unless otherwise shown on the drawings.

F. Measurement.

1. Equipment necessary to determine and control the actual amounts of all materials entering the concrete shall be provided by the concrete manufacturer.
2. All materials shall be measured by weight, except that water may be measured by volume calculated at 8-1/3 pounds per gallon. One bag of cement will be considered as 94 pounds in weight.

G. Mixes.

1. Mix Design: Conform to ACI 318, Section 4.3. Submit data on consecutive tests and standard deviation.
2. Maximum Water-Cement Ratio:

.37 (lbs/lb) - Concrete with superplasticizer
.45 (lbs/lb) - Class A concrete without superplasticizer
.55 (lbs/lb) - Class B concrete without superplasticizer
.65 (lbs/lb) - Class C concrete without superplasticizer
3. Air Content: 5 percent plus or minus 1.5 percent (Class A and B).
4. Slump: 4 inches plus or minus 1 inch for Class A and B without superplasticizer.
7 inches plus or minus 1 inch for Class A and B with superplasticizer.
8 inches plus or minus 1 inch for tremie concrete or as specified by details.

H. Placing Concrete.

1. All concrete shall be placed in clean, damp forms that are not hot to the touch.
2. To prevent segregation, concrete shall be deposited as nearly as practicable in final position and not allowed to drop freely more than necessary and in no case more than five feet, except in an approved funnel or tremie. All concrete shall be placed during daylight unless otherwise authorized at least four hours in advance. Where the reinforcing steel above the top of the concrete being placed becomes coated with laitance or partially set-up concrete, all such concrete shall be removed from the reinforcing steel prior to placing concrete around the bars.
3. Concrete shall be packed carefully and tightly around pipe and other items to secure maximum adhesion.
4. Concrete shall be placed in layers not over 12 inches deep before compacting. Concrete shall be compacted by internal vibrating equipment supplemented by spading and hand-rodding between reinforcing steel and form to eliminate air bubbles and honeycomb. Vibrators shall not be used to move the concrete laterally inside the forms. Duration of vibration shall be limited to the time

necessary to provide satisfactory consolidation without causing segregation, not less than five and not more than 15 seconds per square foot of exposed top surface. The vibrator shall be constantly relocated and shall be placed in each specific spot only once for each layer. The Contractor shall take steps to assure that sufficient personnel are available to devote full time to operating vibrator, spading and rodding.

5. Wall concrete shall be placed in layers as indicated above, with the first lift preceded by a 1-inch minimum layer of 1:2-1/2 cement-sand grout, with a 6-inch to 8-inch slump, placed on existing concrete not more than 20 minutes before concrete placement. The surface of previously placed hardened concrete shall be clean and wet before grouting, or shall be treated with a bonding agent as required. Puddles of water in horizontal recessed keys shall be avoided by the use of drain recesses to outside edge of concrete. Concrete in walls and deep beams shall be placed in lifts not to exceed three layers at 12 inches each for the full length of the pour before proceeding higher. The placing of concrete shall not be delayed more than 20 minutes between layers or lifts.
6. Slab forms shall be thoroughly cleaned after placing wall concrete below. Concrete in beams or walls shall be placed to bottom of floor slab. After concrete in walls below floor slab has been in place for approximately 30 minutes, the concrete for the floor slab and upper portion of the beam shall be placed and vibrated.
7. When concrete is conveyed by chutes, the equipment shall be of proper size and design to insure a continuous flow in the chute. The chutes shall be metal or metal lined, and the different portions shall have approximately the same slope. The slope shall not be less than one vertical to three horizontal or more than one vertical to two horizontal, and there shall be provision for a baffle at the discharge end of the chute to prevent segregation. If the vertical distance between the discharge end of the chute and the surface of the concrete is more than five feet, a spout shall be used. The lower end of the spout shall be kept as near the surface of the deposit as is practicable. All chutes and spouts shall be thoroughly cleaned before and after each run. All debris and water shall be discharged outside the forms.

3.03 CURING AND PROTECTION

A. Curing:

1. Immediately after surface defects have been repaired, apply a spray coat of curing compound to all exposed surfaces, including slabs, walls, beams and columns in accordance with the manufacturer's recommendations. Protect exposed steel keyways and other embedded items from the curing compound. Water cure, as specified in paragraph B hereunder, all concrete surfaces that are to be exposed to wastewater, surfaces that are to be coated with a coal tar epoxy system, and concrete floors requiring a bond for special finishes.

2. Do not apply compound during periods of rainfall. Should the film become damaged from any cause within the required curing period, immediately repair the damaged portions with additional compound. Upon removal of forms, immediately coat the newly exposed surfaces to provide a curing treatment equal to that provided for the surface.
 3. Curing and Sealing Compound: Use clear compound conforming to Federal Specification TT-C-800A, 30% solids content minimum, having test data from an independent laboratory indicating a maximum moisture loss of 0.030 grams per sq. cm. when applied at a coverage rate of 300 sq. ft per gallon, and equal to Super Floor Coat or Super Pliocure by The Euclid Chemical Company or Masterseal 66 by Master Builders. Furnish manufacturer's certification as required.
 4. Apply specified clear curing and sealing compound to all horizontal areas so noted on the Drawings or in the Specifications. Apply immediately after final finishing. Apply this compound to non-structural construction joints of slabs on grade to act as a bond breaker prior to placement of adjacent concrete.
- B. Water Curing Method: Cure all concrete that is to be water cured by either the wet burlap method, by continuous fogging or by covering with waterproof sheet.
1. Wet Burlap Method: Cover concrete surface with a double thickness of burlap, cotton mats, or other approved material, kept thoroughly saturated with water. Keep the forms wet until removed and upon removal, start the curing specified herein immediately. Cure the concrete for a period of 7 days for normal Portland cement or 4 days for high early strength cement. Do not submerge concrete poured in the dry until it has attained sufficient strength to adequately sustain the stress involved and do not subject it to flowing water across its surface until it has cured 4 days.
 2. Continuous Fogging: Perform continuous fogging by fogging with a nozzle which so atomizes the flow of water that a mist, and not a spray, is formed. Fog the concrete surface regularly without allowing any part of the surface to become dry. Take all necessary precautions to prevent erosion of the concrete surface by the water.
 3. Covering with Waterproof Sheets: Keep the entire area to be cured continuously wet by fogging, as specified in the fogging paragraph above, for at least 18 hours and then immediately cover with waterproof curing sheet conforming to ASTM C171, waterproof paper and polyethylene film, free of holes or tears. Keep sheet fully flat, without wrinkles or air bubbles, held down tautly at all edges. Do not use this method on slabs which will be exposed to view.

3.04 PLACING REINFORCEMENT

- A. All reinforcement shall be detailed, fabricated and erected in accordance with the A.C.I. "Manual of Standard Practice for Detailing Reinforced Concrete Structure", (A.C.I. 315), including bar supports and spacers. At splices all reinforcing bars shall be lapped a minimum of twenty-four (24) bar diameters but not less than twelve (12) inches.
- B. The reinforcing shall be fabricated to the shapes and dimensions shown and shall be placed where indicated on the drawing. Before placing, all reinforced steel shall be thoroughly cleaned of rust, mill scale or coatings, which would reduce or destroy the bond.

Reinforcing bars shall conform to the requirements of the latest editions of the A.C.I. Code and the CRSI Manuals.

- C. Wire mesh, unless otherwise shown on the drawings or specified, shall be 6" x 6" No. 10 woven or electrically welded wire fabric conforming to the requirements of ASTM Designation A185, latest revision.
- D. Space chairs and bolsters in accordance with ACI 315 and 318 using height to furnish cover over reinforcing required. Chairs with plastic feet or stainless steel shall be used in all beams and elevated slabs. Chairs for other concrete adjacent to or on the ground may be pieces of concrete block or concrete brick compressed into subgrade with the rebars bearing directly on the pointed edge of the masonry supports, or chairs set on precast concrete pads compressed into the subgrade.
- E. When placed in the forms, reinforcement shall be clean and free of all loose rust, scale, dust, dirt, paint, oil or other foreign material, and shall be accurately and securely positioned both laterally and vertically before placing concrete. Minimum clearances between the steel and face of concrete shall be maintained as shown.
- F. The rebars shall be fastened together at every intersection or at intervals not greater than 24 bar diameters by wire ties or by some alternate method acceptable to the Engineer. In areas where large bars are closer together, the wire ties may be spaced not more than 30 bar diameters apart, rather than as specified above.

3.05 FORMS

- A. Installation and erection shall be in accordance with ACI 347 and as specified hereinafter.
- B. Forms shall conform to shape, lines and dimensions of numbers indicated, and shall be sufficiently tight to prevent leakage of mortar. They shall not deflect under dead load weight of construction as a liquid or of construction load. Forms shall be properly braced or tied together so as to maintain position and shape within specified tolerances. Construct forms so that they can be removed steadily without hammering or prying against the concrete. Forms for exposed concrete shall be carefully made and accurately placed to obtain correct shape and line.

- C. Forms shall be of wood, metal, or other approved materials. Metal forms shall be of a type and manufacture acceptable to the Engineer. Plywood, fiberboard, or absorptive type form linings may be used where appropriate. Sectional forms shall produce a uniform surface and shall be assembled in a modular pattern. Pours will not be scheduled until all erection and bracing is complete. Walers, ties and braces shall be required for all forms. Chamfer strips made from nominal dimensional 1" x 1" lumber cut on the diagonal shall be installed at the top of the forms on all exposed edges of walls, slabs, beams and other structures above grade.
- D. Drip edge shall be made from wood quarter round and installed where shown. Extruded plastic fillets shall be used where detailed. Circular structures shall be formed with special care, and attention to the appearance of the finished structure. Random location of fillers, non-modular sections, and excessive deviations from true circular segments shall be cause for rejection of the forms.
- E. The Contractor shall be fully responsible for the adequacy of formwork in its entirety. Forms shall support required loads and shall maintain their dimensional and surface correctness to produce members required by drawings.
- F. Slots, chases, recesses or other openings as shown on the drawings or as needed for the work of any other trades shall be boxed out.
- G. Box out for all temporary openings and build forms to seal them up when and as required.
- H. After sealing and immediately before the placing of reinforcing, faces of all forms in contact with the concrete shall receive a thorough coating of the liquid form releasing agent, applied in compliance with the Manufacturer's instructions.
- I. Reused forms shall be thoroughly cleaned out of dirt, debris, concrete and foreign matter. Forms shall not be reused if they have developed defects which would affect their tightness and strength or desired surface finish. Used forms shall not be used for architectural concrete.
- J. Forms shall be removed in a manner that will prevent injury to concrete. Supporting forms or shoring shall not be removed until the members have acquired sufficient strength to support their weight and any load thereon.
- K. Removal shall be in sequence as approved by the Engineer. Unless test cylinders warrant another procedure, the forms shall not be removed from members prior to the time listed in the schedule hereinafter unless otherwise directed.
- L. Bonding To Existing Surfaces: Clean existing concrete surfaces that are to have new concrete bonded thereto of all grease, oil, dust, dirt and loose particles and coat with an epoxy bonding agent just prior to placing of the new concrete. Apply the bonding agent as recommended by the manufacturer and allow the agent to become tacky before the new

concrete is placed. Do not allow the bonding agent to overlap or be spilled on the surfaces to be exposed after the work is completed.

3.06 FORM REMOVAL

- A. Maintain formwork in place for the following structural conditions until the concrete has attained the minimum percentage of indicated design compressive strength or for the period of time specified in the following table.

Note: Time periods in the table include all days except those in which the temperature falls below 40 degrees F.

<u>Structural Member or Condition</u>	<u>Normal Strength Concrete</u>	<u>Normal High-Early Strength Concrete</u>	<u>Minimum Compressive Strength for Form Removal (% Design Strength)</u>
Cantilevers	12 days	7 days	90
Over 20 feet between supports	12 days	7 days	90
Stairway	10 days	5 days	80
Floor Slabs	5 days	3 days	70
Free standing walls, column and piers	5 days	3 days	70
Walls, piers columns, sides of beams, footings slabs on grade, and vertical surfaces	24-48 hours	12-24 hours	70
Front face form of curbs	6-24 hours	6 hours	70

3.07 CONCRETE FINISHINGS

- A. Repair of Surface Defects:

1. General: Repair surface defects, including tie holes immediately after form removal. Dampen the area to be patched and an area at least 6 inches wide surrounding it to prevent absorption of water from the patching mortar. Notify the Engineer prior to commencing operations.

2. **Removal of Defective Concrete:** Remove all honeycombed and other defective concrete down to sound concrete. Cut edges perpendicular to the surface or slightly under cut. Sand blast surfaces to receive repair.
3. **Bonding Grout:** Thoroughly dampen surfaces to be patched and apply a coat of bonding grout consisting of one part cement to one part fine sand passing a No. 30 sieve and having the consistency of thick cream.
4. **Placing Patching Mortar:** After the bonding grout begins to lose its water sheen, apply a premixed patching mortar, thoroughly consolidating it into place and striking it off so as to leave the patch slightly higher than the surrounding surface. Leave mortar undisturbed for one hour to permit initial shrinkage and then finally finish.
5. **Tie Holes:** After being cleaned and thoroughly dampened, fill the tie holes solid with patching mortar.

B. Concrete Finishes:

1. **Formed Surfaces:** After removal of forms, chip off all irregular projections, grind flush with adjacent surfaces and finish concrete surfaces in accordance with the following schedule:

<u>Finish Designation</u>	<u>Area Applied</u>
F-1	Exterior walls below grade not exposed to water: Repair defective concrete, fill depressions deeper than 2 inch, and fill tie holes.
F-2	Exterior and interior walls exposed to water: Repair defective concrete, remove fins, fill depressions 3 inch or deeper, and fill tie holes.
F-3	Walls of structures of buildings exposed to view and underside of formed floors or slabs: In addition to Finish F-2, fill depressions and airholes in mortar. Dampen surfaces and then spread a slurry consisting of one part cement and one and one-half parts sand by damp loose volume on the surface with clean burlap pads or sponge rubber floats. Remove any surplus by scraping and then rubbing with clean burlap.
F-4	Tops of walls, beams and similar unformed surfaces occurring adjacent to formed surfaces: Strike smooth after concrete is placed and float to a texture reasonably consistent with that of formed surfaces.

2. Slab Surfaces:

- a. General: After concrete has been consolidated, finish all concrete slabs with a floated finish. After floating, trowel finish all concrete slabs, except for areas to receive roofing, insulation, tile or topping, and immediately light broom finish. Where a finish is not indicated, provide a troweled finish.

Finish

Designation

Area Applied

S-1	Slabs and floors not water bearing: Smooth steel trowel finish.
S-2	Slabs and floors which are water bearing and slab surfaces on which mechanical equipment moves: Steel trowel finish free from trowel marks and all irregularities.
S-3	Slabs, floors and stair treads of structures or buildings exposed to view: Steel trowel finish without local depressions or high points and apply a light hair-broom finish. Do not use stiff bristle brooms or brushes. Leave hair-broom lines parallel to the direction of slab drainage.
S-4	Slabs and floors at slopes greater than 10%: Steel trowel finish without local depressions or high points. Apply a stiff bristle broom finish. Leave broom lines parallel to the direction of slope drainage.
S-5	Exposed edges of slabs, floors and tops of walls: Finish with a 3 inch radius edge if a chamfer is not indicated.

- B. Floated Finish: After concrete has been placed, consolidated, struck off and leveled, do not work the surface further until water sheen has disappeared and the surface has hardened sufficiently to permit floating. During the first floating, check the planeness of the slab with a 10 foot straightedge applied at no less than two angles. Cut down all high spots and fill all low spots to produce a surface having the required tolerance. Then refloat the slab to a uniform sandy texture.
- C. Light Broomed Finish: After floating, power trowel slabs to receive a light broomed finish to produce a smooth surface, relatively free of defects. Before the surface sets, pass a soft broom drag over the surface to produce a surface uniform in texture and appearance.
- D. Troweled Finish: After floating, power trowel slabs to receive a troweled finish to produce a smooth surface, relatively free of defects. Hand trowel after the surface has hardened sufficiently. When a ringing sound is produced as the trowel is moved over the surfaces, perform final troweling by hand to produce a surface which is thoroughly

consolidated, free from trowel marks, uniform in texture and appearance and plane to a tolerance of 1/8 inch in 10 feet as determined by a 10 foot straightedge placed anywhere on the slab in any direction.

- E. Hardener Finish: Where indicated to receive a troweled hardener finish, water cure slabs without application of curing and sealing agent. When slab is at least 20 days old and thoroughly dry, apply the hardener in accordance with the manufacturer's recommendations. Where dry-shake hardener or slip resistant finish is required, apply the hardener or slip-resistant product prior to complete curing and finishing, in accordance with the requirements and recommendations of the product manufacturer.
- F. Saw Cut Joints: Cut joints that are to be saw cut not sooner than 2 hours after the concrete is poured and not later than 8 hours after the pour.

3.07 TESTS

- A. Compressive strength tests shall be made by breaking standard 6-inch diameter by 12-inch high test specimens prepared, cured and broken in accordance with the American Society for Testing Materials Standard Methods C-31 and C-39, latest revision. Four specimen test cylinders shall be taken from each pour of five (5) cubic yards or more. One additional test shall be taken from each thirty (30) cubic yards or fraction thereof in each pour in excess of thirty (30) cubic yards.
- B. Test specimens shall be taken from manhole bottom pours of less than five (5) cubic yards as directed by the Engineer. Test specimens shall be taken in the presence of the Engineer. One cylinder from each pour shall be broken at seven (7) days, the remainder at twenty-eight (28) days. Additional test cylinders may be ordered for determining the characteristics of a new design mix or changes in equipment or methods, and under adverse weather or curing conditions.
- C. Slump test shall be made in accordance with ASTM C143, latest revision, and shall be made with each load and at time of cylinders.
- D. The Contractor shall supply all cylinder molds, slump cones, tools and labor for preparing specimen, and shall provide clean, moist sand or burlap for curing. Cylinder shall not be shipped to the testing laboratory until the third day following preparation, and shall be protected from accidental damage at all times.
- E. The test cylinders shall be tested in a recognized commercial testing laboratory at the expense of the Contractor.

3.08 EXPANSION JOINTS, CONSTRUCTION JOINTS AND WATER STOPS

- A. Expansion Joints shall be placed as indicated on the drawings. Joint materials for surfaces exposed to water and sewage shall conform to ASTM D175, Preformed Joint Filler, non-extruding and resilient (bituminous type), thickness as shown on the drawings. Joint materials for isolation joints, slab-on-grade joints and wall joints not exposed to water

and sewage shall conform to ASTM D994, preformed expansion joint filler for concrete (bituminous type), thickness as shown on the drawings.

- B. Construction Joints shall be located in accordance with a schedule of pours which shall be prepared and submitted by the Contractor. Vertical construction joints shall be held to the minimum number consistent with good standard practice.
- C. Water Stops. Material for water stops shall be 9-inch PVC multi-rib center-bulb type for expansion joints, and 1/4" x 4" and 1/8" x 4" structural steel sheets for construction joints. PVC joint material shall be as manufactured by The Burke Company, or approved equal.

END OF SECTION

SECTION 03600

GROUT

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Provide all labor, materials, tools and equipment and perform all grouting as specified hereinafter and indicated on the Drawings.

1.02 RELATED WORK

- A. Section 03300: Cast-In-Place and Poured Concrete

1.03 SUBMITTALS

- A. Submit manufacturer's literature for review on the following items:
 - 1. Nonshrink grout data including grout properties, mixing, surface preparation and installation instructions.

1.04 DELIVERY AND STORAGE

- A. Deliver and store grouting materials in unbroken containers with seals and labels intact as packaged by the manufacturer.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Nonshrink, Nonmetallic Grout: The Burke Company's Non-Ferrous, Non-Shrink Grout, Sauereisen F-100 Level Fill, Master Builders Masterflow 713, Euclid NS Grout, or equal pre-mixed type.
- B. Nonshrink Metallic Grout: The Burke Company's Metallic Spec Grout, Master Builders Embecco 636 Grout pre-mixed type, or equal.
- C. Epoxy Grout: Sikadur 42 Grout-Pak, or equal, for grouting sleeves for anchor bolts, etc.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Clean all bonding surfaces of dust and oil.

3.02 INSTALLATION

A. Nonshrink Grout:

1. Use nonshrink, nonmetallic grout for grouting precast concrete wall panel connections, column base plates, anchor bolts, reinforcing bars, pipe sleeves, machinery supports and pump base plates. Use epoxy grout for anchor bolts, etc., where indicated on the Drawings.
2. Mix and place nonshrink grout as recommended by the manufacturer.
3. Mix grout as close to the work area as possible and transport quickly to its final position in a manner which will not permit segregation of materials.
4. Cure nonshrink grout with water saturated burlap for at least three days or with an application of Super Rez Seal cure and seal compound applied immediately after grout placement.
5. Do not operate machinery set on grout pads until the grout has cured for at least 24 hours.

END OF SECTION

DIVISION 4

MASONRY

NOT USED

DIVISION 5

METALS

SECTION 05140

STRUCTURAL ALUMINUM

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Scope of Work: The work under this Section includes fabrication and erection of structural aluminum.

1.02 QUALITY ASSURANCE

- A. Qualifications: Fabrication and erection shall be by a qualified fabricator and erector approved by the Engineer. Preparation of Shop Drawings shall not begin until the fabricator and erector have been approved.
- B. Standards: Unless otherwise specified, all materials, workmanship and practices shall conform to the current editions of the following Standards:

- 1. Florida Building Code.**

- 2. Aluminum Construction Manual, latest edition by the Aluminum Association.
 - 3. OSHA Standards.

1.03 SUBMITTALS

- A. Complete Shop Drawings, including material lists, fabrication and erection drawings shall be submitted for approval in accordance with Section 01340. Fabrication shall not be approved until the submission has been approved.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Standard Shapes, Bars & Plates:
 - 1. ASTM B 209 - Alloy 6061-T6.
 - 2. ASTM B 308 - Alloy 6061-T6.
- B. Aluminum Fasteners: Connections of aluminum to aluminum shall be of aluminum. Bolts shall meet the requirements of ASTM B316 for alloy 2024-T4. Bolts shall

have an anodic coating having a minimum thickness of .0002 inches. Nuts shall be 6061-T6. Washers shall be Alclad 2024-T4.

- C. Stainless Steel Fastenings: Connections of aluminum to stainless steel or concrete shall be stainless steel bolts of AISI Type 316.

2.02 FABRICATION

- A. Fabrication shall be in accordance with the specified standards. Size of various members and number or parts indicated on the drawings are minimum and shall be increased as necessary to meet requirements. Stairs shall comply with OSHA standards. Splices not indicated on the Drawings will not be permitted.
- B. Surface Treatment: Treatment is required only if indicated on the Drawings.

PART 3 - EXECUTION

3.01 ERECTION

- A. Erection shall be in accordance with the specified standards and as indicated on the Drawings.
- B. Where the contact of dissimilar metals may cause electrolysis or where aluminum will contact concrete, mortar or plaster, the contact surface of the metals shall be coated with a bituminous coating.**

END OF SECTION

SECTION 05500

MISCELLANEOUS METALS

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Scope of Work: This Section covers the use of miscellaneous metals, shapes and sheets, fittings, fasteners, wirework, Contractor fabricated pipe supports, etc., not specified elsewhere in these Specifications.

1.02 QUALITY ASSURANCE

- A. Standards: Unless otherwise specified, all materials, workmanship and practices shall conform to the current editions of the BOCA Building Code, OSHA Standards, AISC Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings, Code of Standard Practice, American Welding Society Code AWS D1.1, Aluminum Construction Manual and the other Standards referenced in this Section.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Steel: Miscellaneous steel plates, shapes, bars and connections shall conform to the requirements of ASTM Designation A 36 and shall be galvanized by the hot dip method after fabrication in accordance with the requirements of ASTM Designation A 123. Steel shall comply with the provisions of Section 05120.
- B. Steel Pipe: Steel pipe used for miscellaneous members and connections shall conform to the requirements of ASTM Designation A 53, Schedule 40, galvanized except as otherwise indicated.
- C. Anchor Bolts and Fasteners:
 - 1. Anchor bolts securing equipment or any assemblies subject to vibrations or movements, shall be stainless steel hook anchors conforming to ANSI 316 and ASTM A193 grade B8M, unless otherwise noted. Hook anchors shall be to the farthest layer of reinforcing. The minimum length protruding for the face of concrete shall be 6 inches and the minimum length of hook shall be 6 inches. All dimensions and sizes of anchor bolt shall comply with manufacturer's recommendations.
 - 2. Anchor bolts and fasteners not securing equipment or assemblies subject to vibration shall be stainless steel wedge or adhesive anchors conforming to ANSI 316 and ASTM A193 grade B8M, unless otherwise noted. Wedge anchors shall be as manufactured by "HILTI" or equal. Adhesive anchors

shall consist of a self-contained vinylester adhesive cartridge and anchor rods. Adhesive anchor shall be AVA adhesive anchoring system as manufactured by "HILTI", or equal.

- D. Welding Electrodes: Welding electrodes for structural steel shall conform to AWS A5.5, E70XX. Use 4043 filler metal for aluminum. Use type E308 electrode where the base metal is type 304 stainless steel and type E309 where the base metal is type 316 stainless steel or where stainless steel is welded to carbon steel. Field welding of galvanized steel shall not be acceptable.
- E. Castings: Castings for manhole frames, covers and other items shall conform to the requirements of ASTM Designation A 48, Class 30 and the details shown on the drawings. Castings shall be true to pattern in form and dimensions and free of blow holes, cracks and other pouring faults and defects. The seating surfaces between frames and covers shall be machined to fit true as not to rock or rattle. Lifting or "pick" holes shall be provided, but shall not penetrate through the cover. No plugging or filling will be allowed. If the area is subject to flooding, the castings shall be of a waterproof design with rubber gasket and stainless steel bolts to fasten lid to frame.
- F. Aluminum Stairs: Aluminum stairs shall be as indicated on the Drawings. Stairs shall be connected to the appropriate structural members. Stair members shall be constructed to support dead loads and additional live working stresses permitted for materials in BOCA Building Code. Size of various members and number of parts indicated on the Drawings are minimum, and shall be increased as necessary to meet requirements. Stairs shall comply with OSHA Standards.
- G. Aluminum Stair Treads: Aluminum stair treads shall be of the same pattern and alloys as the aluminum grating and shall have a 1¼ inch wide abrasive nosing. Aluminum bars shall have a standard mill finish.
- H. Miscellaneous Aluminum: Miscellaneous aluminum shapes, bars and plates shall be Alloy 6061-T6, except when otherwise specified.

2.02 FABRICATION

- A. Insofar as possible, fabricated material shall be fitted and shop assembled ready for erection. Welding and equipment shall conform to American Welding Society's Code for Welding in Building Construction, latest edition. All work shall be square, plumb and true, accurately fitted with tight joints and intersections. Exposed work shall be finished smooth with welds ground smooth.
- B. Painting and Protective Coating:
 - 1. All ferrous metal, except stainless steel and galvanized surfaces, shall be properly cleaned and given one shop coat of the fabricator's standard primer. Anchors that are built into masonry shall be coated with asphalt paint unless

specified to be galvanized. Metal work to be encased in structural concrete shall be left unpainted unless specified or noted otherwise.

2. Hot-dip galvanizing or zinc coatings applied on products fabricated from rolled, pressed or forged steel shapes, plates, bars and strips shall comply with ASTM Designation A 123. Hot-dip galvanizing or zinc coatings on assembled steel products shall comply with ASTM Designation A 386. The weight of coatings shall be designated in Table 1 for the class and thickness of material to be coated. Galvanized surfaces for which a shop coat of paint is specified shall be chemically treated to provide a bond for the paint. Except for bolts and nuts, all galvanizing shall be done after fabrication.
3. See Section 09900 for additional requirements.

PART 3 - EXECUTION

3.01 ERECTION

- A. Where the contact of dissimilar metals may cause electrolysis and where aluminum will contact concrete, mortar or plaster, the contact surface of the metals shall be coated in accordance with Section 09900.
- B. All work shall be adequately anchored in place a proper elevations, planes and locations.

END OF SECTION

SECTION 05520

ALUMINUM RAILINGS

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Scope of Work: The work under this section includes fabrication and erection of aluminum railings.

1.02 QUALITY ASSURANCE

- A. Standards: Unless otherwise specified, all materials, workmanship and practices shall conform to the following standards:
 - 1. BOCA Building Code.
 - 2. Occupational Safety and Health Administration Standards.

1.03 SUBMITTALS

- A. Shop Drawings and calculations for aluminum railings shall be submitted for approval in accordance with Section 01340 prior to fabrication of these items. All drawings and calculations shall bear the seal of a Professional Engineer registered in the State of Florida.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. The aluminum railing shall be 1½ inch diameter minimum nominal size aluminum pipe, (O.D.1.90 inch) alloy 6063-T6 or Alcoa alloy 6063-T832. Brackets shall be cast aluminum alloy B214. Floor flanges shall be forged aluminum, alloy 6061-T6. Brackets and flanges shall be secured to aluminum framing members with aluminum fasteners. Railings shall be fabricated in shop, made and erected square, plumb, straight and true, designed for adjustment to field variations, accurately fitted with tight joints and intersections. Fittings shall be fastened to pipe members by either inert gas shielded metal arc welding methods as per Alcoa's Welding Alcoa Aluminum, latest edition, or by internal, mechanical, self-tapping screws, combined with a stainless steel, blind, rivet-locking component fastener system. Finish shall be 1 hour anodized -#215R1. Complete railings shall conform to OSHA Standards, BOCA Building Code and Aluminum Construction Manual by the Aluminum Association.

- B. Kickplates: Aluminum kickplates where not specifically called for in the Drawings shall be furnished and installed typically at the edges of all walkways and landings. Kickplates shall be 1/4 inch plate stock (depending on the specific walkway edge detail) meeting OSHA and Standard Building Code requirements and shall project 4 inches above walkway surface. Kickplates shall not infringe on minimum required walkway width and material must be same as that of the railing construction.

2.02 FABRICATION

- A. Insofar as possible, fabricated material shall be fitted and shop assembled ready for erection. Welding and equipment shall conform to American Welding Society's Code for Welding in Building Construction, latest edition. All work shall be square, plumb and true, accurately fitted with tight joints and intersections. Exposed work shall be finished smooth with welds ground smooth.

PART 3 - EXECUTION

3.01 HANDRAILS

- A. Handrails and stair rails shall be designed to withstand a 200# concentrated load applied in any direction at any point on the top rail. Handrails and stair rails shall also be designed to withstand a load of 50#/ft applied horizontally to the top rail. The 200# load will not be applied simultaneously with the 50#/ft load. In addition, the handrails shall be designed to withstand a load of 100#/ft applied vertically downward to the top rail and simultaneously with the 50#/ft horizontal load. The 100#/ft vertical load does not apply to stair rails.
- B. The manufacturer shall submit calculations to the Engineer for approval. Testing of base castings or base extrusions by an independent lab or manufacturer's lab (if manufacturer's lab meets the requirements of the Aluminum Association) will be an acceptable substitute for calculations. Calculations will be required for approval of all other design aspects.

3.02 POST SPACING

- A. Post spacing shall be a maximum of 6'-0". Posts and railings shall be a minimum of 1½" Schedule 40 aluminum pipe alloy 6063-T6, ASTM B429 or ASTM B221. The handrail manufacturer shall show that their posts are of adequate strength to meet the loading requirements. If the manufacturer's posts are not of adequate strength, the manufacturer may reduce the post spacing or add reinforcing dowels or may do both in order to meet loading requirements.

3.03 COMPONENTS

- A. The handrail shall be made of pipes joined together with component fittings. Samples of all components, bases, toe plate and pipe must be submitted for approval. Components that are pop-riveted or glued at the joints will not be acceptable. All components must be mechanically fastened with stainless steel hardware.

3.04 POSTS

- A. Posts shall not interrupt the continuation of the top rail at any point along the railing, including corners and end terminations (OSHA 1910.23). The top surface of the top railing shall be smooth and shall not be interrupted by projecting fittings.

3.05 MIDRAIL

- A. The midrail at a corner return shall be able to withstand a 200# load without loosening. The manufacturer is to determine this dimension for their system. Provide physical tests from a laboratory to confirm compliance.

3.06 TOE PLATE

- A. Toe plate shall conform to OSHA standards. Toe plate shall be a minimum of 4" high and shall be an extrusion that attaches to the posts with clamps which will allow for expansion and contraction between posts. Toe plates shall be set 1/4" above the walking surface. Toe plates shall be provided on handrails as required by OSHA and/or as shown on drawings. Toe plates shall be shipped loose in stock lengths with premanufactured corners for field installation.

3.07 OPENINGS

- A. Openings in the railing shall be guarded by a self-closing gate (OSHA 1910.23). Safety chains shall not be used unless specially shown on the drawings.

3.08 ALUMINUM SURFACES

- A. Aluminum surfaces in contact with concrete, grout or dissimilar metals will be protected with a coat of bituminous paint, mylar isolators or other approved material.

END OF SECTION

DIVISION 6
WOOD AND PLASTICS
NOT USED

DIVISION 7

THERMAL AND MOISTURE

PROTECTION

SECTION 07190

VAPOR BARRIER

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Install vapor barrier under all floor slabs and other locations shown on the Drawings.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Vapor barrier shall be 6 mil polyethylene film or equal as approved by the Engineer.

PART 3 - EXECUTION

3.01 JOB CONDITIONS

- A. Proceed with vapor barrier work only after substrate construction and penetrating work have been completed.

3.02 PREPARATION OF SUBSTRATE

- A. Examine the substrate and the conditions under which vapor barrier work is to be performed. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.03 APPLICATION

- A. Vapor barrier shall be applied parallel with direction of concrete pour, lapping adjacent sides and ends 6 inches minimum.
- B. Seal all joints with continuous approved 2-inch wide plastic tape.

END OF SECTION

DIVISION 8
DOORS AND WINDOWS

SECTION 08710

FINISH HARDWARE

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Scope of Work: The work included in this Section consists of providing all finish hardware as herein tabulated and as shown on the Drawings.
- B. Related Work Described Elsewhere:
 - 1. Structural Aluminum Doors and Frames: Section 05140

1.02 SUBMITTALS

- A. Before ordering any hardware, samples shall be submitted of every different item of "Finish Hardware" to the Engineer for inspection as to quality, finish and design, and obtain written approval for each item before delivering any hardware. In case the samples are disapproved, other samples shall be submitted until satisfactory samples are approved.
- B. Complete Hardware Schedule of Finish Hardware shall be submitted in accordance with Section 01340 for the approval of the Engineer. Each item listed in such schedule shall be in accordance with the approved samples. Each item listed in the Hardware Schedule shall be identified with respect to manufacture, brand, catalog number, materials, finish, dimensions and operations, as well as location, operation and use in the buildings. The Engineer will check the Hardware Schedule for quality and types only, but the Contractor shall be solely responsible for any errors, omissions and conformance with the Hardware Schedule.
- C. Templates: Promptly following approval of the Hardware Schedule by the Engineer, the Contractor shall furnish and deliver template information to the fabricators of items of metal work to which finishing hardware is to be applied, and such deliveries shall be made in ample time to avoid delays in such work of said fabricators. Drawings, schedules and detailed information shall be provided to other trades as necessary for them to accommodate and prepare their work to receive the finishing.

1.03 DELIVERY, STORAGE AND HANDLING

- A. Finish hardware shall be packed in approved manufacturer's containers, complete with trimmings, bolts, screws, washers, etc., as required for application and securement. Each container shall bear a suitable label which shall state the quantity and kind of contents of said container, as well as identifying marks relating to the approved Hardware Schedule and its location in the building.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Butt Hinges: Hager, Lawrence or Stanley
 - 1. Provide all doors with 1 ½ pair stainless steel ball bearing hinges 4½" x 4½", US32D finish, except as otherwise indicated, and except as otherwise needed for proper support or operation of doors. Provide stainless steel pins, non-removable.
- B. Lock/Hatch sets including cylinders: Russwin, Sargent, Yale or Schlage.
- C. Panic Hardware: Russwin, Sargent, Von Duprin or Yale.
- D. Door Bolts: Corbin, Russwin, Sargent, Stanley, or Von Duprin.
- E. Strikes: Wrought box strikes, with extended lip for latch bolts. Provide dust proof strike for foot bolt.
- F. Locks: Equip lock sets with 6 pin tumbler type lock cylinders, combined with a dead bolt, similar to Schlage H/locks. All locks to be in a masterkey system designated by owner. Provide 6 change keys for each lock.
- G. Overhead Closers: LCN, Norton, Russwin, or Sargent.
- H. Holders, Stops, Bumpers: Baldwin, Brookline, Stanley, Eaton, or Glynn Johnson. Size and mount units to comply with manufacturer's recommendations for exposure condition. Reinforce substrate as recommended.
- I. Thresholds: Brookline, Pemco, Rixson, Von Duprin or Zero.
 - 1. Stainless steel, standard groove thread, height to be within A.D.A. tolerances.
- K. Door Stripping and Seals: Accurate, B. Brass WKS, Argil J. May, Pemco or Zero.
 - 1. Provide type recommended by manufacturer for condition of exposure, with easily replaceable resilient stripping elements. On fire rated doors provide type for use with rating. Provide weatherstripping at sill of each exterior door, threshold contact type.

2.02 MATERIALS

- A. Hardware Requirements:

1. All hardware shall be new and free from defects affecting serviceability or appearance. All working parts shall be well fitted and smooth working. All hardware shall be made of aluminum or stainless steel materials.
 2. Hardware application to metal shall be made to standard templates. Template information shall be furnished to door and frame fabricators and other trades requiring same, in order that they may cut, reinforced or otherwise shop prepared for receiving hardware. The Contractor shall be fully responsible for checking all details such as wall trim clearance, levels, rabbets, backsets, etc., in order that all items of hardware shall fit properly.
 3. Complete locksets shall be supplied from a single manufacturer.
 4. Hardware shall be furnished complete with all fastening.
 5. Box strikes for all metal frames shall be furnished.
 5. Finishes shall be US32D, Satin Stainless Steel, except where noted otherwise.
- B. Hardware Schedule. All door sizes, materials, swings, etc. shall be coordinated with the door schedule and floor plans. Total quantities required shall be determined from the Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation of finish hardware shall be per manufacturer's recommendations.

END OF SECTION

DVISION 9

FINISHES

SECTION 09905
PIPING, VALVE AND EQUIPMENT IDENTIFICATION SYSTEM

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. The work included under this Section consists of providing an identification system for piping systems and related equipment.

1.02 QUALITY ASSURANCE

- A. Standards: ANSI Standard A13.1, Scheme for Identification of Piping Systems

1.03 SUBMITTALS

- A. Submit manufacturer's descriptive literature, illustrations, specifications and other pertinent data.

- B. Schedules:

- 1. Provide a typewritten list of all tagged valves giving tag color, shape, letter code and number, the valve size, type, use and general location.
- 2. Provide a complete list of materials to be furnished and surfaces on which they will be used.

- C. Samples:

- 1. Provide a sample of each type valve tag supplied.
- 2. Provide a sample of each type of identification tape supplied.
- 3. Provide manufacturer's color charts for color selection by Engineer.

1.04 PRODUCTS, DELIVERY, STORAGE, AND HANDLING

- A. Delivery of Materials: Except for locally mixed custom colors, deliver sealed containers with labels legible and intact.

- B. Storage of Materials:

- 1. Store only acceptable project materials on project site.
- 2. Store in suitable location.

3. Restrict storage to paint materials and related equipment.
4. Comply with health and fire regulations.

1.05 JOB CONDITIONS

A. Environmental Requirements:

1. Comply with manufacturer's recommendations as to environmental conditions under which coatings and coating systems can be applied.
2. Do not apply finish in areas where dust is being generated.

B. Protection: Cover or otherwise protect finished work of other trades and surfaces not to be painted.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Materials for painting shall conform to requirements of Section 09100.

B. Materials selected for coating systems for each type surface shall be the product of a single manufacturer.

C. Aboveground piping shall be identified by self-adhesive pipe markers equal to those manufactured by W.H. Brady Company or equal.

1. Markers shall be of wording and color as shown in Table 09905-B.

2. Lettering shall be:

a. 23 inches high for pipes 3 inches diameter and larger.

b. 1-1/8 inches high for pipes less than 3 inches diameter.

3. Flow arrows shall be:

a. 23 inches by 6 inches for pipes 3 inches diameter and larger.

b. 1-1/8 inches by 3 inches for pipes less than 3 inches diameter.

D. Buried piping shall be identified by identification tape installed over the centerline of the pipelines.

1. Identification Tape for Ductile Iron Pipe: Identification tape shall be manufactured of inert polyethylene so as to be highly resistant to alkalis, acids, or other destructive agents found in soil, and shall have a minimum thickness of 4 mils. Tape width shall be 6 inches and shall have background color specified below, imprinted with black letters. Imprint shall be as specified below and shall repeat itself a minimum of once every 2 feet for entire length of tape.
2. Identification Tape for Polyvinyl Chloride Pipe: Identification tape shall be manufactured of polyethylene with a minimum thickness of 4 mils and shall have a 1 mil thick metallic foil core. The tape shall be highly resistant to alkalis, acids, and other destructive agents found in soil. Tape width shall be 3 inches and shall have background color specified below, imprinted with black letters. Imprint shall be as specified below and shall repeat itself a minimum of once every 2 feet for entire length of tape.
3. Tape background colors and imprints shall be as follows:

<u>Imprint</u>	<u>Background Color</u>
"Caution-Caution-Raw Water Line Buried Below"	Dk Blue
"Caution-Caution-Potable Water Line Buried Below"	Lt Blue
"Caution-Caution-Chlorine Solution Line Buried Below"	Yellow
"Caution-Caution-Reclaimed Water Line Buried Below"	Lavender
"Caution-Caution-Sewer Line Buried Below"	Green

4. Identification tape shall be "Terra Tape" as manufactured by Reef Industries, Inc. Houston, TX, (800) 231-6074; Allen Systems, Inc., Wheaton, IL (800) 323-1749; or approved equal.
- E. Aboveground Valve Identifications: On all valves, the Contractor shall provide a coded and numbered tap attached with brass chain and/or brass "S" hooks.
1. Tag Types: Tags for valves on pipe shall be brass or anodized aluminum. Colors for aluminum tags shall, where possible, match the color code of the pipe line on which installed. Square tags shall be used to indicate normally closed valves and round tags shall indicate normally open valves.
 2. Coding: In addition to the color coding, each tag shall be stamped or engraved with wording or abbreviations to indicate the valve service and number. All color and letter coding shall be approved by the Engineer. Valve service shall either be as listed or by equipment abbreviations if

associated with a particular piece of equipment. Valve numbering, shall be as approved by the Engineer and/or Owner.

- F. Buried valves shall have valve boxes protected by a concrete pad. The concrete pad for the valve box cover shall have a 3 inch diameter, bronze disc embedded in the surface as shown on the Drawings. The bronze disc shall have the following information neatly stamped on it:
1. Size of valve, inches
 2. Type of valve: Valve numbers shall be as approved by the Engineer and/or Owner and valve number shall follow the valve type as listed below:
 - a. GV - Gate Valve
 - b. BFV - Butterfly Valve
 3. Valve Service - See Table 09200-B for abbreviations
 4. Number of turns to fully open
 5. Direction to open
 6. Year of installation

PART 3 - EXECUTION

3.01 COLOR CODING FOR PIPES AND EQUIPMENT

- A. Piping color codes, and code labels for pipe identification shall conform to Table 09905-B.
- B. General Notes and Guidelines:
1. Pipelines, equipment, or other items which are not listed here shall be assigned a color by the Owner and shall be treated as an integral part of the Contract.
 2. Color coding shall consist of color code painting and identification of all exposed conduits, through lines and pipelines for the transport of gases, liquids, or semi-liquids including all accessories such as valves, insulated pipe coverings, fittings, junction boxes, bus bars, connectors and any operating accessories which are integral to a whole functional mechanical pipe and electrical conduit systems.

3. All moving parts, drive assemblies, and covers for moving parts which are potential hazards shall be Safety Orange.
 4. All safety equipment shall be painted in accordance with OSHA standards.
 5. All inline equipment and appurtenances not assigned another color shall be painted the same base color as the piping. The pipe system shall be painted with the pipe color up to, but not including, the flanges attached to pumps and mechanical equipment assigned another color. Pumps and other mechanical equipment shall be painted gray unless otherwise specified. Motors shall be painted white unless otherwise specified.
 6. All pipe hangers and pipe support floor standards shall be painted with an epoxy coating. Where the contact of dissimilar metals may cause electrolysis and where aluminum will contact concrete, mortar or plaster, the contact surface of the metals shall be coated with coal tar epoxy.
- C. All hangers and pipe supports floor and accessory stands shall be painted to match their piping. The system shall be painted up to, but not including, the face of flanges or the flexible conduit connected to electrical equipment. Structural members used solely for pipe hangers or supports shall be painted to match their piping. Where the contact of dissimilar metals may cause electrolysis and where aluminum will contact concrete, mortar or plaster, the contact surface of the metals shall be coated in accordance with coal tar epoxy.
- D. All systems which are an integral part of the equipment, that is originating from the equipment and returning to the same piece of equipment, shall be painted between and up to, but not including, the face of flanges or connections on the equipment.
- E. All insulated surfaces, unless otherwise specified, shall be given one coat of glue sizing, one prime coat and one finish coat.
- F. System code lettering and arrows shall conform to the requirements of ANSI A 13.1 marked on piping as follows:

Table 09905-A

<u>Key to Classification of Predominant Colors for Piping</u>		<u>Code of Letters, if not otherwise specified</u>
(F) Fire Protection:	Red	White
(D) Dangerous:	Yellow	Black
	Orange	Black
(S) Safe:	Green	Black
	White	Black
	Black	White
	Light Gray	Black
	Dark Gray	White
	Aluminum	Black
(P) Protective:	Blue	White

2. Markers shall be placed no more than 20 feet apart with at least one marker on every straight run and additional markers at turns and where pipe passes through walls.
3. An arrow indicating direction of flow shall be placed adjacent to each marker.
4. All paint shall be Tnemec high solids epoxy.

3.02 FABRICATED EQUIPMENT

- A. Unless otherwise indicated or specifically approved, all fabricated equipment shall be shop primed and finished. See Section 09100 - Painting.
- B. The Contractor shall be responsible for and take whatever steps are necessary to properly protect the shop prime and finish coats against damage from weather or any other cause.
- C. Where specified in other sections of these specifications for mechanical equipment, the Contractor shall apply field coat or coats of paint in accordance with Section 09100. If shop finish coat is unsatisfactory due to poor adhesion or other problems with primer or finish coats, coatings shall be removed and replaced by sandblasting, priming and finishing.
- D. Wherever fabricated equipment is required to be sandblasted, the Contractor shall protect all motors, drives, bearings, gears, etc., from the entry of grit. Any equipment found to contain grit shall be promptly and thoroughly cleaned.

Equipment contaminated by grit in critical areas, such as bearings, gears, seals, etc., shall be replaced at no cost to the Owner.

3.03 INSTALLATION OF IDENTIFICATION TAPE

- A. Identification tape shall be installed for all buried potable water lines and sludge lines in accordance with the manufacturer's installation instructions and as specified herein.
- B. For potable water mains, identification tape shall be installed 1 foot below final grade over centerline of pipe.

3.04 BURIED VALVES

- A. In paved areas, tops of valve box covers shall be set flush with pavement. Following paving operations, a 18 inch square shall be neatly cut in the pavement around the box and the paving removed. The top of the box shall then be adjusted to the proper elevation and a 18 inch square by 6 inch thick concrete pad poured around the box cover. Concrete pads in traffic areas shall be reinforced with No. 4 reinforcement bars as shown on the Drawings. Concrete for the pad shall be 3,000 psi compressive strength.
- B. In unpaved areas, tops of valve box covers shall be set 0.20 foot above finished grade. After the top of the box is set to the proper elevation, a 18 inch square by 6 inch thick concrete pad shall be poured around the box cover. Concrete for the pad shall be 3,000 psi compressive strength.
- C. The bronze, valve identification disc shall be embedded in the concrete pad.

Table 09905 - B
COLOR CODES AND ABBREVIATIONS

ABBREVIATION	SERVICE	CONDUIT, PIPE, AND VALVE COLOR CODE	LETTER AND FLOW ARROW COLOR
RW	Raw Water	Dark Blue	White
WW	Wastewater	Gray	Black
PW	Potable Water	Light Blue	Black
D	Drain/Sludge	Brown	White
CS	Chlorine Solution	Yellow	Black
CGV	Chlorine Gas (Vacuum)	Yellow	Black

ABBREVIATION	SERVICE	CONDUIT, PIPE, AND VALVE COLOR CODE	LETTER AND FLOW ARROW COLOR
CGP	Chlorine Gas (Pressure)	Yellow w/Black 6" Bands Spaced 4' o.c.	Black
	Electrical Conduit w/Conductors Over 120 volts	Black w/ Yellow 6" Bands Spaces 5' o.c.	N/A
	Electrical Conduit w/Conductors 120 volts or less	Interior-Match adjacent wall or equipment color Exterior Gray	N/A
NPW	Non-Potable Water	Lavender	Black

END OF SECTION

DIVISION 10
SPECIALITIES
NOT USED

DIVISION 11

EQUIPMENT

NOT USED

DIVISION 12
FURNISHINGS
NOT USED

DIVISION 13
SPECIAL CONSTRUCTION
NOT USED

DIVISION 14
CONVEYING SYSTEMS
NOT USED

DIVISION 15
MECHANICAL

SECTION 15000

MECHANICAL - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. The Contractor shall furnish and install complete and ready for use, all the equipment, machinery, apparatus, motors, drives, tools, meters, charts and other accessories, and shall perform such operations and tests, all as specified herein, and as indicated on the drawings.
- B. The materials of construction of all equipment furnished and permanently installed on the project shall be of best quality. The workmanship of construction, finish and fit shall be equal to the highest industry standards. All equipment and/or components thereof shall be new, and shall not have been in service at any other installation.
- C. The desired standard of quality for each item of equipment is established by reference on the drawings and in the specifications to specific manufacturer's products. Materials of construction and/or fabrication shall equal or exceed the standard of the referenced product. The Contractor's attention is called to Article 1.06.

1.02 EQUIPMENT WARRANTY

- A. All mechanical and electrical equipment, together with devices of whatever nature and all components, which are furnished and/or installed by the Contractor shall be guaranteed against manufacturing and/or design inadequacies, materials and workmanship not in conformity with the paragraph above, improper assembly, hidden damage, failure of devices and/or components, excessive leakage or other circumstances which would cause the equipment to fail under normal design and/or specific operating conditions for a period of two years or such longer period as may be shown and/or specified from and after the date of acceptance of the equipment by the Owner. Each piece of equipment, device or components thereof which shall fail within the above specified term of the guarantee shall be replaced and installed with reasonable promptness by the Contractor without cost to the Owner.
- B. Rotating machinery shall be designed and fabricated to provide satisfactory operation without excessive wear and without excessive maintenance during its operating life. Rotating parts shall be statically and dynamically balanced and shall operate without excessive vibration.
- C. On all equipment ample mean of lubrication shall be provided for all bearings and other metal parts in sliding contact.

- D. The minimum design criteria for lubrication of moving parts of the equipment shall include one week of continuous operation during which no lubricants shall be added to the system. The system shall also be designed to receive lubricants whether in operation or shut down, and shall not leak or waste lubricants under either condition. The manufacturer's recommendations of grade and quality and a supply of lubricants so recommended in quantities sufficient to conduct startup and testing operations shall be furnished with the equipment. Alemite industrial-type fittings, or equal, shall be used for grease lubrication except as noted.

1.03 SPECIAL TOOLS

- A. Special tools, wrenches and thickness or depth gauges required for removing parts and for making adjustment shall be included with each item of equipment having wearing parts and requiring repairs or adjustments. All accessories such as indicating gauges, indicators and lubrication devices necessary for the proper maintenance and operation of the equipment shall be furnished, stored safely at the site of the work and delivered to the Owner after the equipment is accepted.

1.04 SAFETY REQUIREMENTS

- A. Screens, guards or cages shall be provided for all exposed, rotating or moving parts in accordance with accepted practices of applicable governmental regulatory agencies.

1.05 NAMEPLATES

- A. Each major component of equipment shall have the manufacturer's name, catalog and/or model number, and serial number on a corrosion-resistant plate securely attached to the item of equipment.

1.06 INITIAL OPERATION AND TESTS

- A. Upon completion of all the mechanical work, in a manner satisfactory to the Engineer, the Contractor shall designate a day for initial testing of the equipment. Prior to such completion date, the Contractor shall give the Owner seven (7) days notice thereof in writing, and the Owner will then appoint the personnel which will operate the plant equipment, and on the test day designated, the Contractor shall make the initial test to determine the performance using the personnel designated by the Owner and such personnel of his own as is specified or as he deems necessary to complete the tests.
- B. The initial tests shall be limited to a period of twenty-four (24) hours duration and during this time the mechanical performance of all equipment shall be tested and demonstrated by the Contractor. If the demonstration and tests indicate satisfactory mechanical performance in the operation of the equipment, the Contractor will then be given a three (3) day notice by the Engineer to make a final guarantee test of the plant equipment under normal operation. During the initial tests and the three (3)

day period between the initial tests and the final tests, the Contractor's personnel shall supervise the operation of the plant equipment, assist and train the Owner's operating personnel in their duties. Experts on equipment installation and operation, as specified or necessary as well as complete, written, detailed erection, operation and maintenance instructions, shall be furnished by the Contractor to insure proper training and instruction of the Owner's personnel. A minimum of six complete sets of operation and maintenance instructions shall be provided.

- C. The final guarantee tests shall be for a period of twenty-four (24) hours duration, except as otherwise provided, and shall be made at the conclusion of the three (3) day period of operation and training. These tests shall be made under normal operating conditions under the supervision of the Contractor's personnel. This test is for the purpose of demonstrating that all performance and efficiency guarantees of the equipment and other requirements in compliance with these specifications have been met, that the operation of all equipment is coordinated and that all controls operate satisfactorily in coordination with the equipment installed.
- D. In the event the initial or final guarantee testing and demonstration of equipment and controls does not meet the guarantee conditions or is not demonstrated to the satisfaction of the Engineer, the Contractor shall, at his own expense, make such changes and adjustments in the equipment which he deems necessary and shall conduct further tests until full satisfaction is indicated by the Engineer and written certification is received thereof.

1.07 SHOP PAINT

- A. All ferrous metal on plant equipment, unless otherwise specified or directed by the Engineer, shall receive shop paint compatible with field costs provided by the Contractor, in accordance with the requirements of the section of the specifications entitled, "Painting and Special Coatings in Part A of Technical Specifications.

PART 2 - MATERIALS AND EQUIPMENT

2.01 EQUIPMENT

- A. Equipment Requiring Variations from Structures Shown on the Plans
- B. It is the intent that the Contractor shall furnish equipment which may be installed and shall operate properly in the structure as shown. Should the Contractor select alternate equipment resulting in an alteration to, addition to, enlargement of, or any other changes from the lines, dimensions and grades shown on the drawings, the Contractor shall make such changes or alterations as are required and no additional payment will be made by the Owner for changes in structures occasioned by the selection of alternate equipment. All such variations shall be subject to review and acceptance by the Engineer.

- C. Equipment requiring supplemental services in addition to those shown or specified in order to fulfill the operating objectives and including additional mechanisms, operating steps and/or controls as compared with specified equipment will not be acceptable.

END OF SECTION

SECTION 15400

FUEL STORAGE AND PIPING SYSTEMS

PART 1 - GENERAL

1.01 SCOPE OF WORK:

- A. All work of this section shall be governed by all provisions of the general, supplementary and special conditions of these specifications and the drawings.
- B. Submit manufacturer's data for review before any work is commenced.

PART 2 - PRODUCTS

2.01 Provide valves and specialties as specified under additional Sections of this Specification.

2.02 Pipe: The following schedule covers materials unless otherwise specified under a particular System Section.

A. Material:

- 1. Black steel pipe, Schedule 40, ASTM A53, A120
- 2. Copper tube, Type L, hard drawn, ASTM B88.
- 3. Brass pipe or tube.
- 4. Copper tube, Type L, soft temper, ASTM B88
- 5. All flexible joints shall be U.S. labeled.
- 6. All below grade piping shall be dual wall containment pipe.

2.03 Fittings: Make joints and connections permanent and watertight.

- A. Threaded Steel Pipe Malleable iron 150 lb. banded, black steel to match pipe.
- B. Copper Tube (Hard Drawn): Wrought or cast brass solder joint.
- C. Copper Tube (Soft Temper): Flare.

2.04 Fuel Oil Pump:

- A. See schedule on the drawings for sizes and capacity, (if applicable).

- B. Unit shall be U.S. labeled for fuel oil service.
- C. Submersible, direct drive 1/3 horsepower explosion proof construction.
- D. Pump shall have check valve, air eliminator, expansion relief valve, syphon nozzle and venturi, syphon check valve and pressure test screw.
- E. The entire pumping unit shall be removable from standard manway provided on underground tank.

2.05 SECONDARY CONTAINMENT FUEL STORAGE TANKS

- A. The Insulated Secondary Containment Aboveground Storage Tank Systems for No underline Flammable and Combustible Liquids, Protected Type: Vehicle Impact Protected, and Projectile Resistant shall be tested to and listed for the following:
 1. UL – 142, aboveground steel tanks for flammable and combustible liquids.
 2. UL – 2085, two-hour furnace fire test and two hour simulated pool fire test for insulated and protected tanks.
 3. UL – 2085 and UFC Test Standard (Article 79 or APPENDIX #A-II-F-1), for both Vehicle Impact Protection Resistance.
 4. UL – 2085, Protected aboveground tanks for flammable and combustible liquids.
 5. UL – 2085, Non-Metallic Secondary Containment protected tanks for flammable and combustible liquids with secondary containment Emergency Venting by “Form of Construction”.
 6. CAN/ULC – S601 (ORD – 142.18), Standard for shop fabricated steel aboveground horizontal tanks for flammable and combustible liquids.
 7. CAN/ULC – S655 (ORD – C 142.16), Standard for protected aboveground tank assemblies for flammable and combustible liquids.
 8. CAN/ULC – (ORD – C 142.5), Standard for concrete encased aboveground tank assemblies for flammable and combustible liquids.
 9. CAN/ULC – (ORD – C 142.16), the furnace burn requirements for two hour fire rating.
 10. CAN/URL – (ORD – C 142.25), the open (pool) fire testing for two-hour flammable liquid fire test.
 11. CAN/ULC – (ORD – 142.23), for aboveground tanks for used oil.

12. The requirement for Uniform Fire Code (UFC) for two-hour (firewall) test.
 13. To be tested and certified by the California Air Resources Board (CARB) for Balanced Phase 1 and Phase II Vapor Recovery including methanol and ethanol.
- B. The primary steel tank shall be rectangular in shape and have continuous welds on all exterior seams, manufactured in accordance with UL listing requirements and UL Standard 142.
 - C. The primary steel tank shall be pressure tested at 5 psig for 24 to 48 hours.
 - D. The primary steel tanks shall have “emergency vent” system as per NFPA 30 Code requirements.
 - E. The protected and insulated AST systems shall have a thru-tank leak detector tube to allow for physical checkup and monitoring capability between the primary and the secondary containment.
 - F. The primary steel tank shall be pressurized at 5 psig during concrete encasement.
 - G. The outer surface of the primary steel tank shall be covered by a minimum of ¼” thick (6.4 mm) Styrofoam insulation panels.
 - H. The secondary containment shall consist of a 30 Mil thick (0.76 mm) High Density Polyethylene membrane enclosing the steel tank and insulation material.
 - I. The primary steel tank and the secondary containment shall be encased in 6 inches of monolithic reinforced concrete, with minimum design strength of 4,000 and 5,000 psi at 28 days depending on the tank size. The concrete design shall include the following for long term durability; air entrainment, water reducing admixture, and steel reinforcement. Concrete encasements with seams will not be approved.
 - J. The protected and insulated AST systems shall be of concrete exterior and a continuous and visually verifiable monolithic (seamless) pour on top, bottom, ends and sides and contain no cold joints or heat sinks (heat transfer points). The AST must be shop fabricated and tested in accordance with the UL listings. Designs that use two layers of steel with insulation material between them will not be approved.
 - K. No steel or insulating material shall come in contact with the concrete or other corrosive material.
 - L. All openings shall be from the top only.
 - M. All exposed metal with the exception of stainless steel must be powder coated to inhibit corrosion.

- the
- N. The protected and insulated AST systems shall include a 7 or 15 gallon powder coated or stainless steel, UL listed spill containment, and shall include normally closed valve to release spilled product into the primary steel tank. Spill containment which route spilled product into interstitial area will not be approved.
 - O. The protected and insulated AST systems shall have a coated concrete exterior to resist weather and reflect sunlight. Models with steel exteriors will not be approved.
 - P. The protected and insulated AST systems shall have a warranty of 30 years.
 - Q. The protected and insulated AST systems design shall have been in use for a minimum of eighteen (18) years. The manufacturer must stipulate no reportable AST containment system failure in 28,000 units produced.
 - R. The protected and insulated AST systems shall have two (2) bolts for connecting grounding conductors for lighting protection in accordance with NFPA 780.

PART 3 - EXECUTION

3.01 GENERAL:

- A. The design drawings are generally diagrammatic. They do not show every bend, offset, elbow or other fitting which may be required in the piping for installation in the space allotted. Careful coordination of the work is necessary to avoid conflicts.

3.02 ABOVE GROUND STORAGE TANKS:

- A. Tanks shall have the capacity and dimensions of those shown on the drawings or described in the specifications.
- B. Tank foundation shall adequately support the weight of the storage tank while full.
- C. Tank foundation shall be smooth and level, two (2) layers of 30# roofing felt shall be installed between the tank base and concrete foundation.
- D. All tanks shall be furnished with a shop coat of primer. Certification shall be provided that the shop primer is compatible with the coating system specified in Section 09900. Tanks shall be coated with the applicable painting system.

3.03 JOINTING PIPE:

- A. Threaded Pipe Ream all pipe after cutting and before threading. Use non-hardening pipe compound "Tite-Seal", or equal, on male threads only.
- B. Copper Tube: Ream all pipe after cutting, clean and tin end to be soldered.

- C. Provide nipples of same material and weight as pipe used. Provide extra strong nipples when length of unthreaded part of standard weight nipple is less than 1½".
- 3.04 Screw bushings are prohibited, except where available space prevents use of reducing couplings. Pipe reductions on horizontal piping shall be made with eccentric reducers. Top of piping shall be flat for venting. The bottom of vent and return lines shall be flat for drainage.
- 3.05 EQUIPMENT CONNECTIONS:
- A. Make connections between any piece of equipment and any piping system in this Section of the specifications by mean of unions, flange joints or other fittings which permit equipment to be disconnected and removed for maintenance.
 - B. Install valves or cocks in supply lines to each piece of equipment on supply side of union connections.
- 3.06 TESTS:
- A. Apply a pressure test to all parts of the system before the piping is concealed and before equipment is connected. Use a hydrostatic pressure of not less than 100 psig, applied to the system for a period of four hours. There shall be no leaks at any point in the system at this pressure.
 - B. Level concealed work uncovered until required tests have been completed, but if necessary, make tests on portions of the work and those portions of the work may be concealed after being inspected and approved. Make repairs of defects that are discovered as a result of inspection or tests with new materials. Caulking of screwed joints, cracks or holes will not be accepted. Repeat tests after defects have been eliminated.
 - C. Complete all field testing prior to insulation, wrapping and/or backfill.
 - D. Tanks shall be tested and installed using pea gravel or approved alternate backfill material in accordance with manufacturer's current installation instructions, and as shown on the drawings.
- 3.07 PIPE PROTECTIONS:
- A. Underground piping shall be dual wall non-metallic pipe.
 - B. Wrap fuel oil pipe that touches metal or is exposed to masonry with a layer of 6 mil polyethylene film.
 - C. Spirally wrap all pipe lines embedded in concrete with two layers of 30 lb. felt.
- 3.08 Underground piping shall have a minimum cover of 24".

- 3.09 Place color coded 6" wide 0.004" thickness polyethylene printed plastic identification tape directly above all underground piping systems approximately 12" below finished grade. Tapes shall be continuously printed with "CAUTION" in large bold letters. Printed second line with type of service below. Orange tape is to be used for fuel oil.
- 3.10 Installing contractor shall have valid Specialty Tank Contractor License.

END OF SECTION

DIVISION 16
ELECTRICAL

SECTION 16015
ELECTRICAL REFERENCE SYMBOLS

PART 1 - GENERAL

1.01 SYMBOLS

- A. The foregoing "General Requirements" form a part of this contract and all the requirements set forth shall be binding upon this subcontractor.
- B. In general the symbols used on the drawings conform to the Standard Symbols of the Institute of Electrical and Electronic Engineers with the exception of special systems or agencies as hereinafter noted.
 - 1. Special Symbols as shown in schedules or legends.

1.02 ABBREVIATIONS

- A. The following abbreviations or initials are used.

A/C	Air Conditioning
AC	Alternating Current
AFF	Above Finished Floor
AFG	Above Finished Grade
AHU	Air Handling Unit
AIC	Amps Interrupting Capacity
AMP	Ampere
ANSI	American National Standards Institute
ATS	Automatic Transfer Switch
AUX	Auxiliary
AWG	American Wire Gauge
C	Conduit
CB	Circuit Breaker
CBM	Certified Ballast Manufacturers

Clg	Ceiling
COND	Conductor
Conn	Connection
CT	Current Transformer
CU	Copper
DO	Draw Out
DN	Down
DPST	Double Pole Single Throw
EC	Electrical Contractor
EMT	Electric Metallic Tubing
EO	Electrically Operated
FLA	Full Load Amperes
FM	Factory Mutual
FT	Feet
GFI	Ground Fault Interrupting
Gnd	Ground
Horiz	Horizontal
Hp	Horsepower
Hr	Hour
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society
In	Inches
IPCEA	Insulated Power Cable Engineers Association
JB	Junction Box

KV	Kilovolt
KVA	Kilo-Volt-Amps
KW	Kilowatts
LBS	Pounds
Max	Maximum
MCB	Main Circuit Breaker
MCP	Motor Circuit Protector
Min	Minimum
MLO	Main Lugs Only
MTD	Mounted
N	Neutral
NEC	National Electric Code
NECA	National Electrical Contractors
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIC	Not in Contract
NF	Non-Fused
No	Number
/O	Phase
OL	Overload
OLS	Overloads
OSHA	Occupational Safety and Health Act
P	Pole
PB	Pullbox

PNL	Panel
PR	Pair
Pri	Primary
PT	Potential Transformer
PVC	Polyvinal Chloride
RMS	Root-Means-Square
Recept.	Receptacle
SCA	Short Circuit Amps
SH	Shielded
S/N	Solid Neutral
SPST	Single Pole Single Throw
SW	Switch
SWBD	Switchboard
TEL	Telephone
TYP	Typical
T/P	Twisted Pair
Temp	Temperature
UL	Underwriters Laboratories
V	Volt
W	Wire
WP	Weatherproof

SECTION 16110

RACEWAYS AND CONDUITS

Part 1 - GENERAL

1.01 DESCRIPTION OF WORK.

Extent of raceways is indicated by drawings and schedules. Types of raceways in this section include the following:

- Electrical Metallic Tubing
- Flexible Metal Conduit
- Intermediate Metal Conduit
- Liquid-Tight Flexible Metal Conduit
- Rigid Metal Conduit
- Rigid Nonmetallic Conduit
- Surface Metal Raceways

NEMA Compliance. Comply with applicable requirements to NEMA standards pertaining to raceways.

UL Compliance and Labeling. comply with provisions of UL safety standards pertaining to electrical raceway systems; and provide products and components which have been UL listed and labeled.

NEC Compliance. Comply with requirements as applicable to construction and installation of raceway systems.

1.02 - METAL CONDUIT AND TUBING

General. Provide metal conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) for each service indicated. Where types and grades are not indicated, provide proper selection determined by installer to fulfill wiring requirements, and comply with applicable portions of NEC for raceways.

Rigid Steel Conduit. FS WW-C-0581 and ANSI C80.1.

Rigid Metal Conduit Fittings. FS W-F-408.

Use Type 1 Fittings for rain-tight connections.

Use Type 1 Fittings for concrete tight connections.

Use Type 3 Fittings for other miscellaneous connections.

Electrical Metallic Tubing (EMT). FS WW-C-563 and ANSI C80.3.

NOTE: IN GENERAL EMT RACEWAYS SHALL NOT BE USED ON THIS PROJECT

EMT Fittings. FS W-F-408.

Use Type 1 Fittings for rain-tight connections.

Use Type 2 Fittings for concrete tight connections.

Use Type 3 Fittings for other miscellaneous connections.

Flexible Metal Conduits. FW WW-C-566, of the following type:

Type 2. Zinc-coated steel

Flexible Metal Conduit Fittings. FS W-F-406, Type 1, Class 1, and Style A.

Liquid-Tight Flexible Metal Conduit. Provide liquid-tight flexible metal conduit; construct of single strip, flexible, continuous, interlocked, and double-wrapped steel; galvanized inside and outside; coat with liquid-tight jacket of flexible polyvinyl chloride (PVC).

1.03 - WIREWAYS

General. Provide electrical raceways of types, grades, sizes, weights (wall thicknesses), number of channels, for each type service indicated. Provide complete assembly of raceway including, but not necessarily limited to, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps and other components and accessories as needed for complete system. Where types and grades are not indicated, provide proper selection as determined by installer to fulfill wiring requirements, and comply with applicable provisions of NEC for electrical raceways.

PART 2 - PRODUCTS

2.01 INSTALLATION OF ELECTRICAL RACEWAYS

Install electrical raceways where indicated; in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA "Standard of Installation", and comply with recognized industry practices.

Coordinate with other work, including metal can concrete deck work, as necessary to interface installation of electrical raceways and components with other work.

Coat under floor metal raceways with bitumastic type protective coating prior to placing concrete.

Level and square raceway runs, and install at proper elevations/heights.

Complete installation of electrical raceways before starting installation of cables/wires within raceways.

Install PVC-coated conduit and fittings in highly corrosive atmospheres, and elsewhere as indicated.

Install flexible conduit for motor connections, and for other electrical equipment connections where subject to movement and vibration.

Install liquid-tight flexible conduit for connection of motors and for other electrical equipment where subject to movement and vibration, and also where subject to one or more of the following conditions:

Exterior location, moist or humid atmosphere where condensate can be expected to accumulate, corrosive atmosphere, subjected to water spray, subjected to dripping oil, grease, or water.

Where ever possible, install horizontal raceway runs above water and steam piping.

END OF SECTION

SECTION 16120

WIRES AND CABLES

Part 1 - GENERAL

1.01 Description of Work:

Extent of electrical wire and electrical cable work is indicated by drawings and schedules.

Types of wire, cable and connectors in this section include the following:

- Copper Conductors
- Tab Type Connectors
- Split-Bolt Connectors

Applications for wire, cable and connectors required for project as follows:

- Power Distribution circuitry
- Lighting Circuitry
- Appliance and Equipment circuitry
- Motor-Branch Circuitry

PART 2 QUALITY ASSURANCE

2.01 - NEC Compliance.

Comply with NEC as applicable to construction and installation of electrical wire, cable and connectors.

UL Compliance. Comply with UL standards pertaining to wire, cable and connectors.

UL Labels. Provide electrical wires, cables and connectors which have been UL listed and labeled.

NEMA/ICEA Compliance. Comply with applicable portions of NEMA/Insulated Cable Engineers Association standards pertaining to material, construction and testing of wire and cable.

ANSI/ASTM. Comply with applicable portions of ANSI/ASTM standards pertaining to construction of wire and cable.

PART 3 EXECUTION

3.01 Acceptable Manufacturers.

Available Manufacturers. Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

Manufacturers. Subject to compliance with requirements, provide products of one of the following (for each type of wire, cable and connector):

Wire and Cable

General Cable Corporation
Southwire Company
Triangle PWC, Inc.

Connectors

AMP, Inc.
Burndy Corporation
Ideal Industries, Inc.
Thomas and Betts Company

3.02 Wire, Cable and Connectors

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

Wire. Provide factory-fabricated wire of sizes, ratings, materials and types indicated for each service. Where not indicated, provide proper selection as determined by installer to comply with project's installation requirements and NEC standards. Select from the following types, materials, conductors

configurations, insulation and coverings:

UL Type: MTW
UL Type: THHN
UL Type: THWN

Material: Copper

Conductors: Solid (AWG 20 to AWG 8 only)
Conductors: Concentric-lay-stranded (standard flexibility)
Outer Covering: Thermoplastic

Cable. Provide factory-fabricated, metal connectors of sizes, ratings, materials, types and classes as indicated for each service. Where not indicated, provide proper selection as determined by installer to comply with installation requirements and NEC standards.

3.03 Connectors.

Provide factory-fabricated, metal connectors of sizes, ratings, material, types and classes as indicated for each service. Where not indicated, provide proper selection as determined by installer to comply with installation requirements

and NEC standards. Select from the following types, classes, kinds and styles.

Type: Pressure
Class: Noninsulated
Kind: Copper (for Cu to Cu connection)
Style: Butt connection
Style: Split-bolt parallel connection
Style: Tap connection
Style: Pigtail connection

PART 4 INSTALLATION

4.01 General. Install electrical cables, wires and connectors as indicated, in compliance with manufacturer's written instruction, applicable requirements of NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices.

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

Use pulling compound or lubricant, where necessary; compound must not deteriorate conductor or installation.

Keep conductor splices to minimum.

Install splices and tapes which have mechanical strength and insulation rating equivalent-or-better than conductor.

Field Quality Control. Prior to Dd, test cable and wire for continuity of circuitry, and also for short circuits. Correct malfunctions when detected.

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

END OF SECTION

SECTION 16180
SWITCHBOARD

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A: Work consists of furnishing all labor, material and equipment and performing all operations necessary for installation of the completed low voltage drawout switchgear ready for use as specified and shown on the Drawings. Omission of a specific item obviously necessary for the proper functioning of the equipment shall not relieve the Contractor of the responsibility of furnishing and installing the item as a part of the Contract.

1.02 QUALITY ASSURANCE

- A. Codes and Standards: All work shall be performed in accordance with the following:
1. Institute Electrical and Electronics Engineers (IEEE Std. 44G-1974).
 2. National Electrical Manufacturer's Association (MG-1-1978).
 3. American National Standards Institute (ANSI).
- B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, and are limited to, the following:
1. Square D
 2. General Electric

1.03 SUBMITTALS

- A. Shop Drawings: Submit on all specified equipment and include at least the following:
1. Sufficient information to indicate complete compliance with specifications. Such data shall include "cuts", catalog data sheets, drawings and/or certifications as necessary.
 2. Plainly mark on all submittals any deviations from or exceptions to the Contract Documents.
 3. Where "cuts", catalog data sheets, or drawings have several items shown on lists of data, such as voltages, phases, or speeds, clearly mark the information to indicate exactly what will be supplied.

4. Complete calculations including curves and table to show compliance with specified performance requirements.
5. Operation and maintenance manual.
6. Show changes to be made during construction. Include changes in equipment ratings and alterations in locations of duct and conduit runs.

1.04 WORKMANSHIP

- A. Work under this section shall be accomplished by persons skilled in performance of the required task. All work shall be done in a first class manner in keeping with conventions of the trade. Work under this section shall be closely coordinated with work of other trades to avoid the interference.
- B. Working Clearances-General. Verify working clearances around equipment with electrical services to comply with code requirements. Should there be apparent violations of working clearances, notify the Engineer before proceeding with connections of equipment.
- C. The unit shall be the current product of a manufacturer regularly engaged in the production of such equipment and shall be fully tested in the plant of the manufacturer.
- D. Fuses. Install fuses in all fused equipment and provide fuses in the amount of 50 percent used per type and ampere rating. Fuses shall be turned over to the Owner for spares.

1.05 MANUFACTURER'S SERVICES

- A. The Contractor shall furnish the services of a qualified manufacturer's representative for whatever length of time may be required to check out the installation and to make the unit operable and acceptable to the Engineer and/or Owner.
- B. General: This specification outlines the overall fabrication, performance and functional requirements of service entrance switchgear and distribution sections. It shall meet the overall design requirements as specified herein.
- C. Deviations. Any exceptions or deviations shall be defined in writing at the time of bid.

PART 2 - PRODUCTS

2.01 GENERAL:

- A. The specifications and associated drawings describe the indoor low voltage metal enclosed switchboard assembly. The assembly is to be designed for use on a 277/480 volt, 3 phase, 4 wire 60Hz system, with 50,000 amperes symmetrical fault

current available. Equipment is to be complete from the incoming line connections to the outgoing feeder connections. Any items not specifically mentioned but obviously necessary for proper operation are implied in this description.

- B. The low voltage section shall be designed, manufactured and tested in accordance with applicable NEMA and IEEE standards for switchboards.
- C. The enclosure shall be finished with medium gray ANSI #49 enamel applied over arust inhibiting phosphate primer. Equipment shall be equipped with Service Entrance Label when UL recognized components are specified.

2.02 ENCLOSURE

- A. The enclosure and internal barriers shall be fabricated of steel members in accordance with NEMA standards. Steel lifting straps are to be provided with each shipping group to lift the structure from the top with a crane.
- B. The equipment shall be assembled, adjusted and tested at the factory and shall be sectionalized, if required, for shipping as requested or approved. The largest section is not to exceed 78 inches wide, 24 inches deep, and 91 inches high to enable installation at the job site.

2.03 CIRCUIT BREAKERS

- A. The circuit breakers shall be group mounted stationary mount, molded case breakers.
- B. The circuit breaker trip device is to be of a solid state design which requires no external power connections and is provided with an adjustable long-time delay, instantaneous and short-time delay over current/short circuit protection. Include ground fault tripping as an integral part of the solid state trip device. Settings are to be continuous between calibrated points. Provisions for testing and calibrating shall be provided. Breakers are to have UL label.

2.04 CIRCUIT MONITORS

- A. Provide solid state circuit monitor including all necessary current and potential transformers required for system operation. Circuit monitors to be capable of wave form capture and provide LCD cover display of amps, volts, kw, kva, kvar, and power factor.

END OF SECTION

SECTION 16211

AUTOMATIC TRANSFER SWITCH

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The extent of automatic transfer switch installation is indicated by drawings and schedules. Furnish and install switch as shown on plans.

PART 2 - QUALITY ASSURANCE

2.01 NEC COMPLIANCE

- A. Comply with NEC as applicable to construction and installation of.
 - 1. UL Compliance and Labeling. Provide automatic transfer switch which has been UL listed and labeled.
 - 2. NEMA Compliance. Comply with NEMA standards for automatic transfer switching.
 - 3. Submittals. Product data. Submit manufacturer's data on specific devices required for this project.

PART 3 - PRODUCTS

3.01 MANUFACTURER

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

ASCO
ZENITH
RUSSELL

3.02 GENERAL REQUIREMENTS

- A. The automatic transfer switch shall consist of a power transfer module and a control module, interconnected to provide complete automatic operation. The automatic transfer switch shall be mechanically held and electrically operated by a single-solenoid mechanism energized from the source to which the load is to be transferred. The switch shall be rated for continuous duty and be inherently double throw. The switch shall be mechanically interlocked to ensure only one of two possible positions - normal or emergency. The automatic transfer switch shall be suitable for use with

emergency sources, such as engine or turbine generator source, or other utility source.

- B. All main contacts shall be of silver composition. This shall be protected by arcing contacts in sizes 400 amp and over. They shall be of the blow-on configuration and of segmented construction in ratings 600 amps and over. The operating transfer time in either direction shall not exceed one-sixth (1/6) of a second.
- C. All contacts, coils, springs, and control elements shall be conveniently removable from the front of the transfer switch without major disassembly or disconnection of power conductors.
- D. The control module shall be supplied with a protective cover and be mounted separately from the transfer switch for ease of maintenance. Sensing and control logic shall be solid state and mounted on plug in printed circuit boards. Printed circuit boards shall be keyed to prevent incorrect installation. Interfacing relays shall be industrial-control-grade, plug in type with dust covers and locking chips.
- E. Automatic transfer switches utilizing components of molded case circuit breakers, contactors, or parts thereof which have not been intended for continuous duty or repetitive load transfer switching are not acceptable.
- F. The automatic transfer switch shall conform to the requirements of NEMA Standard ICS 2-447 and Underwriters' Laboratories UL-1008, and shall be UL listed as follows:
 - 1. For use in emergency systems in accordance with Articles 517 and 700 of the National Electrical Code.
- G. Rated in amps for total system transfer including control motors, electric discharge lamps, electric heating and tungsten filament lamp load. Switches rated above 400 amps shall be suitable for 30% or 400 amps tungsten filament lamp load, whichever is higher.
- H. The automatic transfer switch shall be rated to withstand the 42,000 rms symmetrical short circuit current available at the automatic transfer switch terminals, with the type of overcurrent protection, voltage, and X/R ratio as shown on the plans.
- I. The automatic transfer switch shall be mounted in a Type 1 enclosure. Switch and accessory devices shall be supplied by one manufacturer, with number of poles rated as shown on the plans.
- J. A manual bypass shall be included.

3.03 TESTING

- A. Certified laboratory test data on a switch of the same design and rating shall be provided to confirm to the following switching abilities:
 - 1. Overload and endurance per Table 21.2 and 23.2 of UL-1008 when enclosed according to Paragraph 1.6.
- B. Temperature rise tests after the overload and endurance tests to confirm the ability of the transfer switches to carry their rated current within the allowable temperature limits of the insulation in contacts with current carrying parts.
- C. Withstand current tests per Paragraph 25 of UL-1008 for 42,000 amps rms symmetrical, at 480 volts and X/R ratio of 6.6.
- D. No welding of contacts. Transfer switch must be operable to alternate source after the withstand current test.
- E. Dielectric tests at 1960 volts, rms, minimum after the withstand current test.
- F. All production units should be subjected to the following factory tests:
 - 1. The complete automatic transfer switch shall be tested to ensure proper operation of the individual components and correct overall sequence of operation, and to ensure that the operating transfer time, voltage, frequency, and time delay settings are in compliance with the specification requirements.
 - 2. The complete automatic transfer switch shall be subjected to a dielectric strength test per NEMA Standard ICS 1.109.05.
 - 3. The control panel shall meet or exceed the voltage surge withstand capability in accordance with ANSI C37.90a-1978 and the impulse withstand voltage test in accordance with NEMA Standard ICS1-109.

3.04 OPERATION

- A. Two pole switches shall be suited for single phase service and three pole switches for three phase service. Neutral conductor terminal lugs shall be provided as required for the power system.
- B. The automatic transfer switch control panel for single phase and for three phase shall utilize solid state sensing for automatic, positive operation. The following provided:
 - 1. For single phase switches, the normal source voltage across live lines shall be monitored, and for three phase switches all phases of the normal shall be monitored line to line. Close differential voltage sensing shall be provided. The pickup voltage shall be adjustable from 72% to 100% of nominal, and

the dropout voltage shall be adjustable from 70% to 98% of the pickup value.
The transfer to emergency will be initiated upon reduction of normal source to 85% of nominal voltage and retransfer to normal shall occur when normal source restores to 95% of nominal.

- C. A test to momentarily simulate normal source failure.
- D. Harnessing between transfer switch and control panel shall be built in disconnect for routine maintenance.
- E. All moveable parts of the operating mechanism shall remain in positive mechanical contact with the main contacts during the transfer operation without the use of separate mechanical interlocks. Automatic operation of the switch shall not require power from any source other than the line to line voltage of the source to which the switch is transferring.

3.05 ACCESSORIES

- A. Switches shall include a time delay to ignore momentary outages. It shall delay closing of the engine start contacts for a fixed time of 3 seconds.
- B. Switches shall include a time delay on transfer from normal to emergency, field adjustable from .6 to 60 seconds.
- C. Switches shall include a time delay on retransfer from emergency to normal, field adjustable from 1 to 30 minutes. The time delay shall be automatically bypassed if the emergency source fails and the normal source is available.
- D. The switches shall include voltage and frequency sensing of the emergency source and shall be factory set to allow transfer to emergency when that source is approximately at 90% of rated voltage and frequency.
- E. Gold plated contacts rated 10 amps, 32 volts DC which close when the normal source fails shall be provided to initiate engine starting.
- F. Include 4 position manual off automatic test selector switch, indicating pilot lights and low fuel alarm pilot light on unit door.
- G. The unit shall include a programmable exercise timer which will start and run the standby generator.
- H. The unit shall have an 'in phase monitor' to delay retransfer to utility power until generator and utility are within 10 degrees of peak sine wave.
- K. The unit to have a 'maintenance bypass' option whereby automatic transfer is overridden, manually bypassed, drawn out on a racking mechanism, serviced or replaced and put back in service within 1 minute of exercising the mechanism. A

detailed instruction for this operation to be on a laminated plaque affixed to the front of the switch.

3.06 CERTIFICATION

- A. On request, the manufacturer shall provide a letter certifying compliance with all requirements of the transfer switch specification. The certification shall identify equipment by serial number and shall include no exceptions to the specifications, except those stipulated with the submittal.

3.07 SUBMITTAL, OPERATOR'S MANUAL, AND WARRANTY

- A. Submittal shall include specification sheets showing all standard and optional accessories to be supplied; schematic wiring diagrams, dimensions drawings; and interconnection diagrams identifying by terminal number each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.
- B. Each transfer switch shall be provided with an operator's manual providing installation and operating instructions.
- C. Each automatic transfer switch and generator set shall be warranted by the generator set manufacturer for one year from date placed in service.

END OF SECTION

SECTION 16231

SPECIFICATIONS: GENERATOR SET

1) **Scope of Work**

- a) It is the intent of this specification to secure an engine driven generator set that has been prototype tested, factory built, production tested, and site tested, together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein. All equipment shall be new and of current production by an international firm which manufactures the generator set and controls.
- b) See additional Bypass/Isolation ATS section for installation within generator set housing.

2) **General Requirements**

- a) It is the intent of this specification to secure a generator set system that has been tested during design verification, production and at the final job site. The generator set will be of the latest commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied and installed shall meet the requirements of the National Electrical Code, along with all applicable local codes and regulations. All equipment shall be new and of current production of a national firm that manufactures the generator set and controls, transfer switches, switchgear, and assembles the generator sets as a complete and coordinated system. There will be one source responsibility for warranty, parts, and service through a local representative with factory-trained servicemen.

3) **Submittal**

- a) The submittal shall include prototype test certification and specification sheets showing all standard and optional accessories to be supplied, schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal number, each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.

4) **Codes and Standards**

- a) The generator set shall conform to the requirements of the following codes and standards:
 - i) CSA C22.2, No. 14 – M91 Industrial Control Equipment.

- ii) EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements, Part 2: Industrial.
- iii) EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
- iv) IEC8528 part 4. Control Systems for Generator Sets
- v) IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
- vi) IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
- vii) Mil Std 461D –1993. Military Standard, Electromagnetic Interference Characteristics.
- viii) Mil Std 462D - 1993. Military Standard, Measurement of Electromagnetic Interference Characteristics.
- ix) NFPA70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
- x) NFPA99 – Essential Electrical Systems for Health Care Facilities
- xi) NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.
- xii) UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed

5) Testing

- a) To assure that the equipment has been designed and built to the highest reliability and quality standards, the manufacturer and/or local representative shall be responsible for three separate tests: design prototype tests, final production tests, and site tests.
 - i) Design Prototype Tests: Components of the emergency system such as the engine/generator set, transfer switch, and accessories shall not be subjected to prototype tests since the tests are potentially damaging. Rather, similar design prototypes and preproduction models shall be subject to the following tests.
 - (1) Maximum power (kW).
 - (2) Maximum motor starting (kVA) at 35% instantaneous voltage dip.
 - (3) Alternator temperature rise by embedded thermocouple and/or by resistance method per NEMA MG1-32.40.

- (4) Governor speed regulation under steady-state and transient conditions.
- (5) Voltage regulation and generator transient response.
- (6) Harmonic analysis, voltage waveform deviation, and telephone influence factor.
- (7) Three-phase short circuit tests.
- (8) Alternator cooling air flow.
- (9) Torsional analysis to verify that the generator set is free of harmful torsional stresses.
- (10) Endurance testing.

b) Production Tests

- i) Final Production Tests: Each generator set shall be tested under varying loads with guards and exhaust system in place. Tests shall include:
 - ii) Single-step load pickup.
 - iii) Transient and steady—state governing.
 - iv) Safety shutdown device testing.
 - v) Voltage regulation.
 - vi) Rated Power @ 0.8 PF
 - vii) Maximum Power.
 - viii) Upon request, arrangements to either witness this test will be made, or a certified test record will be sent prior to shipment.

c) Site Tests

- i) Site Tests: An installation check, start-up, and building load test shall be performed by the manufacturer's local representative. The engineer, regular operators, and the maintenance staff shall be notified of the time and date of the site test. The tests shall include:
 - ii) Fuel, lubricating oil, and antifreeze shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected.

- iii) Accessories that normally function while the set is standing by shall be checked prior to cranking the engine. These shall include: block heaters, battery charger, alternator strip heaters, remote annunciator, etc.
- iv) Start-up under test mode to check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage and frequency, and phase rotation.
- v) Automatic start-up by means of simulated power outage to test remote-automatic starting, transfer of the load, and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted for proper system coordination. Engine coolant temperature, oil pressure, and battery charge level along with generator set voltage, amperes, and frequency shall be monitored throughout the test. An external resistive load bank shall be connected to the system for 4 hours test.

6) **Warranty & Maintenance**

- a) A one year warranty for the generator set shall be included to guarantee against defective material and workmanship in accordance with the manufacturer's published warranty from date of start-up. Optional warranties shall be available upon request.
- b) The generator set manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall be regularly engaged in a maintenance contract program to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating conditions, adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and proper functioning of all systems.

7) **Equipment**

- a) The generator set shall be a Kohler model 1000REOZDC with a 7M4046 alternator. It shall provide 1000 kW, 1250 kVA when operating at 277/480 volts, .8 power factor. The generator set shall be capable of this rating while operating in an ambient condition of 104°F (40°C) and 1312 feet above sea level.
- b) The generator set shall be capable of starting motor loads of 3900 kVA inrush, with a maximum voltage dip of 35%.
- c) Vibration isolators shall be provided between the base and the floor.

8) Engine

- a) The 1943 cubic-inch-displacement engine shall deliver a minimum of 1495 hp at a governed speed of 1800 rpm. The engine shall be equipped with the following:
 - i) An electronic isochronous governor capable of +.25% steady-state frequency regulation.
 - ii) 24 Volt positive engagement solenoid shift-starting motor.
 - iii) 70-Ampere minimum automatic battery charging alternator with solid-state voltage regulation.
 - iv) Positive displacement, full pressure lubrication oil pump, cartridge oil filters, dipstick, and oil drain.
 - v) Dry-type replaceable air cleaner elements for normal applications.
 - vi) Engine-driven or electric fuel transfer pump capable of lifting fuel 0 feet, fuel filters, and electric solenoid fuel shut-off valve.
- b) The turbocharged and after-cooled engine shall be fueled with No. 2 diesel
- c) The engine shall have a minimum of 16 cylinders, and be liquid-cooled by a unit-mounted radiator, blower fan, water pump, and thermostats. **This system shall properly cool the engine with up to 0.5 inches H₂O static pressure on the fan in an ambient temperature up to 122F/50C.**
- d) The engine shall be EPA certified and conform to Tier II non-road emissions

9) Alternator

- a) The alternator shall be a Fast Response™ II permanent magnet brushless design
- b) The alternator shall be salient-pole, brushless, 4-lead reconnectable, self-ventilated of drip-proof construction with amortisseur rotor windings and skewed stator for smooth voltage waveform. The insulation shall meet the NEMA standard (MG1-33.40) for Class H and be insulated with epoxy varnish to be fungus resistant per MIL 1-24092. **Temperature rise of the rotor and stator shall be limited to 105°C.** The excitation system shall be of brushless construction controlled by a solid-state voltage regulator capable of maintaining voltage within +/- .25% at any constant load from 0% to 100% of rating. The regulator must be isolated to prevent tracking when connected to SCR loads, and provide individual adjustments for voltage range, stability and volts-per-hertz operations; and be protected from the environment by conformal coating.

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

10) Controller

- a) Standards
 - i) Control The generator set must meet NFPA-110 Level 1 requirements (1996 version) and must have an integral alarm horn as required by NFPA.
 - ii) NFPA-99 and NEC must also be accommodated.
 - iii) Set control must be listed under UL 508.
- b) Applicability
 - i) For standardization purposes, the control described herein must be available on generator sets 20 kW and larger.
 - ii) The control must be usable on 12- or 24-volt starting systems.
 - iii) Environment
 - (1) -40°C to +70°C operating temperature range
 - (2) 5-95% humidity, non condensing
 - iv) It shall be possible to mount the control on the generator set or remotely within 40 feet of the generator set. If mounted on the generator set, the control must be able to be mounted in any of 4 orientations for ease of viewing.
- c) Hardware Requirements
 - i) The control shall have a run-off/reset-auto three-position selector switch. If required, in the plans and specs, a version of the control shall have a key operated selector switch.

- ii) A controller mounted latch type emergency stop push button must be supplied.
 - iii) It shall be possible to adjust alternator output voltage at the control.
 - iv) Five indicating lights:
 - (1) system ready - green
 - (2) not in auto - yellow
 - (3) programming mode - yellow
 - (4) system warning - yellow
 - (5) system shutdown - red
 - v) Lighted display with two lines of 20 alphanumeric characters for messages. Panel lights must be supplied as standard.
 - vi) Sixteen position snap action sealed keypad for menu selection and data entry.
 - vii) For ease of use, an operating guide must be on the controller faceplate.
 - viii) An audible alarm must be supplied in the control.
- d) Control Functional Requirements
- i) Field programmable time delay for engine start. Adjustment range, 0-5 minutes in 1 second increments.
 - ii) Field programmable time delay engine cool-down. Adjustment range, 0-10 minutes in 1 second increments.
 - iii) It shall be possible to start the generator set and run it at an idle speed during warm-up. The idle time must be user adjustable. Engine cooldown at idle must also be available. Required for ECM equipped engines only.
 - iv) Real time clock and calendar for time stamping of events.
 - v) Output with adjustable timer for an ether injection starting system. Adjustment range, 0-10 seconds.
 - vi) Output for shedding of loads if the generator set reaches a user programmable percentage of its kW rating. Load shed must also be enabled if the generator set output frequency falls below 59 Hz (60 Hz system) or 49 Hz (50 Hz system).
 - vii) Programmable cyclic cranking that allows up to six crank cycles and up to 45 seconds of crank time per crank cycle.

- viii) The capability to reduce controller current battery draw, for applications where no continuous battery charging is available, must be provided. The controller vacuum fluorescent display should automatically be turned off after 5 minutes of no controller activity.
 - ix) The controller must provide alternator protection for overload and short circuit matched to each individual alternator and duty cycle.
 - x) A $\pm 2\%$ digital voltage regulator must be incorporated into the controller software. No separate voltage regulator is acceptable. The digital voltage regulator must be applicable on single or three phase systems.
 - xi) It must be possible to exercise the generator set by programming a running time into the controller. This feature must also be enabled through the PC software.
- e) Generator Set System Monitoring Requirements
- i) All monitored functions must be viewable on the digital display.
 - ii) The following generator set functions must be monitored:
 - (1) all output voltages - single phase, three phase, line to line, and line to neutral, 0.25% accuracy
 - (2) all single phase and three phase currents, 0.25% accuracy
 - (3) output frequency, 0.25% accuracy
 - (4) power factor by phase with leading/lagging indication
 - (5) total instantaneous kilowatt loading and kilowatts per phase, 0.5% accuracy
 - (6) kVARS total and per phase, 0.5% accuracy
 - (7) kVA total and per phase, 0.5% accuracy
 - (8) kW hours
 - (9) a display of percent generator set duty level - actual kW loading divided by the kW rating
 - iii) Engine parameters listed below shall be monitored: *(required for ECM equipped engines only)
 - (1) coolant temperature both in English and metric units
 - (2) oil pressure in English and metric units
 - (3) battery voltage
 - (4) rpm
 - (5) lube oil temperature*
 - (6) lube oil level*
 - (7) crankcase pressure*
 - (8) coolant level*
 - (9) coolant pressure*
 - (10) fuel pressure*
 - (11) fuel temperature*

- (12) fuel rate*
- (13) fuel used during the last run*
- (14) ambient temperature*

iv) Operational records since system start up must be stored in the controller.

- (1) run time hours
- (2) run time loaded
- (3) run time unloaded
- (4) number of starts
- (5) factory test date
- (6) last run data including date, duration, and whether loaded or unloaded
- (7) kW hours

v) The following operational records must also be available in a re-settable form for maintenance purposes:

- (1) run time hours
- (2) run time loaded
- (3) run time unloaded
- (4) kilowatt hours
- (5) days of operation
- (6) number of starts
- (7) start date after reset

vi) The controller must store the last one hundred generator set system events with date and time of the event.

vii) For maintenance and service purposes, the following information must be stored in the control and displayed on demand:

- (1) manufacturer's model and serial number
- (2) battery voltage
- (3) generator set kilowatt rating
- (4) rated current
- (5) system voltage
- (6) system frequency
- (7) number of phases

f) The control must be capable of detecting the following conditions, indicate if the condition will shutdown the generator set or provide a warning, and annunciate the situation, using words and phrases, on the digital display.

i) Will cause a system shutdown:

- (1) air damper tripped (if used)
- (2) customer programmed digital auxiliary input ON (any of the 21 inputs available)
- (3) customer programmed analog auxiliary input out of bounds (any of 7 inputs for ECM equipped engines and 5 inputs for non ECM engines)

- (4) emergency stop
- (5) high coolant temperature
- (6) high oil temperature
- (7) controller internal fault
- (8) locked rotor - fail to rotate
- (9) low coolant level
- (10) low oil pressure
- (11) Master switch error
- (12) NFPA common alarm
- (13) Over-crank
- (14) Over-speed with user adjustable level, range 65-70 Hz on 60 Hz systems and 55-70 Hz on 50 Hz systems
- (15) generator set over-voltage with user adjustable level, range 105% to 135%
- (16) over-frequency with user adjustable level, range 102% to 140%
- (17) under-frequency with user adjustable level, range 80% to 90%
- (18) generator set under-voltage with user adjustable level, range 70% to 95%
- (19) coolant temperature signal loss
- (20) oil pressure gauge signal loss

ii) Will cause a warning but leave the generator set running:

- (1) battery charger failure
- (2) customer programmed digital auxiliary input on (any of the 21 inputs available)
- (3) customer programmed analog auxiliary input on (any of the 7 inputs available on ECM engines and 5 inputs for non ECM engines)
- (4) power system supplying load
- (5) ground fault detected - detection by others
- (6) high battery voltage - Level must be user adjustable.
- (7) Range 29-33 volts for 24-volt systems.
- (8) high coolant temperature
- (9) load shed
- (10) loss of AC sensing
- (11) under-frequency
- (12) low battery voltage – level must be user adjustable, Range 20-25 volts for 24-volt systems.
- (13) low coolant temperature
- (14) low fuel level or pressure
- (15) low oil pressure
- (16) NFPA common alarms
- (17) Over-current
- (18) speed sensor fault
- (19) weak battery
- (20) alternator protection activated

g) Inputs and Outputs

i) Inputs

- (1) There shall be 21 dry contact inputs that can be user configured to shutdown the generator set or provide a warning.
- (2) There shall be 7 user programmable analog inputs for ECM engines (5 for non ECM engines) for monitoring and control.
- (3) Each analog input can accept 0-5 volt analog signals.
- (4) Resolution must be 1 part in 10,000.
- (5) Each input can be programmed to provide up to 4 trip values – 2 warnings and 2 shutdowns.
- (6) It must be possible to view the analog value on the display.
- (7) It shall be possible to define each user configured input using words or phrases that will be viewable on the digital display.
- (8) Additional standard inputs required:
 - (a) Input for an external ground fault detector. Digital display must show "ground fault" upon detection of a ground fault.
 - (b) Reset of system faults.
 - (c) Remote two wire start.
 - (d) Remote emergency stop.
- (9) Idle mode enable

ii) Outputs

- (1) All NFPA 110 Level 1 outputs must be available.
- (2) There shall be thirty outputs available for interfacing to other equipment:
 - (a) Any of these outputs shall be able to be user configured from a list of over 25 functions and faults.
 - (b) These outputs shall drive optional dry contacts.
- (3) A programmable user defined common fault output with over 40 selections shall be available.

h) System Programming

- i) It must be possible to disable programming so the system can only be monitored.
- ii) It shall be possible to program the control with the controller keypad or using an IBM compatible personal computer.
- iii) Programming access is to be enabled only at the controller and must be password protected.
- iv) The following must be programmable from the controller keypad:
 - (1) Time delay settings:
 - (a) Generator set run time (0 to 72 hours) - exercise

- (b) load shed
- (c) engine start
- (d) engine cool-down
- (e) over-voltage and under-voltage delays
- (f) starting aid
- (g) crank on and crank pause time
- (h) idle time

(2) Trip point settings:

- (a) high battery voltage
- (b) low battery voltage
- (c) over-speed
- (d) under-frequency
- (e) over-frequency
- (f) over-voltage
- (g) under-voltage
- (h) load shed

i) Communications

- i) If the generator set engine is equipped with an ECM (engine control module), the controller must communicate to the ECM for control, monitoring, and diagnostics. SAE J1939 standard communications is required.
- ii) Industry standard Modbus RTU communication shall be available.
- iii) A Modbus master will be able to monitor controller data.
- iv) A Modbus master will be able to alter parameters.
- v) The Modbus master must be capable of starting and stopping the generator set.

j) Communications & Personal Computer Software

- i) The controller must have the capability to communicate to a personal computer (IBM or compatible) running Windows '9X or Windows NT.
- ii) Both RS-232 and RS-485 communication formats shall be available.
- iii) A variety of connections shall be available based on requirements:
 - (1) A single connection to a PC. A cable length of up to 1220 m (4000 ft) must be supported.
 - (2) Multiple devices at a single location connected to a PC.
 - (3) A single connection from a device to a PC over phone lines.
 - (4) Multiple devices to a PC over phone lines.
- iv) When equipped with communications modules, transfer switches and power monitors along with generator set controllers must be able to be connected to the same communication network with no additional interfaces being required.

- v) The capability to connect up to 128 devices (generator set controls and transfer switches) on a single network must be supported.
- vi) Cabling is to be device to device in a daisy chain fashion with no limitation on device locations within the network.
- vii) The network must be self- powered. No power wiring between devices is allowed.
- viii) A single software package with the following capabilities is required:
 - (1) Any combination of transfer switches and generator set controls.
 - (2) Up to 128 devices at a single site must be supported.
 - (3) The same software package must support communications over phone lines. The software shall allow communications with up to 128 sites (phone numbers) including phone number fields large enough for International communication.
 - (4) Access to individual devices by the software shall be protected by password.
 - (5) To support future expansion, it must be possible to add devices (ATS and generator set controllers), up to 128 and sites up to 128, with the installed software. Changing to a different software package is not acceptable.
 - (6) All displays, data inquires, and program functions allowed on the controllers, both generator set and ATS, shall also be available through the software.
 - (7) A single software screen must be capable of displaying data from multiple devices simultaneously.
 - (8) It shall be possible to reset shutdown faults, and restart the generator set using the software.
 - (9) If a transfer switch is used, it must be possible to start the generator set and transfer the loads to the generator.

11) Accessories

- a) A 100% rated line circuit breaker of 1600 amperes, 1600 amps sensor, 600 volt rated, molded case type, generator mounted.
- b) Engine block heater. Thermostatically controlled and sized to maintain manufacturers recommended engine coolant temperature to meet the start-up requirements of NFPA-99 and NFPA-110, Level 1.
- c) Battery rack, and battery cables, capable of holding the manufacturer's recommended batteries, shall be supplied.

- d) 12-volt lead-antimony battery(ies) capable of delivering the manufacturer's recommended minimum cold-cranking Amps required at 0°F, per SAE Standard J-537, shall be supplied.
- e) 10-Ampere automatic float and equalize battery charger with +/- 1% constant voltage regulation from no load to full load over +/-10% AC input line variation, current limited during engine cranking and short circuit conditions, temperature compensated for ambient temperatures from -40°C to +60°C, 5% accurate voltmeter and ammeter, fused, reverse polarity and transient protected. Charger to have alarms for low battery voltage, high battery voltage, and loss of D.C. power.
- f) The engine exhaust silencer shall be coated to be temperature and rust resistance, rated for hospital application. The silencer will reduce total engine exhaust noise by 25-35 dB(A). **(mount within enclosure)**
- g) Gas-proof, seamless, stainless steel, flexible exhaust bellows with threaded NPT connection.
- h) Two flexible fuel lines rated at a minimum of 257°F and 100 psi ending in pipe thread.
- i) The 20 relay dry contact kit provides normally open and normally closed contacts in a form C configuration to activate warning devices and other customer provided accessories allowing remote monitoring of the generator set. Typically, lamps, audible alarms, or other devices signal faults or status conditions.
- j) Run Relay to provide a three-pole, double-throw relay with 10 amps at 250 VAC contacts for indicating that the generator is running.
- k) Generator heater to prevent the accumulation of moisture for dampness in the generator windings.
- l) Main fuel tank to be provided by Division 15**
- m) 275 gallon UL 142 double-wall fuel day-tank with the following accessories:
(installed within enclosure – NEMA 3R day-tank is not acceptable)
 - i) Supply and return connections
 - ii) Normal and emergency vents installed
 - iii) Rupture basin switch
 - iv) Low and high fuel level alarm switch
 - v) Day-tank control panel
 - vi) 4 GPM supply pump, 120VAC
 - vii) 8 GPM return pump, 120VAc
 - viii) Day-tank pump control system

12) Remote Serial Annunciator

- a) Annunciator must meet the following specifications:
 - i) Operating temperature range: -20° to 70°C (-4° to 158°F)
 - ii) Storage temperature range: -40° to 85°C (-40° to 185°F)
 - iii) Humidity range: 5-95% noncondensing
 - iv) Enclosure: NEMA 2
 - v) Power supply: 12- or 24-VDC
 - vi) Power draw: 200 mA
- b) Standards:
 - i) NFPA 110, Level 1
 - ii) NFPA 99
 - iii) UL 508 Recognized
 - iv) CE Directive (Voltage and EMC)
 - v) EN610000-4-4 Fast Transient Immunity
- c) Hardware Requirements
 - i) Front panel--
 - ii) Up to (24) Light-emitting diode (LED) indicators for shutdowns, warnings (pre-alarms), and status
 - iii) Up to (19) Light-emitting diode (LED) indicators, an audible horn, an alarm silence button, and a lamp test button required by NFPA 110, Level 1.
 - iv) LEDs must be activated to indicate: shutdowns, warnings (pre-alarms), or status
 - v) Must have a minimum of (3) LED colors to define function
 - vi) Must have LEDs with blinking functions to indicate status

vii) LEDs required to activate for the following shutdown and/or warning conditions:

- (1) Overcrank
- (2) Low Coolant Temperature
- (3) High Engine Temperature
- (4) Low Oil Pressure
- (5) Overspeed
- (6) Emergency Stop
- (7) Low Fuel
- (8) Low Coolant Level
- (9) Not-In-Auto
- (10) High Battery Voltage
- (11) Low Battery Voltage
- (12) Battery Charger Failure
- (13) Common Fault

viii) LEDs required to activate upon the following status conditions:

- (1) Lamp test
- (2) Alarm silence
- (3) System ready
- (4) Generator running
- (5) Communications
- (6) EPS Supplying Load

- d) Up to (3) user-defined inputs shall each activate an LED and an audible horn for shutdowns, warnings, or status conditions.
- e) Annunciator shall have removable text inserts for assigning user-defined inputs, assigning generator identification, and replacement.
- f) Front panel of annunciator shall be a sealed membrane and shall be capable of both surface-mounting and flush-mounting.
- g) Network Communication
 - i) Provide an RS-485 connection at the annunciator from the generator controller. Maximum distance shall be 1220 m (4000 ft.) from the generator controller to the furthest annunciator.
 - ii) No other external wiring required, except power, to activate the LEDs and horn.

iii) Provide up to (4) annunciators per generator. Multiple annunciators shall communicate via RS-485 serial bus.

13) Generator Enclosure:

A weatherproof type enclosure shall be provided to house the engine/generator and accessories. The enclosure is to be in complete compliance with the National Electrical Code (NEC), and the National Fire Protection Association (NFPA) with regard to clearances around electrical equipment specified herein. The enclosure shall conform to the following construction and design criteria as set forth. Enclosure shall be manufactured by Advanced Manufacturing & Power Systems, Inc., DeLand, FL. (A.M.P.S.) Ph. (386) 822-5565.

-Rigidity wind test equal to 150 MPH

-Roof load equal to 50 lbs. per sq. ft.

-Rain test equal to 4" per hour

Enclosure shall consist of a roof, two (2) sidewalls, two (2) end walls, and be manufactured of formed aluminum components. The enclosure is to be provided with a means for securely attaching the entire structure to the base/fuel tank as specified within.

Roof, sidewalls and end walls shall be of formed 0.090 marine grade aluminum. The roof is to be bolted to both side and end walls to form a complete weather and wind resistance assembly.

A minimum clearance of 36" shall be allowed for walkway space between the generator frame and interior sidewalls. A minimum walkway clearance of 42" shall be allowed between the generator end frame and the interior rear wall of the enclosure. The radiator front face shall be sealed to the front wall utilizing and 2" minimum rubber gasket material to minimize recirculation of radiator air discharge and prevent the transmission of vibration from the packaged generator set to the enclosure.

Wall framing shall be incorporated in the panels by forming an open back box structure. Skin material shall be minimum thickness .090" marine grade aluminum. Enclosure shall have a baked on powder-coat finish for maximum corrosion resistance. Exterior skin panels shall be integral to the wall structure and not separate pieces riveted onto framing members. Wall panels shall be no wider than 36" each and shall be removable without the use of special tools. Wall and roof panels shall be designed so that field replacement can be accomplished without disassembly of the entire structure if damage should occur.

A minimum of sixteen colors shall be available for enclosure exterior. Standard enclosure exterior color is WHITE unless otherwise specified.

Roof assembly shall be peaked to aid in rainwater runoff. Cambered roof designs and roofs with thicknesses of less than 0.090" nominally shall not be considered. Roof assemblies are to be mechanically fastened to the vertical wall sections. Glued or crimped roofs shall not be allowed nor considered as an acceptable alternative.

Air handling shall be as follows: Air will enter the enclosure through a Hood, Plenum or Sound Attenuated Louvers/Baffles, as determined by the specific application and shall allow for the airflow demand for proper cooling to generator set package. The cooling air Inlet system shall prevent water intrusion into the enclosure with the generator set operating at full rated load while allowing for a maximum air restriction of less than 0.25" H₂O. Radiator Discharge shall be through a gravity operated extruded aluminum backdraft type damper and into a vertical discharge plenum or hood. Discharge plenum/hood shall discharge air upward and be provided with a means to positively drain any and all water entering the discharge device. Air discharge devices shall in no event restrict airflow by more than 0.25" H₂O. To ensure adequate airflow for cooling and combustion the static restriction over the entire system shall not exceed 0.50" H₂O. Both Intake and Discharge hoods and plenums shall be provided with removable bird/rodent screening to prevent the entrance of debris, birds, rodents and other vermin.

Acoustical insulation materials shall consist of a UL Classified Thermofiber® insulation material with a heat/fire resistance rating up to 2400° F and provide superior sound attenuation performance. Acoustical insulation material on interior roof and walls is to be mechanically held in place by 0.032" mill finished perforated aluminum with tuned engineered hole diameter for optimum sound attenuation at 1000 Hz. Interior perforated aluminum material shall protect the insulation material as well as allow noise to permeate the absorptive material.

A minimum of two (2) single personnel access doors shall be provided. Doors shall be manufactured of the same material as enclosure. Doors shall be fully gasketed to form a weather tight perimeter seal. Door hinges shall be full length stainless steel piano type and shall be attached with stainless steel hardware. Door handles shall be of a corrosion resistant material and shall provide for a lockable, secure entry point into the enclosure. Doors shall be insulated with no less insulation than is provided in the enclosure walls for sound attenuation.

Enclosure manufacturer shall provide all necessary hardware to **internally mount the exhaust silencer(s)** specified herein. Silencer mounting hardware shall maintain the weatherproof integrity of the enclosure system. The silencer should discharge upward into the radiator discharge plenum or hood where possible; otherwise the enclosure manufacturer shall provide an aluminum rain collar and rain dress shield. Rain Collar and Dress Shield shall be manufactured of

aluminum or stainless steel and designed as a circular fabricated part that does not require hole indexing by the installing contractor during site installation

As a minimum the enclosure shall provide an average 25db(A) sound reduction as measured at one meter, five feet above grade level under free field conditions.

Electrical:

The main enclosure compartment shall contain (1) 100-Ampere, 120/240 Volt, AC distribution panel with properly sized branch circuit breakers for the loads supplied. Lighting shall include (5) 4', two-tube, florescent lighting fixtures for illumination. Two (2) lighting control 3-way switches shall be supplied adjacent to the enclosure entrance doors. (2) 20-ampere, Duplex, GFI receptacles shall be provided adjacent to each 3-way switch.

The following additional items shall be wired to the load center: day tank pumps and controls, engine jacket water heaters, battery charger, and generator space heater.

All wiring shall be in EMT conduit with the exception of where the conduit transitions at the engine/generator. Flexible metallic tubing shall be used where conduit connects to equipment subject to vibration.

Electrical Equipment Room:

The enclosure shall contain an integrated electrical equipment room to house the Russelectric Bypass Isolation Automatic Transfer Switch and Utility Entrance Circuit Breaker. The electrical room shall be segregated from the main portion of the enclosure with a partition wall. The electrical room shall have a minimum of (2) 4', two-tube, florescent lighting fixtures for illumination. The lighting control switch shall be adjacent to the electrical room entrance door. The electrical equipment room shall contain a roof mounted, 13,000 BTU/H air conditioning module with interior control panel.

Structural steel base with interior steel floor:

A base under frame with interior finished floor shall be provided and designed to support the installed equipment specified. The floor structure shall be rated for a minimum distributed load of no less than 200 lbs/ft² and reinforced as required to support equipment-loading requirements. The under frame assembly shall consist of structural or formed steel channel or I-beams welded together to form the outer perimeter of the sub-frame. Structural or formed steel cross-members shall be installed and welded on nominal 16 inch centers to create a welded steel support structure for internal equipment installation and distributed load support. The top

deck interior shall consist of a minimum 3/16" diamond steel deck plate mechanically fastened to the under frame structure. Seams of the interior deck plate shall be solid seam welded their entire width. Tack welded or caulked seams will not be allowed. Vibration isolator mounts shall be each located above a frame member and securely welded to the top plate to ensure adequate load support. Isolator mounting plates are to be 1" thick steel plate, tapped for isolator bolting. The entire steel frame, interior floor and under frame shall be coated with a wear resistant, high quality anti-corrosive material and topcoat.

Four-point lifting provisions shall be provided and have sufficient capacity suitable for rigging the entire Frame/Enclosure assembly with all equipment installed.

END SECTION GENERATOR SET

SECTION 16330

UNDERGROUND DUCT LINES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Description of Assembly

1. Underground duct lines where shown shall be of individual conduits encased in concrete. The conduit shall be of plastic, unless indicated or specified otherwise. The conduit used shall not be smaller than 4 inches in diameter, inside, unless otherwise noted. The concrete encasement surrounding the duct bank shall be reinforced as shown and rectangular in cross-section, having a minimum concrete thickness of three inches. Conduit shall be separated by a minimum concrete thickness of three inches.

2. The concrete work shall conform to Section on "Concrete".

The top of the concrete envelope shall be not less than 18 inches below grade. Concrete shall be installed in a continuous pour to eliminate joints in the duct run. Duct lines shall have a continuous slope downward toward manholes and away from buildings with a pitch of not less than 3 inches in 100 feet. Changes in direction of runs exceeding a total of 10 degrees either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 25 feet, except that manufactured bends may be made up on one or more curved or straightened sections or combinations thereof. Manufactured bends shall have a minimum radius of 36 inches. Right angle bends shall be rigid steel black mastic coated.

3. Conduits shall terminate in end-bells where duct lines enter manholes. Separators shall be of precast concrete, high impact polystyrene, steel or any combination of these. The joints of the conduits shall be staggered by rows so as to provide a duct line having the maximum strength. During construction partially complete duct lines shall be protected from the entrance of debris, such as mud, sand and dirt by means of suitable conduit plugs. As the duct line is completed, a testing mandrel not less than 13 inches long with a diameter 1/4 inch less than the size of the stiff bristles shall be drawn through until the conduit is clear of all particles of earth, sand or gravel; conduit plug shall then be immediately installed. Pull string and mandrel shall be installed in all empty conduits.
4. Plastic conduit, fittings and joints shall not have been stored in the sun or weather. In any excessively heated space, or unevenly supported during storage. Use and installed shall be in accordance with the National Electrical Code requirements for the installation of non-metallic rigid conduit. Plastic conduit shall be protected against the direct rays of the sun prior to installation. Conduit shall be Carlon Type EB, Queen City Plastics, or equal. Conduit shall be U.L. listed and conform to NEMA Standard TC6-1972.

5. Trenches for duct banks shall be completely dry before setting conduits or pouring concrete. Well pointing as required will be provided if necessary to keep trench dry.
6. Wires and cables in manhole and vaults shall be placed on cable racks. Manhole shall be cleaned of all loose materials, dirt and debris immediately after completion of new work and shall be in a clean condition with insulators. Racks shall be McGraw Edison NOB-LOC type, Chance or equal.
7. Backfilling shall be in layers not more than 8 inches deep, and shall be thoroughly tamped. The first layer shall be earth or sand, free from particles that would be retained on a 1/4" inch sieve. The succeeding layers shall be excavated material having stones no larger than would pass through a 4-inch ring. The backfill shall be level with adjacent surface, except that in sodded or paved areas, a space equal to the thickness of the sod or paving shall be left.
8. The surface disturbed during the installation of duct shall be restored to its original elevation and condition if not refinished in connection with site work.
9. All unused conduit openings shall be plugged or capped with a suitable device designed for the purpose; caulking compound shall not be used for plugging conduit openings. Pull string and mandrel shall be provided.
10. One No. 4 bare stranded copper counterpoise shall be run above all duct banks and shall be run into all manholes and handholes and grounded. Counterpoise shall run to building and be grounded at each building service ground.

1.02 SUBMITTALS

A. Submit shop drawings or cut sheets on:

1. Conduit
2. Fittings
3. Separators
4. PVC solvent

END OF SECTION

SECTION 16340

HANDHOLES AND MANHOLES

PART 1 - GENERAL

1.01 DESCRIPTION

A. General Description:

1. The design of concrete mixture shall be the responsibility of the contractor as set forth in ASTM Standard C-94 for ready-mixed concrete. The concrete produced shall have the following characteristics:

Compressive strength at 28 days shall be not less than 2500 PSI.

The slump when tested in accordance with ASTM Standard C-143, shall be not more than 3 inches for vibrated concrete and 4 inches for non-vibrated concrete. Ready-mixed concrete shall be Standard C-94, using Alternative No. 2 for the mix design. With each load of concrete delivered, the producer shall furnish in duplicate before unloading at the site, delivery tickets of certification as required by ASTM C-94.

2. At contractor's option, concrete may be mixed by volume at the project site in an approved type batch mixer in the manner specified for stationary mixers in ASTM Standard C-94. The portions of cement, aggregate and water shall be selected to provide the characteristics indicated below for the compressive strength specified. Conformance with the strength requirements shall be as determined in accordance with ASTM Standard C-39.
3. Handholes may be of the precast type if approved prior to bidding, submit drawings, calculations and necessary detail to determine acceptability 15 days prior to bid date.
4. Brick used where indicated shall be sewer and manhole brick conforming to ASTM C-32, Grade MS.
5. Mortar shall be mixed in proportions of 1-part Portland Cement, 1/4-part hydrated lime and between 2-1/4 and 3 parts sand by volume).
6. Reinforcing bars shall be deformed and comply with either of the following ASTM Standards: Billet Steel Bars A-615 or Rail Steel Bars A-616.
7. Material for concrete forms shall be smooth boards exterior grade plywood or metal.
8. Drainage Pipe and Fittings shall be cast-iron, extra strength. Drains shall be plan pattern in accordance with Specifications WM-P-541.
9. Metal Frames, Covers and Gratings, except as indicated or specified otherwise, shall conform to Specification RR-F-621, and shall be of cast iron. Frames and covers of steel

shall be welded by qualified welders in accordance with standard commercial practice. Steel covers shall be rolled steel floor plate having an approved antislip surface. Steel gratings shall be of welded construction and conform to the applicable requirements of Specification RR-G-661, Type 1.

10. Pulling-in irons shall be steel bars bent in the firm indicated, and cast in the walls and floors. In the floor, they shall be centered above or below, and opposite the conduits entering the handhole. Pulling-in irons shall be project into the handhole approximately 4 inches. Irons shall be zinc-coated after fabrication in accordance with Specifications MIL-Z-17871.
11. Cable Racks, including hooks and insulators, shall be installed in handhole and shall be sufficient to accommodate the present and future cables and shall be spaced not more than 18 inches apart horizontally. The wall bracket shall be Channel or T-Section steel. The hooks shall be of steel or malleable iron and shall be of the removable type. Insulators shall be dry-process glazed porcelain. The metal portion of racks shall be zinc-coated after fabrication in accordance with Specification MIL-Z-17871.
12. Horizontal concrete surfaces of floors shall have a smooth trowel finish. Frames and covers shall be watertight and covers shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair their strength or appearance. Exposed metal shall have a smooth finish and sharp lines arises. Provide all necessary lugs, rabbets and brackets. Set pulling-in irons and other built-in items in place before depositing concrete.
13. Excavation for handhole shall be to depths indicated and of whatever substance encountered. Excavated material not required or suitable for backfill shall be removed from the project site. Provide sheeting and shoring as necessary for protection of work and safety of personnel. Remove water from excavation by pumping or other approved method. Backfilling around structures shall consist of earth, loam, sand-clay, or sand and gravel, free from large clods of earth or stones not over 1-inch in size. Approved backfill material shall be placed symmetrically on all sides in loose layers not more than 9-inches deep. Each layer shall be moistened, if necessary, and compacted with mechanical or hand tampers. Surfaces disturbed during the installation of handholes shall be restored to its original elevation and condition as herein specified for underground service lines.
14. After installation, cast-iron frames, covers and grating not buried in masonry shall be cleaned to the bare metal of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint. Steel frames and covers not buried in masonry shall be cleaned of mortar, dirt and grease by an approved blasting method and shall be cleaned to bare metal. Surfaces contaminated with rust, dirt, oil, grease, or other contaminants shall be washed with solvents until thoroughly clean. Immediately after cleaning, surface shall be coated with a pretreatment coating conforming to specification MIL-P-15328 or be given a crystalline phosphate coating conforming to Specification TT-C-490, Method 1, as soon as practicable after the pretreatment coating had dried, treated

surfaces shall be primed with a coat of zinc chromate primer conforming to Specification TT-P-645 and one coat of synthetic gloss enamel conforming to Specification TT-E-489.

15. Caulking compound for the sealing of conduits, ducts and sleeves shall be of putty-like consistence workable with the hands at a temperature as low as 35 degrees F., shall not slump at a temperature of 300 degrees F., and will not harden materially when exposed to air. The compound shall readily caulk or adhere to clean surfaces of the following: Plastic conduit, concrete, masonry, sheathers of cables, and the common metals. The compound shall form a seal with the foregoing without any of the ingredients. The compound shall have no injurious effect upon the hands of workman or upon the materials.
16. All unused conduit openings shall be plugged or capped with a suitable device designed for the purpose. Caulking compound shall not be used for plugging conduit openings.
17. Precase handholes and manholes are acceptable. Precast handholes and manholes will meet the following design loading: Design loading shall include dead load, live load, impact, loads due to water table, and any other loads which may be placed up on the structure. Live loading shall be for H-20 and/or H-20-S16 per A.A.S.H.O. Standard Specifications for Highway Bridges. Designed wheel load shall be 16 kips. Live load shall be that loading which produces the maximum sheer and bending moments in the structure. Manufacturer shall be Brooks Products or equal.

1.02 SUBMITTALS

1. Submit shop drawings on handhole showing all details and accessories.

END OF SECTION

SECTION 16390

GROUNDING

PART 1 - GENERAL

1.01 - Description of Work. Extent of grounding work is indicated by drawings and schedules.

Application of grounding work in this section include the following:

Underground Metal Piping	Service Equipment
Metal Building Frames	Enclosures
Grounding Electrodes	Equipment
Separately Derived Systems	

Requirements of this section apply to electrical grounding work specified elsewhere in these specifications.

Conductors. Copper cable; strand dia. 0.045"; 14 strands.

Ground Rods. Solid copper 5/8" dia. x 10'.

PART 2 - INSTALLATION

2.10 - GENERAL

Install electrical grounding systems where shown, in accordance with applicable portion of NEC, with NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products comply with requirements and serve intended functions.

END OF SECTION

SECTION 16480
MOTOR CONTROL CENTER

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

The location and size of the motor control center is shown on the drawing.

1.02 QUALITY ASSURANCE

Motor control center shall be as manufactured by General Electric, Allen Bradley, or Cuttler Hammer no equivalent.

The manufacturer of the motor control center shall also be the manufacturer of the major components assembled within.

1.03 SUBMITTALS

Before fabrication of motor control center is commenced, the manufacturer shall submit shop drawings on the layout and construction as specified in the project manual.

Where "cuts", catalog data sheets, or drawings have several items shown, such as options or voltages and phases, clearly mark the information to indicate exactly what will be supplied.

PART 2 - PRODUCTS

2.01 EQUIPMENT DESCRIPTION

The motor control center shall be of standard, indoor construction type. The arrangement of the equipment and devices shall be substantially as indicated on the drawings.

All wiring in the motor control center shall be Class I, Type B, unless otherwise noted on the drawings. Inter-wiring shall be provided between starter and control assemblies in a single section or between sections. A connection diagram and a main assembly drawing of the complete motor control center shall be provided.

Enclosure shall be NEMA Type I. All bus, wiring, devices, and appliances shall be completely enclosed and protected. Enclosure and structural parts of sections and units shall be given a phosphatizing or equal treatment prior to a zinc chromate or iron oxide primer coat. For indoor use, the enclosure parts shall be coated with ANSI gray synthetic enamel and then baked.

Operation shall be suitable for service voltage characteristics as noted on the drawings.

The motor control center shall consist of units as shown on the drawings. Control center shall be accessible from the front as called for on the drawings.

A grounding bus shall be provided on the motor control center. The grounding bus shall be 1/4-inch x 1-inch minimum, or as called for on the drawings.

Each control unit shall be designed for mounting within a vertical section in such a manner that the control equipment shall be completely enclosed and isolated from all other units. Unit side plates shall be permanently attached so they cannot be accidentally discarded. Each circuit breaker or combination circuit breaker/starter shall have a single door mounted on hinges which permit it to swing open at least 100 degrees. Doors shall be fastened to the stationary structure so they can be closed to cover the bus bars when the component has been removed. Components containing magnetic starters shall have reset buttons in the cover for external resetting of all overload relays without opening the door. Each component shall have an engraved bakelite legend plate.

Each disconnect shall be provided with a mechanism for manual operation from the outside with the door closed. It shall be possible to lock the disconnect in the "off" position with padlocks having up to 5/16-inch hasp diameter. The door of each unit shall be interlocked so that it cannot be opened while the disconnect is in the "on" position.

Circuit breakers for the motor control center shall be molded case circuit breakers with frame and trip as called for on the drawings. Unless otherwise noted on the drawings, circuit breakers shall have an interrupting capability of 22,000 RMS symmetrical amperes minimum at 480 volts. All circuit breakers shall be provided with thermal long time and instantaneous magnetic trips, or magnetic trip only as called for on the drawings.

Motor starter unit shall be of the combination type consisting of a motor circuit protector, and a magnetic starter. The magnetic type starter shall have ambient temperature compensated overload protection on each phase, and a manual reset button operable from the outside of the enclosure. Combination type motor starter unit size 1 and 2 shall be of the draw-out construction on both power and control circuits.

All combination motor starters shall be provided with all the devices as called for on the drawings. The magnetic starter shall have 2-N.O. and 2-N.C. auxiliary contacts or as called for on the drawings. Where the number of contacts called for is not available on the running contactor, the magnetic starter shall be provided with an auxiliary relay to complete the number of contacts required. The number of auxiliary contacts called for on the drawings is in addition to the contacts required for the running contactor seal-in function and for the running red light. All pilot devices shall be mounted and wired on starter units. Wiring shall not be acceptable across hinges.

Every motor shall be individually protected against loss of phase, under voltage, phase reversal and overload.

Components and devices in the motor control center shall be UL "listed" where called for on the drawings. The sections which contain all UL "listed" components and devices shall have the UL label on them.

Individual control transformers with fuses on the primary and secondary sides shall be furnished for each unit as called for on the drawings. All control transformers shall meet the following minimum requirements.

Sufficient volt-ampere capacity to handle the seal-in volt-ampere load of all control devices (starter coils, relays, pilot lights) which it serves.

Sufficient volt-ampere capacity so that the total in rush current of all control devices (starter coils, relays, pilot lights) which it serves will not cause the secondary voltage to drop below 85% of rated voltage when the primary voltage has been reduced to 90% of rated voltage.

The bus on the motor control center shall be braced for the rating called for on the drawings. The bus shall be tin plated copper minimum rating shall be 600 amps.

Bracing shall be UL listed for the rating called for on the drawings.

Provide rubber matting running the full length of the motor control center front. The rubber matting shall be natural or synthetic rubber free from foreign matter with a cloth backing and ribbed front. Rubber matting shall be 24-inch wide, 1/4-inch thick, shall have a dielectric strength of 20,000 volts and shall comply with the ASTM Standards for dielectric strength.

PART 3 - INSTALLATION

Furnish, deliver, install, wire completely, test and place in satisfactory and successful operating condition the motor control center indicated on the drawings and as specified.

Install, inside the cover of each starter unit, a typewritten list stating the horsepower rating of each motor served, the motor nameplate full-load amperes and the rating of the overload heaters installed.

3.02 MANUFACTURERS SERVICES

The manufacturer of the motor control center shall provide an experienced engineer for such time as is required to check out the completed installation and make the system operable and acceptable to the Engineer and Owner.

END OF SECTION

SECTION 16950

TEST AND PERFORMANCE VERIFICATION

PART 1 - GENERAL

1.01 GENERAL

- A. The foregoing "General Requirements", Div.1, Specification Section 01650, form a part of this contract and all the requirements set forth shall be binding upon this subcontractor.
- B. Operate system for a 3-day period. Do performance verification work as required to show that the System is operating correctly in accordance with design. Supply instruments required to read data. Adjust System to operate at the required performance levels. Tabulate data for submission. Submit data on 8-1/2" X 11" sheets with time and name of checker with one copy for each brochure. Where specific performance verification information is called for in the specifications, use copies of the sheets provided for recording readings. Data shall be submitted and approved before Check-Out Memos are signed or a request for final inspection is made.
- C. At completion of construction after all performance verification information is called for in the specifications, use copies of the sheets provided for recording readings. Data shall be submitted and approved before Instruction to Owner or a request for final inspection.

1.02 TESTS

A. System:

- 1. After wires or cables are in place, but before being connected to devices and equipment, the system shall be tested for shorts, opens, intentional and unintentional grounds by means of an approved type of constant "megger".

All wires in conduit that are shorted or unintentionally grounded shall be replaced.

- 2. Take readings of voltage and amperage at main switch for each new panel, and at the end of the longest branch circuit at each panel. The above readings shall be taken (1) "no-load" conditions and (2) at "full-load" conditions with all equipment using electricity.

B. Motors:

- 1 First run each motor, submit five (5) copies of the Test Information at least two weeks before request for final inspection. See form at the end of this Section.

2. With the system energized, line-to-line voltage and line current measurements shall be made at the motors under full load conditions. Should measured values deviate +10% from the nameplate ratings, the condition shall be corrected. Notify the Engineer immediately should deviations occur.
 3. Test the insulation resistances of all motor windings to ground with a "megger" before applying line voltage to the motors. If these values are less than 1 megohm the contractor furnishing the motor shall be responsible for correcting the error.
 4. Check power factor of all motors at full load.
- C. Grounds:
1. The resistance between ground and absolute earth shall not exceed 25 ohms and shall be measured by the Electrical Contractor before equipment is placed in operation. Testing shall be performed on all ground rod installations. Testing shall be three (3) point method in accordance with IEEE recommended practice.
- D. Transformers:
1. Tests: Transformer shall be tested and results shall be submitted to the Engineer. The test shall include ratio, polarity, no-loss, load loss, resistance measurements, impedance, temperature, impulse strength in liquid-filled transformers, sound level and exciting current and low-frequency dielectric strength. A certified copy of the temperature, impedance and sound level tests performed previously on a transformer which is a duplicate electrically will be accepted in lieu of temperature, impedance and sound level tests. Minimum impedance shall be 5.00%. All test results shall show comparative data to prove tests equal or greater than ANSI and NEMA Standards.

END OF SECTION