



## Lot 1 Navigational aids

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## SECTION 01101 - SCOPE OF WORKS

### PART 1 - GENERAL

#### 1.10 SUMMARY

- . Work of this Contract includes manufacture, fabrication, erection, supply, supervision, labor, materials, tools, equipment, training, flight test and commissioning required to perform all work under Supply Package Lot 1: Navigational Aids.
  
- A. The design, documentation, manufacturing, supply, supervision and control of manufacture and delivery shall be carried out and directly supervised by a specialist organization, with at least 5 years of experience in the installation and commissioning of this type of system.
  
- B. The scope of works includes the following navigational aids for Melville Hall Airport:
  - 0. Doppler VHF Omnidirectional Range (DVOR);
  - 1. Distance Measuring Equipment (DME);
  
- C. The scope of work includes the following systems and other items to support the navigational aids:
  - 0. Equipment shelter;
  - 1. Distribution board;
  - 2. Uninterruptible power supply.

**END OF SECTION: 01101 SCOPE OF WORKS**

## SECTION 02821 - FENCES AND GATES

### PART 1 - GENERAL

#### 1.10 DESCRIPTION

- A. This item covers the requirements for furnishing materials and constructing fences and gates in accordance with the details included herein and shown on the drawings.
- B. The type of fence to be erected shall be chain-link fencing as shown on the applicable drawing.
- C. The contractor shall include all supplementary parts necessary or required for a complete and satisfactory installation within the true meaning and intent of the drawings.
- D. All runs of the fence shall present the same general appearance and the product of one manufacturer only will be accepted, except for items which do not influence the appearance of the completed fence.
- E. No used, rerolled, or open seam steel shall be permitted.
- F. The posts and supports shall be constructed in accordance with the details included herein and/or as shown on the drawings or as directed by the Supervisor.
- G. Included in the item are connections to buildings or existing fences and the provision of electrical grounds.

### PART 2. PRODUCTS

#### 2.1 MATERIALS

- H. Chain-link fence fabric shall have PVC coating.  
Mesh size shall be approximately 50 x 50 mm.  
The core wire shall be galvanized and the wire diameter shall be 2.5 mm.
- I. Barbed wire shall be 2-strand twisted 2.5 mm thick galvanized steel wire with 4-point barbs of 2 mm galvanized steel wire.  
The barbs shall be spaced approximately 120 mm. The minimum weight of zinc-

coating shall be 150 gram per square metre.  
The wires shall be spaced as shown on the drawings or as directed by the Supervisor.

- J. Wirefabric ties and wire ties shall be 3 mm galvanized steel wire and PVC coated.  
Tension wire shall be 4 mm galvanized steel wire and PVC coated.
  
- K. Double leaf gates and single leaf gates where required shall be constructed to match the existing.  
Gates may consist of steel pipes, suitably braced and filled with security mesh fence, welded to the pipes or consist of top and bottom rails with vertical bars.  
The gates shall be hot-dip galvanized after fabrication.
  
- L. Hot-dip galvanized hardware shall be furnished with each gate.  
Hardware shall be of design standard with the manufacturer. The zinc-coating shall be in accordance with the requirements of ASTM A 153.  
The hardware shall be fixed to the gate frame by means of bolts or screws.  
Each gate shall be furnished with one padlock with three keys, or as directed by the Supervisor.
  
- M. Posts and supports shall be of the type directed by the Supervisor to match the existing.  
If the Contractor wishes to propose an alternative standard design of a certain manufacturer, he shall be required to submit his substitution in accordance with the Conditions of Contract.
  
- N. Fittings and fastenings shall be hot dip galvanized steel of the design standard of the manufacturer.
  
- O. All other steelware used for any part of the chain link fencing shall be hot dip galvanized steel of design standard with the manufacturer, and of sufficient strength to provide a balanced design when used in conjunction with fabric, posts, gates and wires.
  
- P. Zinc-coating on gates, gate posts, supports, fittings and other structural steelware shall be of a minimum weight of 450 gram per square metre.
  
- Q. Structural members of gates which are in contact shall be fully welded by a method which will produce a continuous weld on all sides and faces of joints at exposed edges. Surplus welding material shall be removed. Welding of the hardware to the gate frame after galvanizing will not be permitted, to avoid damaging of the zinc-coating.

- R. Reinforced concrete shall be in accordance with Section 03311, using 25 mm maximum coarse aggregate.

## **PART 1 - EXECUTION**

### **1.10 GENERAL**

- . The fence shall be constructed in accordance with the requirements of the Supervisor and as specified herein, with new materials and all work shall be performed in a workmanlike manner satisfactory to the Supervisor.
  
- A. Prior to the beginning of the work, the Contractor shall locate the position of the work by establishing and marking the fence line. At locations of small natural or drainage ditches where it is not practical for the fence to conform to the general contour of the ground surface, the Contractor, when directed, shall use longer posts and strands of barbed wire stretched thereon to span the opening below the fence, vertical clearance between wire shall not be more than 0.15 m.
  
- B. The new fence shall be permanently tied to the terminating points or existing fences whenever required by the Supervisor.
  
- C. The finished fence shall be plumb, taut, true to line, and ground contour, and complete in every detail.
  
- D. When directed, the Contractor shall be required to stake down the chain-link fence at several points between the posts.
  
- E. To keep stock on adjoining property enclosed at all times, the Contractor shall arrange the work so that construction of the new fence will immediately follow removal of existing fence.
  
- F. The unfenced section shall be of such length that the livestock can be kept in the proper field. The work shall progress in this manner and at the close of the working day the newly constructed fence shall be tied to the existing fence.
  
- G. Openings in the fence shall be guarded when livestock is in the adjoining property.

### **1.11 CLEARING FENCE LINE**

- . The site of the fence shall be sufficiently cleared of obstructions, and surface irregularities shall be graded so that the fence will conform to the general contour of the ground.

- A. The fence line shall be cleared to minimum width of 1 metre on each side of the centre line of the fence.
- B. This clearing shall consist of the removal of all stumps, brush, rocks, trees, or other obstructions which will interfere with proper construction of the fence. The clearing must be within the airport boundaries.
- C. Stumps within the cleared areas of the fence line shall be grubbed or excavated.
- D. The bottom of the fence shall be placed at a uniform distance above the ground as specified by the Supervisor.
- E. As directed by the Supervisor, existing fences which coincide with, or are in a position to interfere with the new fence location shall be removed by the Contractor as a part of the construction work.
- F. All holes remaining after stump and post removal shall be refilled with suitable soil, gravel, or other material subject to the acceptance of the Supervisor and shall be properly compacted with tampers.
- G. The work shall include the handling and disposal of all material cleared, excavated or removed, regardless of the type, character, composition, or condition of such material encountered.
- H. Performance of the work under this clause shall be considered as a subsidiary obligation of the Contractor covered under the item "Chain-Link Fence".
- I. Grading operation exceeding fill or excavation layers of 0.15 m thickness shall not be considered as normal grading.
- J. If so ordered by the Supervisor, fill or excavation exceeding the 0.15 m shall be carried out by the Contractor.

## **1.12 INSTALLING POSTS AND SUPPORTS**

- . All posts shall be spaced as shown on the drawings.
- A. Line and corner posts and supports shall be set in concrete bases as shown on the drawings. The top of the base shall be slightly above the ground surface, trowel finished, and sloped to drain.
- B. Holes of full depth and size for the concrete bases for posts shall be provided.

- C. the concrete bases shall be allowed to cure for 7 days before top rails, tension wire and fabric are installed.
- D. Should rock be encountered at a depth less than the planned footing depth, a hole 50 mm larger than the greatest dimension of the posts shall be drilled to a depth of 300 mm.
- E. After the posts are set, the remainder of the drilled hole shall be filled with grout, at Contractor's expense.
- F. If top rails are required, an expansion coupling shall be placed at approximately 30 metres intervals to take care of expansion and contraction of the rail.
- G. All corner and support posts etc. shall be braced as shown on the drawings.
- H. Support posts shall be set at approx. 100 metres intervals and braced as shown on the drawings.

### **1.13 INSTALLING BARBED WIRE AND TENSION WIRE**

- A. All barbed wire and tension wire shall be placed on the side of the posts away from the airport or as directed by the Supervisor, at the height indicated on the plan.
- B. The wire shall be carefully stretched and hung without sag and with true alignment. Care shall be taken not to stretch the wire so tightly that it will pull up corner, support and gate posts.
- C. All wires shall be fastened securely to each post by fasteners or clips designed for use with the posts furnished.
- D. The wires shall be wrapped around end, corner and gate posts, and the ends of all horizontal wires shall be tied with snug, tight twists.
- E. The wires shall be secured to each post to prevent slipping out of line or becoming loose.
- F. Splices in barbed and tension wire shall be permitted if made with an approved galvanized bolt-clamp splice.
- G. The bottom tension wire shall clear the ground by not more than 0.1 m at any place.

#### **1.14 ELECTRICAL GROUNDS**

- . Where a power line/cable passes over or under the fence, electrical grounds shall be constructed.
- A. The electrical grounds shall be installed 10 m before and 10 m after the point of crossing.
- B. The electrical grounds shall be accomplished with a copperclad rod 2.4 m long and a minimum of 15 mm in diameter driven vertically until the top is 150 mm below the ground surface.
- C. A solid copper conductor shall be clamped to the rod and to the fence in such a manner that each element of the fence is grounded.
- D. Installation of ground rods shall not constitute a pay item and shall be considered incidental to fence construction.

#### **1.15 INSTALLING FABRIC**

- . The chain link fabric shall be installed by a method as recommended by the supplier.
- A. Standard chain-link fence stretching equipment shall be provided for stretching the fabric before tying it to the wire or rails and posts.
- B. Stretching operations shall be repeated about every 30 metres.

#### **1.16 INSTALLING GATES**

- . The gates shall be hung on gate fittings to match the existing. They shall be attached in such a manner that the gate cannot be lifted off the hinges.
- A. Gates shall be so erected as to swing in the direction indicated or as directed by the Supervisor and shall be provided with gate stops.
- B. All hardware shall be thoroughly secured, properly adjusted, and left in perfect working order.
- C. Hinges and diagonal bracing in gates shall be adjusted so that the gates will hang level.

### **1.17 CONNECTION WITH EXISTING FENCE**

- A. Wherever the new fence joins an existing fence, either at a corner or at the intersection of straight fence lines, a corner post with a brace post shall be set at the junction and braced the same as shown on the drawings.
  
- B. If the connection is made at other than the corner of the new fence (e.g. to a building), the last span of the old fence shall contain a brace span.

### **1.18 CLEANING-UP SITE**

- A. The Contractor shall remove from the vicinity of the completed work all tools, equipment, etc. belonging to him or used under his direction during the construction.

**END OF SECTION : 02821 FENCES AND GATES**

## **SECTION 03312 - CONCRETE BASES, FOUNDATIONS, PITS AND WIND CONE MARKERS**

### **PART 1 - GENERAL**

#### **1.1 DESCRIPTION**

- A. This item shall consist of the furnishing and installation of concrete bases or footings for airfield lighting units, PAPI, floodlighting poles, windcones, concrete pits for transformers, earth rods, test links, pull boxes, fuel tanks, generators, distance to go markers and bands for windcones, in accordance with this specification and all conforming the locations and dimensions as shown on the drawings or as required by the Supervisor.
  
- B. This item shall also include all excavation, backfilling, removal and restoration of any paved or unpaved area and all formwork etc. to complete the item.
  
- C. The items under this section shall be provided or constructed in close co-operation with the supplier of the equipment, in order to avoid all interference with materials installed in a later stage of the work, with special reference to hole, pipe, bolt and thread sizes.

#### **1.2 RELATED SECTIONS**

- A. Sections to be referred to, related to this Section:
  - 1. Section 02766 - Pavement Marking
  - 2. Section 03311 - Structural Concrete

### **PART 2 - PRODUCTS**

#### **1.3 CONCRETE**

- . Concrete and reinforcements for bases, pits, foundations and markers shall conform to Section for structural concrete as specified in Section 3311.
  
- A. Aggregates shall have a maximum size of 25 mm.
  
- B. Quality shall be that of structural cement concrete.

## 1.4 CONDUIT ELBOW ASSEMBLIES

- . Elbows as used in concrete light bases or footings, if any, shall conform to the dimensions on the drawings.
- A. The elbows shall be hot-dip galvanised, (the weight of the coating shall be not less than 0.75 kg per square metre) or PVC or glass fibre.
- B. If required, elbows are to be provided with a threaded socket at the top end and with an earthing device at the lower end and consisting of a bolt, two nuts with two washers, all nickel plated brass.

## 1.5 STEEL BASE PLATE

- . Steel base plate as used for hollow concrete bases, if any, shall be fabricated from 10 mm minimum thickness standard steel plate or as shown on drawings.
- A. The dimensions of the base plates with bolt circles shall be as shown on the applicable drawings.
- B. The plates shall be treated after fabrication for corrosion protection by hot-dip galvanising. The minimum weight of the coating shall be not less than 0.75 kg per square metre. The entire top of the base plate shall be wiped smooth after application of the coating so that a flat surface within  $\pm 0.25$  mm is provided.
- C. The steel base plate shall be provided with stainless steel bolts and nuts as indicated on the drawings.
- D. Stainless steel earthing bolts with washers and nuts shall be supplied if indicated on the drawings.

## PART 1 - EXECUTION

### 1.10 EXCAVATION

- . The Contractor shall do all excavation of sufficient size to permit the placing of the structure. Excavated material not required or acceptable for backfill shall be disposed of.
- A. Common excavation shall not be carried below the required depth. When this is done, the trench or pit shall be backfilled at the Contractor's expense with material approved by the Supervisor and compacted to at least the density of the surrounding earth material.

- B. Boulders, logs, or any other objectionable material encountered in excavation shall be removed. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface either level, stepped, or serrated, as directed by the Supervisor. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed.
- C. When concrete is to rest on a surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall not be made until just before the concrete or reinforcing steel is to be placed.
- D. Where a firm foundation is not encountered at the design grade, due to unstable soil, this soil shall be removed and replaced with sand or with approved granular material. The Supervisor shall determine the depth of removal of unstable soil and the amount of backfill necessary. The backfill shall be compacted and shaped to a firm but slightly yielding condition to form the bed for the structure.
- E. The foundation of the structure shall be controlled and compacted to the depth and density specified by the Supervisor.
- F. Where indicated on the drawings working floors of blinding concrete 50 mm thick shall be made.
- G. The Contractor shall do such bracing, sheeting, or shoring necessary to perform and protect the excavation and the structure as required for safety and conformance to governing laws, and perform all grading and pumping, if necessary, to prevent water running in and keep the excavated pits dry.
- H. The bracing, sheeting, or shoring shall be removed by the Contractor after placing and completion of the structure. Removal shall be effected in a manner, which will not disturb or mark finished concrete.

### **1.11 CONCRETE LIGHT BASES, FOUNDATIONS OR FOOTINGS AND PITS**

- . Concrete bases, footings, transformer pits, test link pits and earthing rod pits shall be constructed as indicated on the drawings and figures. Bases, footings and pits may be prefabricated or cast in place.
- A. Bases, footings and pits shall not be placed or constructed before earthwork operations in that particular area are finished. Prefabricated bases shall be placed in mortar on 50 mm of blinding concrete.
- B. After formwork and, where applicable, steel conduits, support tube sockets, and/or steel reinforcements have been placed, concrete shall be poured and the top of the footing, pit or cover, trowel finished.

- C. The bases, footings and pits shall be cured for at least 4 days. They are to be protected against damage, particularly during pavement operations. To avoid damage to the bases and pits, it shall be allowed to keep roller wheels a small distance away, as directed by the Supervisor, from the base walls. Compaction of backfill and base material shall be accomplished with pneumatic tampers. The conduit holes are to be plugged both sides by readily removable plugs.
- D. After concrete has hardened and after approval of the Supervisor, the steel base plates shall be placed. A sealing strip between steel base plate and concrete shall be supplied and placed.

### **1.12 CONCRETE FOOTING FOR FLOOD LIGHT POLE**

- . The bases for the light poles shall be constructed in reinforced Portland cement concrete in accordance with the requirements for structural concrete as specified in Section 3311 and as shown on the drawings.
- A. The concrete bases shall be built on prepared foundations, conform to the dimensions indicated on the drawings or as required by the Supervisor.
- B. Instructions of the manufacturer of the poles shall strictly be followed with regard to conduits, anchor bolts, etc.
- C. The required reinforcement, anchor bolts, lighting poles and conduits shall be placed as indicated on the drawings and shall be approved by the Supervisor before the concrete is poured.
- D. In order to achieve a firm bond between the base and the surrounding soil, backfilling along the vertical faces of the base will not be permitted. The volume of poured concrete shall be equal to the volume of excavation, as indicated on the drawings.

### **1.13 FOUNDATION SLABS FOR PAPI SYSTEMS**

- . The Contractor shall construct reinforced concrete foundation slabs for each indicator.
- A. The dimensions and details of the slabs shall be as indicated on the drawings.
- B. Reinforcement shall be as shown on the drawings.
- C. After excavation to the required depth, the subgrade shall be compacted to the density as required by the Supervisor and the concrete for the slabs is to be placed on a separation layer of polyethylene sheeting.

- D. Anchors for the supports shall be placed according to Manufacturer's instructions. The surface of the slabs shall be smooth finished and the concrete properly cured during the first seven days.
- E. After approval of the Supervisor the units shall be assembled and the excavation shall be filled with stone chippings or clean gravel.

#### **1.14 FOUNDATIONS FOR WINDCONES, FUEL TANKS AND GENERATORS**

- . The bases for these assemblies shall be constructed of reinforced Portland cement concrete with cast-in foundation bolts, all in accordance with the applicable drawings and with the instructions of the supplier of the above assemblies.
- A. Concrete and reinforcement shall conform to section for structural concrete as specified in Section 3311.

#### **1.15 WIND CONE CIRCULAR BANDS**

- . The locations of the wind cones shall be marked by a circular band of reinforced cement concrete, as shown on the drawings.
- A. Such a band shall be centred around the wind cone support. The band is to be elevated above finished terrain level.
- B. The subsoil shall be levelled and compacted to 95% of the MDD at OMC.
- C. In the centre plane of this band a light reinforcement should be placed of wire mesh, diameter 6 mm, spacing 200 mm.
- D. The upperside of the concrete band shall be painted with black and reflective white marking paint, which shall meet the requirements of section pavement markings as specified in Section 02766.
- E. Expansion joints shall be made as indicated on the drawings.

#### **END OF SECTION: 03312 CONCRETE BASES, FOUNDATIONS, PITS AND WIND CONE MARKERS**

## SECTION 16001 - GENERAL PROVISIONS – ELECTRICAL

### PART 1 - GENERAL

#### 1.10 SCOPE OF WORKS

- . The works described under this supply package comprise fabrication, delivery, installation, and testing complete in all details of the electrical systems, all work and materials incidental to the proper completion of the works as described and defined in the Contract documents.
- A. All items of the works, materials, work, etc. specified and/or shown on the drawings shall be included, unless it is specifically mentioned as being supplied or carried out by others.  
Actions, which in these Specifications are specified in the passive mode, without explicit mentioning who will perform the described action, shall be performed by the Contractor.
- B. If anything has been omitted or not enumerated in the specifications and drawings of any item of work, which is necessary and usually furnished with the materials and is standard practice in electrical installations, then such items are deemed to be included in this works.
- C. In general, references to requirements specified in other sections of the Specification or in other Contract documents are not explicitly stated. The Contractor shall comply with all requirements stated anywhere in the Contract documents.

#### 1.11 UTILITY CONNECTIONS

- . All permits and electrical fees required for this work shall be obtained by and at the expense of the Contractor.
- A. The electrical distribution boards in the ATC equipment room shall be connected to the internal power distribution system of the facility. This system is backed up by a diesel driven generator and an uninterruptible power system.
- B. The Contractor shall obtain certificates of final inspection and approval from the jurisdictional authorities, and submit these to the Project Manager before taking over.

#### 1.12 DEFINITIONS

- . Supplementary to the terms defined in the Conditions of Contract, the following terms used in this division of the Specification shall be defined as stated below:
  0. “Dangerous voltage”: A voltage above 50 V AC or DC in a circuit connected directly or indirectly to a power source or power storage.
  1. “Finished space”: A room or space that is not unfinished as defined in item 9. Any space ordinarily visible to the public, including exterior spaces.
  2. “Install”: To erect, mount and connect complete with all related accessories.

3. "Lifetime", "Useful lifetime": The period of time the plant or component will maintain full functionality with max. 10% drop in MTBF, provided that normal preventive maintenance has been carried out in accordance with the manufacturer's recommendations.
4. "Normal conditions": The state, where the plant is in operation or ready for operation, with all lids, doors and covers closed, and with ambient temperature and supply voltage and -frequency within specified limits.
5. "Provide": To supply, install and test complete and ready for safe and reliable regular operation the particular plant referred to.
6. "Public area": A room or space that is ordinarily accessible to the public including the passengers.
7. "Supply": To purchase, procure, acquire and deliver complete with all related accessories.
8. "Unfinished space": A room or space that is ordinarily only accessible to maintenance personnel. A room, which on the finish schedule has exposed building structures for ceiling, walls and floors.

### **1.13 ELECTRICAL CHARACTERISTICS**

- . Unless otherwise shown on the drawings, the nominal secondary voltage will be 230/400 V  $\pm$  7%, 50 Hz  $\pm$  1% in a three phase neutral system.

### **PART 1 - PRODUCTS**

- . Not applicable

## **PART 1 - EXECUTION**

### **1.10 SAFETY REQUIREMENTS**

- . All plant and installations supplied under this contract shall provide maximum protection against electric shock, during installation and when used under normal conditions during the lifetime of the system. This requirement shall be the prime and overall consideration for the Contractor in the selection of materials and working methods, and in the layout of details of the installations.
  
- A. No work shall be carried out on energized systems carrying dangerous voltage, except when it is strictly necessary for testing and/or adjustment. Such work on energized systems shall be carried out only by specially instructed persons, and shall be constantly supervised by a competent supervisor, who must not take part in the work.
  
- B. No exposed live conductive parts carrying dangerous voltage shall be left unattended at any time.
  
- C. If an electrical system of any voltage is partly energized, accidental energizing of the remaining system shall be effectively prevented by padlocking.

**END OF SECTION: 16001 GENERAL PROVISIONS ELECTRICAL**

## SECTION 16050 - BASIC ELECTRICAL REQUIREMENTS

### PART 1 - GENERAL

#### 1.10 DESCRIPTION

- . It is understood and agreed that the Contractor has, by careful examination of drawings and specifications, and the Site where appropriate, satisfied himself as to the nature and location of the Works, and all conditions which shall be met in the order to carry out the works in this supply package.
- A. Professions of ignorance regarding this requirement of the work shall in no way serve to modify the conditions of the Contract.
  - 0. The scope of works consist of furnishing and installing complete electrical systems. The Contractor shall provide all supervision, labour, materials, equipment, machinery and all other items necessary to complete the systems. The Contractor shall note that all items of equipment are specified in the singular; however, the Contractor shall provide and install the number of items of equipment as indicated on drawings and as required for complete systems.
- B. It is the intention of specifications and drawings to call for finished work, tested and ready for operation.
- C. Any apparatus, appliance, material or work not shown on the drawings but mentioned in specifications or vice versa or any incidental accessories necessary to make the work complete and perfect in all respects and ready for operation, even if not particularly specified, shall be furnished, delivered and installed by the Contractor without additional expense to the Contracting Authority.
- D. Minor details not usually shown or specified, but necessary for proper installation and operation, shall be included in the Contractor's estimate, the same as is herein specified or shown.

#### 1.11 APPLICABLES CODES AND STANDARDS

- . The following codes and standards are valid for the complete scope of works as described in section 01101:
  - 0. ICAO – International Civil Aviation Organization:

***Annex 10, Aeronautical Telecommunications, Volume I, fifth edition***

***Annex 14, Aerodrome Design and Operations, fourth edition***

***Aerodrome Design Manual, Part 5, Electrical Systems, first edition***

- 1. IEC - International Electrical Committee:

***IEC 60364, Electrical installations in buildings, edition 4.0***

***IEC 60929, Degrees of protection provided by enclosures of electrical equipment (IP Code)***

***IEC 61394, Characteristics of greases for aluminium, aluminium alloy and steel bare conductors, edition 1.0***

2. NETA - International Electrical Testing Association:

***NETA Acceptance Testing Specifications, edition 2005.***

3. ANSI – American National Standards Institute

***A13.A table 3, Cable labelling***

***C12.1 – Code for Electricity Metering***

***C39.1 – Electrical Analogue Indicating Instruments***

***C57.13 – Instrument Transformers***

4. IEEE – Institute of Electrical and Electronics Engineers

***1184 - Guide for Selection and Sizing of Batteries for Uninterruptible Power Systems.***

***C62.41 – Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits***

5. NEMA – National Electrical Manufacturers Association

***AB 1 – Molded Case Circuit Breakers***

***FU 1 – Fuses***

***KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches***

***PB 2 – Dead Front Distribution Switchboards (600 V max)***

***PB 2.1 – Proper Handling, Installation, Operation and Maintenance of Dead front Switchboards Rated 600 V or less***

***PE 1 - Uninterruptible Power Systems***

6. ASHRAE – American Society of Heating Refrigerating and Air Conditioning Engineers

***Standard 62.1-2004 – Ventilation for Acceptable Indoor Quality***

7. OSHA – Occupational Safety and Health Administration

***29 CFR, Occupational Safety and Health Regulations***

**1.12 SPECIFICATIONS AND DRAWINGS**

- . It is intent of specifications and the accompanying drawings to provide a complete workable facility. Drawings and specifications are complementary and what is called for by one shall be as binding as if called for by both. Items shown on drawings are not necessarily included in the specifications. In case of conflict between drawings and specifications, the conflict shall be resolved by the Project Manager.
- A. If directed by the Project Manager, the Contractor shall, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the works.

### **1.13 SUBMITTALS**

- . Submittals shall be made in accordance with the Contract.

### **1.14 APPROVAL**

- . Approval of electrical materials and equipment shall be based on Manufacturer's published data. Where materials or equipment are specified to be constructed and/or tested in accordance with International Standards, proof of such conformance shall be submitted for approval as well as copies of the standards. A reputable manufacturers certified statement indicating complete compliance of each item with the applicable International Standards, or other commercial standard specified shall be submitted but will not be sufficient as proof of compliance. A certified copy of test reports to the referenced standards shall be submitted to the Project Manager on his request.

### **1.15 SUBSTITUTION OF MATERIAL AND EQUIPMENT**

- . Unless substitution is specifically forbidden, alternatives may be submitted for approval.

### **1.16 CLIMATIC CONDITIONS**

- . Climatic conditions and weather characteristics on the project site are available by the Contracting Authority.

### **1.17 DELIVERY, STORAGE AND HANDLING**

- . Deliver electrical materials and equipment in the Manufacturer's original cartons or containers with seals intact as applicable. Unless otherwise specified, deliver conductors in sealed cartons or on sealed reels, ends of reeled conductors factory sealed. Deliver large multi-component assemblies in sections that facilitate field handling and installation.
- A. Store materials and equipment off the ground and under cover. Prevent corrosion, contamination or deterioration. Unless the equipment item is specifically designed for outdoor exposure in a non-operating mode, all items shall be stored in a protected environment.
- B. Handle materials in accordance with best industry practices and manufacturers recommendations. Lift large or heavy items only at the points designed by the manufacturer. Use padded slings and hooks for lifting as necessary to prevent damage as indicated in accompanying certificates of lifting devices.

- C. The Contractor shall inform the Project Manager of receiving of equipment to inspect before installation and if approved shall submit all installation manuals to the Project Manager to witness adequate installation and erection.

### **1.18 PROTECTION**

- . Provide protection for electrical materials and equipment until final acceptance. Keep electrical equipment, materials and insulation dry at all times. If partial dismantling of equipment is required for installation, box or wrap the removed parts until reinstalled.

### **1.19 COOPERATION WITH OTHER TRADES**

- . The Contractor shall give full cooperation to other trades and shall furnish (in writing, with copies to the Project Manager) any information necessary to permit the work of all other trades to be installed satisfactorily and with least possible interference or delay.

### **1.20 SAFETY SIGNS**

- . All access panels to electrical equipment, power distribution apparatus and grounding pits shall have appropriate warning labels in English conforming to local practice reading "DANGER OF ELECTRICAL SHOCK".
- A. All signs shall be of durable quality and comprise a substrate of 22 gauge aluminium, pre-drilled for fixing and with reduced corners, free of burrs or sharp edges. Symbols and lettering shall be screen printed and have a minimum height of 3 cm.

## **PART 1 - PRODUCTS**

### **1.10 STANDARD PRODUCTS**

- . Materials and equipment to be provided shall be essentially the standard catalogued products of a manufacturer regularly engaged in the manufacturing of such products. Materials and equipment shall meet the applicable requirements of the specifications and shall essentially duplicate material and equipment that have been in satisfactory use at least 2 years.
- A. Standard catalogue items and IEC standard sizes, ratings, capacities and voltages shall be given preference.

### **1.11 PROHIBITED MATERIALS**

- . Aluminium conduits, fittings, supports and conductors shall not be acceptable unless specially approved for each use and location.

### **1.12 EQUIPMENT AND ENCLOSURES**

- . All equipment shall be properly derated for ambient heat, altitude and similar climatic conditions which will affect the operation and performance.
- A. Outdoor electrical equipment and enclosures shall be vermin, rain and dustproof, indoor electrical equipment/enclosures shall be dustproof, unless otherwise specified or indicated on related documents or drawings.
- B. Equipment located in damp or wet locations shall meet exterior requirements.

### **1.13 FACTORY FINISHES**

- . All metallic materials shall be protected against corrosion. All ferrous metals such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers and miscellaneous parts not of corrosion-resistant steel, shall be hot-dip galvanized except where other equivalent protective treatment is specifically approved.

### **1.14 NAMEPLATES**

- . Nameplates shall designate the function and location of the equipment for which they are used. The designations shall be submitted for approval with shop drawings. Nameplates, which will be used indoors, shall be 3-layer black-white-black, engraved to show black letters on white background. Edges of nameplates shall be bevelled. The nameplates shall be made of non-corrodible material and be fastened by rivets or self tapping screws or even adhesive to be approved by the Project Manager.

### **1.15 COMMON REQUIREMENTS**

- . Where two or more units of the same class of material or equipment are required, the Contractor shall provide products of a single Manufacturer.

## **PART 1 - EXECUTION**

### **1.10 PROTECTION DURING CONSTRUCTION**

- . Throughout the Contract, the Contractor shall provide protection for materials and equipment against loss or damage.

### **1.11 EXCAVATION AND BACKFILLING**

- . Shall be done by such equipment and methods according to the dimensions of concrete pits for test link points and inspection of the earth electrodes.

### **1.12 INSTALLATION**

- . Install electrical work in accordance with the Codes and Standards specified in this section, except where more stringent requirements are indicated or specified. Verify that materials and equipment properly fit the installation space with clearances as specified. Perform work as required to correct improper installations at no additional cost to the Contracting Authority.

### **1.13 CONNECTIONS TO FIXED ELECTRICAL EQUIPMENT**

- . The Contractor shall provide and install power cables to all fixed electrical equipment complete and ready for operation including load break switches.
- A. Where connections are made to equipment furnished by other Contractors or the Contracting Authority, the Contractor shall obtain exact locations of connections from persons furnishing said equipment and/or from shop drawings of the equipment manufacturer.
- B. Throughout the course of the work minor changes and adjustments to drawings and specifications may be requested by the Project Manager. The Contractor shall make such adjustments without additional cost to the Contracting Authority where such minor adjustments are necessary to the proper installation and operation of the work and are within the intent of the Contract Documents.

### **1.14 ELECTRICAL SUPERVISION AND WORKMANSHIP**

- . In addition to supervision required under the Contract, an approved, experienced electrical Project Manager shall supervise the electrical construction work from beginning through completion and final acceptance. Employ skilled craftsmen experienced in the installation of types of electrical materials and equipment specified. Use specialized installation tools and equipment as applicable. Produce acceptable installations free of defects.

### **1.15 TESTING**

- . The Contractor shall carry out all site testing (detailed hereinafter and in each corresponding section) and shall provide all instruments and equipment necessary for satisfactorily carrying out the tests.
- A. All electrical equipment covered by specifications shall be subject to inspection during manufacture. The inspection shall be carried out by the Project Manager who may carry out or witness any tests that may be deemed necessary. All

required materials for inspection and testing as well as all testing equipment shall be furnished by the Contractor and included in the Contract Price. The Contractor shall carry out all tests specified in the latest relevant Standards to the satisfaction and in presence of the Project Manager.

- B. Tests shall be carried out prior to the shipment. The Contractor shall give due notice of not less than fourteen days to the Project Manager as to when the different parts of the equipment will be ready for different tests involved. Where third party inspection services are used, they shall be in accordance with the Standard Quality Assurance Procedures.
- C. Shipment of materials and equipment shall not be effected unless the Project Manager's release note is obtained. No release note issued by the Project Manager shall relieve the Contractor from his liability to supply equipment according to specifications or exonerate him from any of his guarantee according to the Contract Documents. Failure to notify the Project Manager that tests shall be carried out may necessitate the tests being carried out again in the presence of the Project Manager at no extra cost to the Contracting Authority.
- D. As the records of all testing shall be submitted to the Project Manager immediately after the tests are conducted and shall also form part of the record documents, the format of the test report shall be agreed upon the Project Manager, prior to the commencement of testing.
- E. The Contractor shall conduct tests during and at the completion of the installation and immediately prior to setting the installation to work to demonstrate amongst other things the following:
  - 0. That equipment complies with specifications;
  - 1. That installations comply with approved Standards (Current Edition), the Electricity Supply Regulations, Licensing Authorities and Fire Regulations where applicable;
  - 2. That all protective devices are correctly adjusted and operate satisfactorily;
  - 3. That all conduit, trunking and cable tray systems are mechanically and electrically continuous and properly earthed;
  - 4. That the entire earth continuity and bonding of the entire installation to the general mass of earth is satisfactory;
  - 5. That the polarity of all switches, circuit breakers and the phase rotation of the respective systems are correct;
  - 6. That all instruments are correctly calibrated and accurate;
  - 7. That all alarm, indication, emergency, fail safe and protection system function to design.
- F. The Contractor shall also demonstrate the satisfactory operation of any section of the installation to external authorities such as Fire Officers, Factory Inspectors, Licensing Authorities, Insurance Company Representatives.
- G. Should defects occur to any section of the installation after commissioning, the Project Manager reserves the right to call for such further tests as may be necessary to identify the nature and location of the defect and to demonstrate

the satisfactory completion of the remedial works. The Contractor shall bear all costs involved in carrying out the additional testing.

- H. Individual materials and methods of the installations shall be tested as detailed in the corresponding specification sections.

#### **1.16 COMMISSIONING AND START-UP**

- . Before energising any equipment supplied by others or by the Contracting Authority, and to which the Contractor is required to make electrical connections, the Contractor has to satisfy himself that such equipment is in the de-energized condition, has no phase-to-phase or phase-to-earth faults and that it is properly earthed. The actual commissioning and operational testing of the equipment shall be the responsibility of the Contractor of the equipment.

#### **END OF SECTION: 16050 BASIC ELECTRICAL REQUIREMENTS**

**SECTION 16075**  
**ELECTRICAL IDENTIFICATION**

**PART 1 - GENERAL**

**1.10 DESCRIPTION**

- . This Section includes electrical identification materials and devices required to comply with the applicable codes and standards and authorities having jurisdiction.

**1.11 RELATED SECTION**

- . The following sections include requirements which relate to the work of this section:
  0. Section 16050: Basic electrical requirements
  1. Section 16100: Grounding
  2. Section 16129: Indoor cables and wires
  3. Section 16178: Underground cables

## PART 1 - PRODUCTS

### 1.10 RACEWAY AND CABLE LABELS

- . Labels shall comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of colour field for each raceway and cable size.
  - 0. Colour: Black letters on orange field.
  - 1. Legend: Voltage indication.
- A. Adhesive labels shall be pre-printed, flexible, self-adhesive vinyl with legend, overlaminated with a clear, weather- and chemical-resistant coating.
- B. Pre-tensioned, wraparound plastic sleeves shall be flexible, pre-printed, colour-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pre-tensioned gripping action when placed in position.
- C. Coloured adhesive tape shall be self-adhesive vinyl tape not less than 0.08 mm thick, 25 mm high and 51 mm wide.
- D. Underground-line warning tape shall be permanent, bright-coloured, continuous-printed, vinyl tape.
  - 0. Not less than 152 mm wide by 0.102 mm thick.
  - 1. Compounded for permanent direct-burial service.
  - 2. Embedded continuous metallic strip or core.
  - 3. Printed legend indicating type of underground line.
- E. Tape markers shall be vinyl or vinyl-cloth, self-adhesive, wraparound type with pre-printed numbers and letters.
- F. Aluminium, wraparound marker bands shall consist of bands cut from 0.4 mm thick aluminium sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.
- G. Plasticized card-stock tags shall be vinyl cloth with pre-printed and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.
- H. Aluminium-faced, card-stock tags shall be a weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminium sheet, 0.05 mm thick, laminated with moisture-resistant acrylic adhesive, punched for fasteners, and pre-printed with legends to suit each application.
- I. Brass or aluminium tags shall be 51 x 51 x 1.3 mm metal tags with stamped legend, punched for fastener.

## 1.11 NAMEPLATES AND SIGNS

- . Safety Signs shall be compliant with OSHA, 29 CFR, Chapter XVII, Part 1910.145.
- A. Engraved plastic nameplates and signs shall consist of an engraving stock, melamine plastic laminate, minimum 1.6 mm thick for signs up to 129 cm<sup>2</sup> and 3.2 mm thick for larger sizes. Other requirements are:
  - 0. Engraved legend with black letters on white face.
  - 1. Punched or drilled for mechanical fasteners.
- B. Baked-enamel signs for interior use shall be pre-printed aluminium signs, punched or drilled for fasteners, with colours, legend, and size required for the application. 6.4-mm grommets in corners for mounting.
- C. Exterior, metal-backed, butyrate signs shall be weather-resistant, non-fading, pre-printed, cellulose-acetate butyrate signs with 1-mm galvanized-steel backing; and with colours, legend, and size required for the application. For mounting in corners 6.4-mm grommets shall be used.
- D. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

## 1.12 MISCELLANEOUS IDENTIFICATION PRODUCTS

- . Cable ties shall be fungus-inert, self-extinguishing, one-piece, self-locking, type 6/6 nylon cable ties compliant to the following requirements:
  - 0. Minimum Width: 5 mm.
  - 1. Tensile Strength: 22.3 kg minimum.
  - 2. Temperature Range: -40 to +85 °C.
  - 3. Colour: According to colour-coding.
- A. Paint shall be formulated for the type of surface and intended use and compliant to the following requirements:
  - 0. Primer for galvanized metal: Single-component acrylic vehicle formulated for galvanized surfaces.
  - 1. Primer for masonry units: Heavy-duty-resin block filler.
  - 2. Primer for concrete: Clear, alkali-resistant, binder-type sealer.
  - 3. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

## PART 1 - EXECUTION

### 1.10 INSTALLATION

- . The identification of materials and devices shall be installed at locations for most convenient viewing without interference with operation and maintenance of equipment.
- A. The coordination of names, abbreviations, colours and other designations shall correspond with designations in the Contract or with those required by codes and standards. Consistent designation shall be used throughout the Project.
- B. If identification is applied to surfaces that require finish, identification shall be installed after completing finish work.
- C. Surfaces shall be cleaned before applying self-adhesive identification products.
- D. In circuits with more than 600 V, the raceway and cable shall be identified with "DANGER--HIGH VOLTAGE" in black letters 51 mm high, stencilled with paint at 3-m intervals over a continuous, painted orange background. Identify the following:
  - 0. Entire floor area directly above conduits running beneath and within 305 mm of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
  - 1. Wall surfaces directly external to conduits concealed within wall.
  - 2. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.
  - 3. Entire surface of exposed conduits.
- E. Painted identification shall be installed according to the Manufacturer's written instructions and as follows:
  - 0. Clean surfaces of dust, loose material, and oily films before painting.
    - 1. Prime surfaces using type of primer specified for surface.
    - 2. Apply one intermediate and one finish coat of enamel.
- F. Colour banding raceways and exposed cables shall be as listed below:
  - 0. Bands: Pre-tensioned, wraparound plastic sleeves; coloured adhesive tape; or a combination of both. Make each colour band 51 mm wide, completely encircling conduit, and place adjacent bands of two-colour markings in contact, side by side.
  - 1. Band Locations: At changes in direction, at penetrations of walls and floors, at 15 m maximum intervals in straight runs, and at 7.6 m maximum intervals in congested areas.
  - 2. The following colours shall be applied to the systems as listed below:

***Fire Alarm System: Red;***

***Fire-Suppression Supervisory and Control System: Red and yellow;***

***Combined Fire Alarm and Security System: Red and blue;***

***Security System: Blue and yellow;***

***Mechanical and Electrical Supervisory System: Green and blue;***

***Telecommunication System: Green and yellow.***

- G. Caution labels for indoor boxes and enclosures for power and lighting shall be pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Labels shall be installed on exterior of door or cover.
- H. Circuit identification labels on boxes shall be installed externally as following:
  - 0. Exposed boxes: pressure-sensitive, self-adhesive plastic label on cover.
  - 1. Concealed boxes: plasticized card-stock tags.
  - 2. Labelling legend: permanent, waterproof listing of panel and circuit number or equivalent.
- I. During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 150 to 200 mm below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 400 mm overall, use a single line marker. Install line marker for underground wiring, both direct- buried cables and cables in raceway.
- J. The following colours shall be used for service, feeder and branche-circuit phase conductors:
  - 0. 230-V Conductors: Phase A: Black;  
**Phase B: Red;**  
**Phase C: Blue.**
  - 1. Factory apply colour the entire length of conductors, except the following field-applied, colour-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:

***Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 150 mm from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 25 mm wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.***

***Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 76 mm from the terminal and spaced 76 mm apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.***

- K. Metal tags or aluminium, wraparound marker bands shall be used for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms as follows:
  - 0. Legend: 6.4 mm steel letter and number stamping or embossing with legend corresponding to indicated circuit designations;

1. Tag Fasteners: Nylon cable ties;
  2. Band Fasteners: Integral ears.
- L. Identification to conductors shall be applied as follows:
0. Conductors to be extended in the future: Indicate source and circuit numbers;
  1. Multiple power or lighting circuits in the same enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use colour-coding to identify circuits' voltage and phase;
  2. Multiple control and communication circuits in the same enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, colour-coding, or cable marking tape.
- M. Warning, caution, and instruction signs shall be applied as follows:
0. Warnings, cautions, and instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
  1. Emergency operation: Install engraved laminated signs with white legend on red background with minimum 9 mm high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- N. Equipment identification labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 13 mm high lettering on 38 mm high label; where two lines of text are required, use labels 50 mm high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment using mechanical fasteners:
0. Distribution boards, electrical cabinets, and enclosures;
  1. Access doors and panels for concealed electrical items;
  2. Electrical switchgear and switchboards;
  3. Electrical substations;
  4. Emergency system boxes and enclosures;
  5. Motor-control centres;
  6. Disconnect switches;
  7. Enclosed circuit breakers;
  8. Motor starters;
  9. Push-button stations;
  10. Power transfer equipment;
  11. Contactors;
  12. Remote-controlled switches;

13. Dimmers;
14. Control devices;
15. Transformers;
16. Inverters;
17. Rectifiers;
18. Frequency converters;
19. Battery racks;
20. Power-generating units;
21. Telephone switching equipment;
22. Clock/program master equipment;
23. Call system master station;
24. TV/audio-monitoring master station;
25. Fire alarm master station or control panel;
26. Security-monitoring master station or control panel.

**END OF SECTION: 16075 ELECTRICAL IDENTIFICATION**

## **SECTION 16100**

### **GROUNDING**

#### **PART 1 - GENERAL**

##### **1.10 SUMMARY**

- . This section shall consist of the design, manufacture, fabrication, supply and installation, testing and commissioning and putting into operation of the grounding system.
- A. Section includes all work, products and materials required for grounding of the electrical and communication installations of Supply Package Lot 1, Navigational Aids.

##### **1.11 SYSTEM DESCRIPTION**

- . Electrical system grounding.
- A. Safety grounding of electrical equipment and installations.
- B. Grounding of all metal parts

##### **1.12 RELATED SECTIONS**

- . Section 16050: Basic electrical requirements

##### **1.13 PERFORMANCE REQUIREMENTS**

- . Overall resistance max. 1 Ohm.

##### **1.14 SUBMITTALS**

- . Shop drawings: Indicate layout and installation details of grounding components.
- A. Product data: Submit data for grounding electrodes and connectors.
- B. Test reports: Indicate continuity measurements.

## **PART 1 - PRODUCTS**

- . All metal parts of the installation shall be grounded with copper wire and earth rod electrodes as indicated on the drawing. Connections according to requirements of the International Electrical Code.

### **1.11 ROD ELECTRODES**

- . Diameter of steel rod: min. 16 mm. Length of steel rod: min. 3000 mm. Solid copper wire, min. 50 mm<sup>2</sup>, securely fastened to the bottom end of a driving steel rod.
- A. All copper-clad rods to be driven into the ground shall be provided with a detachable driving head to eliminate any deformation of the top end of the rod caused by the hammer blows.
- B. Connector for connecting the grounding electrode conductor to the grounding rod shall be copper or bronze and shall be UL listed for the purpose.

### **1.12 GROUNDING AND BONDING CONDUCTORS**

- . Bare stranded copper wire.
- A. For bonding lengths of raceway, cable tray or conduit: Proprietary connectors, factory made specifically for the raceway-, cable tray- or conduit system.

### **1.13 MECHANICAL CONNECTORS**

- . Connections between flat steel electrode and stainless steel electrode conductor: bolted with stainless steel, hexagonal head bolts and nuts, size min. M8, AISI 316S or equal quality.
- A. Connections between copper electrodes and copper electrode conductors: proprietary connectors of copper or bronze with dimensions exactly matching the two conductors to be connected. The connectors must be UL listed for the purpose.
- B. Concrete embedded connections between solid copper wire electrode and solid copper wire electrode conductor: UL listed pressure connectors.
- C. Connections between grounding- or bonding conductor and concrete reinforcement bars: UL listed pressure connectors or bolted connectors of copper, bronze or stainless steel, exactly matching the dimensions of the reinforcement bar and the conductor.
- D. Connections between cable armour or cable screen at entry into panels or appliances: Proprietary screwed armour connection brass glands, or galvanized or chrome-plated steel C-clamps.
- E. Other connections: according to requirements of the International Electrical Code.

### **1.14 BOLTED CONNECTIONS**

- . Bolted-pressure-type connectors, or compression type (C-clamp).

## **PART 1 - EXECUTION**

### **1.10 INSTALLATION**

- . Bond all exposed non-current carrying metalwork to the grounding collector terminal by using bonding conductors. Do not use the metalwork, as for example pipes, ducts, conduit, cable trays, structural steel, in lieu of grounding- or bonding conductors.
- A. Provide continuity between tray components. Provide two bare copper equipment grounding conductor through entire length of tray; bond to each component. Connections to tray may be made using mechanical connectors or compression connectors.
- B. For bonding of cable screens to metal enclosures, strip cable jacket or outer insulation from screen and use C-clamps or equal type of connector, which will ensure a big area of metallic contact surface. Place the clamps inside the panel not more than 50 mm from the cable entry. Do not use "Pig tails" for bonding of cable screens.

### **1.11 FIELD QUALITY CONTROL**

- . Inspect and test in accordance with NETA ATS.

## **END OF SECTION: 16100 GROUNDING**

**SECTION 16110**  
**LIGHTNING AND SURGE PROTECTION**

**PART 1 - GENERAL**

**1.10 DESCRIPTION**

- . Section includes all supply, products, work and services required for over-voltage- and surge protection electrical installations.
- A. Surge protection shall be provided on all cables for power supply of the equipment part of the Supply Package Lot 1, Navigational Aids, entering the AGL building, the equipment shelter or other buildings.
- B. Surge protection shall be provided on all low and extra low voltage cables for control of the equipment part of the Supply Package Lot 1, Navigational Aids, entering the AGL building, the equipment shelter or other buildings.

**1.11 RELATED SECTIONS**

- . The following sections include requirements which relate to the work of this section:
  - 0. Section 16050: Basic electrical requirements
  - 1. Section 16075: Electrical identification
  - 2. Section 16100: Grounding system

**PART 1 - PRODUCT**

**1.10 COMPONENTS**

- . Surge arresters
  - 0. Fine protection, low voltage circuits: Metal oxide varistor type with sine wave tracking. Rated 8/20  $\mu$ s surge current > 10 kA, residual voltage at rated surge current < 500 V. Response time < 5  $\mu$ s.
  - 1. Protection of extra-low voltage control circuits and telecommunication circuits: Metal oxide varistor or zener / avalanche diode type, with residual voltage < 200 V. Response time < 1  $\mu$ s. If a lower residual voltage value is specified or recommended by the manufacturer of the protected equipment, the manufacturer's value shall apply.

## **PART 1 - EXECUTION**

### **1.10 INSTALLATION**

- . Install in accordance with recommendation suppliers.

### **1.11 FIELD QUALITY CONTROL**

- . Perform inspection and testing in accordance recommendation suppliers.
- A. Obtain approval of Project Manager's Representative before backfilling trenches.

### **1.12 TESTING**

- . All grounding systems shall be tested.
- A. Test reports shall be prepared and shall be included in maintenance manuals.

**END OF SECTION: 16110 LIGHTING AND SURGE PROTECTION**

**SECTION 16129**  
**INDOOR CABLES AND WIRES**

**PART 1 - GENERAL**

**1.10 DESCRIPTION**

- . This section describes the furnishing and installation of indoor cables and wires for power supply, control and back indication in cable trenches and on cable trays, between the Control Tower distribution board, the control consoles and other equipment in the ATC tower.

**1.11 RELATED SECTIONS**

- . The following sections include requirements which are related to the work of this section:
  0. Section 16050: Basic electrical requirements
  1. Section 16075: Electrical identification
  2. Section 16100: Grounding
  3. Section 16129: Lightning and surge protection

## **PART 1 - PRODUCTS**

### **1.10 GENERAL REQUIREMENTS**

- . All cables and wires used indoor will be PVC sheathed, termite proof and with copper conductors. Unless specifically indicated on the drawings, all cables for indoor use may be without metal shield. Cable type, size, number of conductors, strand and service voltage is as specified on the drawings.

### **1.11 POWER CABLES**

- . These cables shall have a PVC insulated rubber bedding and PVC outer sheath.

### **1.12 CONTROL CABLES**

- . These cables shall be of the telephone type indoor cable with a tinned copper wire of 0.8 mm diameter, a PVC insulation of 0.4 mm and a PVC outer sheath of 1.8 mm.

### **1.13 CABLE MARKERS**

- . If not mentioned otherwise in the applicable sections, all cables in cable trenches or on cable trays shall be identified by means of standard strips to be approved by the Engineer and stamped according to circuit identification as indicated on the drawings with letters and numbers 6 mm high.
- A. Circuit markers shall be secured to the cable with binding wire. Circuit markers for indoor cables shall be spaced at approximately 5 m distance, with additional markers at each end.

## **PART 1 - EXECUTION**

### **1.10 SEPARATION**

- . Low voltage and control cables shall be placed on separate cable trays or in cable elements. Minimum distance shall be 15 cm between cables of different voltage rating.

**END OF SECTION: 16129 INDOOR CABLES AND WIRES**

## **SECTION 16178**

### **UNDERGROUND CABLING**

#### **PART 1 - GENERAL**

##### **1.10 SUMMARY**

- . This section describes the furnishing and installation of underground low voltage (LV) and remote control (RC) cable for the navigational aids between the equipment shelter and the navigational aids.
- A. The following cables shall be used:
  - 0. Low voltage cable (LV)
  - 1. Remote control cable (RC)
- B. These cables shall be installed in trenches, ducts and conduits at the locations and in accordance with the design, as shown on the drawings.
- C. This section shall include cable joints, cable marking and testing of the installation and all incidentals necessary to place the cables in operational condition to the satisfaction of the Project Manager.

##### **1.11 RELATED SECTIONS**

- . The following sections include requirements which are related to the work of this section:
  - 0. Section 16050: Basic electrical requirements
  - 1. Section 16075: Electrical identification
  - 2. Section 16100: Grounding
  - 3. Section 16110: Lightning and surge protection

##### **1.12 DELIVERY, STORAGE AND HANDLING**

- . Protect equipment from extreme temperature and humidity and store in a conditioned space. Prevent corrosion and contamination. Keep all electrical equipment dry at all times.
- A. Protect equipment from rodents, dust and debris by wrapping unit in transparent dust tight cover and storing away from construction activity.
- B. Handle equipment and materials in accordance with the Manufacturer's recommendations.

##### **1.13 MAINTENANCE SERVICE**

- . Provide service and maintenance of system during the entire Warranty period.

## PART 1 - PRODUCTS

### 1.10 GENERAL REQUIREMENTS

- . All LV and RC cables used in the field shall be suitable for direct burial with a metal shield as specified.
- A. All cables are subject to acceptance through the Contractor's certificate of guarantee. The length of cable on drum to be supplied shall be at least 500 m.
- B. All cables shall be marked with indications of type, core size, voltage rating and name of Manufacturer. Each cable shall be labelled with cable tags for identification of the cable.

### 1.11 MATERIAL REQUIREMENTS

#### A. LV-cable

1. General data:
  - Rated voltage 600 V
  - Number of conductors x cross sectional area (nr. x mm<sup>2</sup>) 2 or 5 conductors, sizes as indicated on the drawings
2. Conductor:
  - Type & material Tinned copper
  - The conductors are cabled and wrapped with a plastic tape
3. Insulation:
  - Type & material XLPE
4. Inner sheath:
  - Type & material PVC
5. Metallic screen:
  - Type & material Braid of galvanized steel wires, underneath with a flat braided earth continuity conductor of tinned copper wires.
6. Outer sheath:
  - Type & material PVC

The outer sheath shall be made watertight and ultra violet resistant. The outer sheath will be resistant to environmental conditions (heat, cold, water, chemicals, micro organisms etc.).

#### B. RC-cable

1. General data:
  - Rated voltage 600 V

- |    |   |  |
|----|---|--|
| 2. | Number of conductors x cross sectional area (nr x mm <sup>2</sup> )   | as shown on the drawings   |
| 3. | Conductor:<br>Type & material   | Tinned copper  |
| 4. | Conductors:<br>The conductors are cabled and wrapped with a plastic tape.   |  |
| 5. | Insulation:<br>Type & material  | XLPE   |
| 6. | Inner sheath:<br>Type & material  | Polyvinyl-chloride (PVC)   |
| 7. | Metallic screen:  | Braid of galvanized steel wires, underneath with a flat braided earth continuity conductor of tinned copper wires. |
| 8. | Outer sheath:<br>Type & material<br>The outer sheath will be made watertight and ultra violet resistant. The outer sheath will be resistant to local environmental conditions (heat, cold, water, chemicals). | PVC  |

- C. Cable joints: In-line connection of LV or RC cables shall consist of a plastic mould around a joint, which is to be filled with an epoxy resin, preferably using the pressure method and finally taped for water tightness.

## 1.12 CABLE MARKERS

- . Cable markers shall be as specified in section 16075, Electrical identification.

## PART 1 - EXECUTION

### 1.10 GENERAL INSTRUCTION METHOD

- . The Contractor shall install the specified LV and RC cables at the locations indicated on the circuit and trenching layout plans.

### 1.11 INSTALLATION

- . Installation in trenches
  0. The LV and RC cables shall be unreeled in place alongside or in the trench and shall be carefully placed on the sand bedding on the bottom of the trench.
  1. The cables shall not be unreeled at one spot along the trench and then from there pulled into the trench and dragged through the trench.
  2. Both cables are laid parallel in the same trench and they shall be placed apart with a minimum distance of 30 cm centre to centre.

3. The trench shall be wide enough to accomplish this.
  4. Cables crossing over each other shall have a minimum of 10 cm vertical displacement with the topmost cable depth at or below the minimum required depth below finished grade.
  5. When straightening out the cables, tension in the cables shall be avoided.
  6. The amount of slack cable at straight sections, in ducts and at connections shall be stipulated by the Project Manager and agreed by the Contractor before cable laying, no additional payment is made for this type of slack.
  7. RC cables shall be kept apart at least 30 cm from AGL cables and LV cables up to 600 V and water mains, and should be kept at least 50 cm apart from HV power cables up to 5 kV and also 50 cm from HV power cables of more than 5 kV.
- A. Installation in ducts
0. At a crossing with the runway, a taxiway, etc. the LV and RC cables will be installed in ducts.
  1. The maximum number and voltage ratings of cables installed in each single pipe of duct or conduit, shall be as follows:

***Power cables of the same voltage may be installed in the same duct.***

***Power cables of different voltage, but less than 600 V may be installed in the same duct.***

***Power cables of less than 600 V should not be installed in the same duct, with control, telephone, or coaxial type cables.***

***Power cables of more than 600 V should not be installed in the same duct, with control, telephone, coaxial or power cables of less than 600 V.***

***Control, telephone, and coaxial cables may be installed in the same duct.***

***Joints made in any cable shall not be installed in any duct.***

2. Joints made in any cable shall not be installed in any duct. The Contractor shall make sure that the complete duct is open, continuous and clear of debris before installing cables. A pulling wire is to be used for pulling the rope for the cable installation. The cable shall be installed in a manner to prevent harmful stretching of the conductor, injury to the insulation, or damage to the outer protective covering. The ends of all cables shall be capped or sealed with tropical moisture-seal tape or crimp socket before installing and it shall be left sealed until connections are made.
3. Where more than one cable is to be installed in a duct or conduit under the same contract, all cables shall be installed at the same time. The pulling of cable through ducts shall be accomplished with the use of cable grips or pulling eyes. Maximum pulling tensions shall be obtained from the Manufacturer of the cable for straight ends and bends.
4. A lubricant recommended for the type of cable being installed shall be used where pulling lubricant is required. Duct markers temporarily removed for

excavations shall be replaced as required. Kinks or cuts in the insulation or the sheath of the cable shall not be permitted and will cause rejection of that part of the cable length. Such cable shall be replaced by the Contractor without any additional cost for the Contracting Authority. After installation of cables in ducts, the Contractor has to make sure that the ends of ducts are provided with plugs to avoid clogging.

#### **1.12 CABLE TAGS AND MARKERS**

- . All LV and RC cables shall be identified as specified in section 16075, Electrical identification.

**END OF SECTION: UNDERGROUND CABLING**

## **SECTION 16210**

### **UNINTERRUPTIBLE POWER SYSTEM**

#### **PART 1 - GENERAL**

##### **1.10 SUMMARY**

- . This section shall consist of the design, manufacture, fabrication, supply and installation, testing and commissioning and putting into operation of static uninterruptible power supply (UPS) systems with a capacity of 3 kVA and located in the equipment shelter.

##### **1.11 RELATED SECTIONS**

- . The following sections include requirements which are related to the work of this section:
  0. Section 16050: Basic electrical requirements
  1. Section 16075: Electrical identification
  2. Section 16100: Grounding
  3. Section 16110: Lightning and surge protection
  4. Section 16129: Indoor cables and wires
  5. Section 16178: Underground cabling

## **1.12 SUBMITTALS**

- . Shop Drawings: Indicate electrical characteristics and connection requirements. Provide battery rack dimensions; battery type, size, dimensions, and weight; detailed equipment outlines, weight, and dimensions; location of conduit entry and exit; single-line diagram indicating metering, control, and external wiring requirements; heat rejection and air flow requirements.
- A. Product Data: Submit catalogue sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics and connection requirements.

## **1.13 CLOSEOUT SUBMITTALS**

- . Operation and Maintenance Data: Submit description of operating procedures; servicing procedures; list of major components; recommended remedial and preventive maintenance procedures; and spare parts list.

## **1.14 QUALIFICATIONS**

- . Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years documented experience.

## **1.15 DELIVERY, STORAGE AND HANDLING**

- . Protect equipment from dust and debris by wrapping unit in transparent dust-tight cover and storing away from construction activity.
- A. Deliver batteries no sooner than 21 days before charging.

## **PART 1 - PRODUCTS**

### **1.10 ENVIRONMENTAL CONDITIONS.**

- . The UPS system will be capable of operating under the following environmental conditions without degradation of its characteristics.
  0. Ambient temperature: 0° to 55° (C)
  1. Maximum relative humidity: 95% non-condensing
  2. Maximum elevation: 500 meters

### **1.11 ELECTRICAL CHARACTERISTIC OF THE UPS**

- . The rectifier/charger will be 12 Pulse for (40-300 KVA rated) with galvanic isolation and will be designed to match input electrical characteristic as follows:
  0. Input Voltage 230/400 V  $\pm$ 15%
  1. Input Frequency 50 Hz  $\pm$  10%
  2. Input Power Factor >0.95
  3. Input Current Distortion <5%

- A. A walk-in circuit will eliminate over currents during start-up by imposing a gradual increase of the rectifier/charger DC output voltage over a period of approximately 10 seconds.
- B. The rectifier/charger will incorporate a programmable input current limiter in order to preset maximum power level specified by the battery supplier or the generator supplier.
- C. The battery set will be lead acid, dry type, maintenance free batteries with 10 years (life expectancy) plus for float (application at 25° C) operation. The batteries will be installed in battery cabinets equipped with appropriate insulation.
- D. Back up time of the battery will be not less than 9 minutes at full load condition at load pf 0.8. Lagging.
- E. A battery calculation is to be submitted by the Contractor according to IEEE 485 and IEEE 1184 at 25 degree Celsius and 1.7 Volts per cell basis.
- F. Battery Standard Manufacture: ISO 9001. Case and cover EN 61056, EN 60896, IEC 1056, IEC 896, BS 6133, BS 6290.
- G. Battery monitoring system shall be equipped with remote and local monitoring real time and historical individual battery voltage, current at ambient temperature so that estimated individual battery life and capacity can be calculated. It must generate alarm and warning via front panel and dry contact.
- H. The UPS module is to be supplied with manufacturer standard moulded case circuit breakers that enable on load connection and disconnection of the battery to be made when necessary. The circuit breakers will be able to trip from the module.
- I. The UPS inverter will be PWM and 3 legs of IGBT component capable of accepting the output of the rectifier/charger or emergency battery and providing an alternating current output.
- J. The inverters will supply power not less than rated as indicated at max. p.f. 0.8 lagging.

0. Output Voltage, transient and recovering:

**Steady state at load step 0-100-0%: 230V ± 1%**

**Transient 100% steeped load: 230V ± 2%**

**Transient recovery time to ± 1% RMS: < 20 msec.**

**Output 100% Unbalanced Load : 400/230 V ± 3%**

1. Output Frequency:

**Steady state: 50 Hz ± 1%**

**Free running: 50 Hz ± 0.008%**

**Slew rate (df/dt): 0.5 Hz /sec. to 2 Hz/sec**

## ***With mains synchronisation***

***0.25 Hz to 2 Hz adjustable***

- K. When feeding the load the output filter of the inverters unit will limit the total harmonic distortion generated as follows:
  - 0. 100% linear load (Phase to Phase): max. 2%
  - 1. 100% non-linear load (Phase to Phase): max. 3%
- L. The UPS will be provided with a single step static switch enabling instantaneous load transfer from inverter to the bypass AC input source and vice-versa without interruption or disturbance provided that the bypass source voltage and frequency are within the limits.
- M. The UPS module shall be capable of supplying 165% of the rated power at full load for 60 sec. during normal operation (input power present). The inverters will be able to supply current up to 2.33 times full load current for 1 second in order to clear short circuit faults.
- N. The UPS module will operate at an overall system efficiency not less than 92.5% from 50% to full load.

### **1.12 CONTROLS AND MONITORS**

- . The UPS module will incorporate multi-processor based control and indicating alpha numeric display panel. All instrumentation, alarms and indicators showing the operating of UPS module will be incorporated on the display panel. Simple LED's alarm indications will be installed at the standard front panel and shall remain live even after the relevant module has been shutdown.
- A. All alarms and other indications will maintain memory even after the failure of the relevant module and able to remote diagnostic by a central supervisor computer console.
- B. The display unit on the UPS module will indicate at least the following information:
  - 0. Automatic Battery Test;
  - 1. Battery test procedure (to evaluate remaining life of battery);
  - 2. Real time battery protection time;
  - 3. Low battery shutdown imminent;
  - 4. Position of switching devices.

### **1.13 METERING**

- . The display will indicate the following measurements:
  - 0. Inverters output line-to-line voltages, line to neutral voltage;
  - 1. Inverters output currents;
  - 2. Inverters output frequency;
  - 3. Voltage across battery terminals;
  - 4. Battery charge or discharge current;
  - 5. Battery discharge time;

6. Normal AC input source line-to-line voltages, line-to-neutral voltage;
7. Rectifier/Charger input currents;
8. Output power and load crest factor.

## **PART 1 - EXECUTION**

### **1.10 INSTALLATION**

- . Install in accordance with the Manufacturer's instructions.
- A. Do not install unless temperature and humidity is maintained within limits defined by the Manufacturer.
- B. Do not install in rooms until permanent doors and windows have been erected and other openings to the outside have been permanently closed.
- C. The installation and the initial start up procedure shall be witnessed by factory-trained personnel.

### **1.11 FIELD QUALITY CONTROL**

- . Verify specification performance criteria.
- A. Measure battery discharge and recharge times.
- B. Simulate fault in each system component and utility power.
- C. Operate unit at utility supply for eight hours and record temperature rises.
- D. Perform other tests as recommended by Manufacturer.

### **1.12 TRAINING AND INSTRUCTION**

- . The Contractor shall take care without charge for instruction and training of the Employer's personnel by a factory-authorized service representative, to demonstrate adjustment, operation and maintenance of the system and to train Employer's personnel.

### **1.13 SPARE PARTS**

- . Spare parts shall be included for a period of three (3) years.

**END OF SECTION:16210 UPS**

## **SECTION 20010**

### **CODES OF PRACTICE**

#### **PART 1 - GENERAL**

##### **1.10 DESCRIPTION**

- . This section covers the Codes of Practice to be used in the design, manufacture, fabrication, installation, testing, commissioning, adjustment and setting to work of the facilities to be provided.
- A. Details of the equipment to be installed in each facility are stated in the relevant specifications.

##### **1.11 RELATED SECTIONS**

- . The following sections include requirements which are related to the work of this section:
  0. Section 16050: Basic electrical requirements
  1. Section 16075: Electrical identification
  2. Section 16100: Grounding
  3. Section 16110: Lightning and surge protection
  4. Section 16129: Indoor cables and wires
  5. Section 16178: Underground cabling
  6. Section 16210: Uninterruptible power system
  7. Section 20120: Distance measuring equipment
  8. Section 20210: Doppler VHF Omnidirectional Range

##### **1.12 CIRCUIT DESIGN**

- . All goods shall be designed to provide operational reliability for the service required. The use of 'quality approved' components is not alone sufficient to provide a satisfactory standard of reliability. The design itself must ensure an adequate margin of safety against component failure under the worst anticipated operational hazards.
- A. Circuits shall be designed such that no component will be required to operate under marginal conditions, which form an essential part of the required function of equipment.
- B. Equipment shall be designed to deal with the maximum voltage and frequency variations, ripple and wave for distortion of the available supplies. Circuits shall be arranged to cope with over voltage transients where these could possibly occur.
- C. Components and circuits shall be arranged as fail-safe systems. If this is not possible, other protective measures shall be applied.

- D. Components shall be designed to operate in as near ambient temperature conditions and be well within their rated operating limits.
- E. Neon indicators shall be connected such a way that they light when the fuse or thermal overload cut-out is intact and passing current.
- F. Switches shall be designed so that all positions of the switch are definite and are clearly indicated. The design shall be such as to guard against false or in definite indexing due to wear caused by normal switch operation. Incorrect connection of the indexing device to the switch, if they can be separated, shall be prevented by a method which only permits connection of the two components in one way.
- G. Preset controls shall have adequate coverage to allow for drift of associated component values and shall incorporate means which will prevent undesired movement but which will permit subsequent adjustment.
- H. In low voltage equipment it shall be possible to remove and replace sub-assemblies (including plug-in-circuit boards) with the power applied. No risk of damage or permanent loss of performance shall result.

### 1.13 CONSTRUCTION

#### Electrical wiring, connections and precautions

- 0. To prevent flexure under shock and vibration, conductors which run inside equipment racks or are subject to bending or twisting, shall be formed into cable-forms and protected against possible damage.
  - 1. Consideration should be given to the provision of spare cables and/or cores in each cable form, loom, or wiring harness.
  - 2. Wiring between major units in cabinet equipment shall be by separate cable, run in open flexible conduit, having removable lids.
  - 3. Cables shall never be unsupported. At intervals throughout their length they shall be securely clamped. Robust cable grips shall be provided at all cable entries, in order that the ends of conductors connected to terminals are relieved of mechanical load. Where leads of cable-forms are secured in clamps or other holders, the pressure exerted on the wires shall not be excessive and the clamps shall not cause tension in the cable or lead.
  - 4. Cables and wiring shall be adequately protected against damage from liquids, heat and contact with a moving object or from friction at edges or sharp corners. Where cables or electric cord are bent round corners, or pass through holes, sharp edges shall be removed and grommets shall be used.
  - 5. The radius on which a cable-form, loom, or wiring harness is bent shall not be less than the smallest radius specified for the largest diameter individual cable.
  - 6. Where cables cross a hinge, sufficient slack shall be left so that the cables are not strained by the movements of the hinge. The cables should be subjected, preferably, to torsion rather than ending in those situations. Protection against abrasion shall be provided.

7. In the internal wiring of electronic circuits, functional colour coding, shall be used and shall conform to the relevant IEC-standards as described in section 16050, Basic Electrical Requirements
8. Identification numbers shall be used in addition to the colour coding.
9. Wires with thermoplastic covering shall not have sharp bends in close proximity to a soldered tag.
10. Cable connections to major assemblies shall be grouped on a panel in an accessible position and shall be of the multi-pole plug and socket type.
11. Wires in cable forms shall not be twisted together unless this is a design requirement. Where twisting is necessary, the twist should have a minimum lay of ten times the outside diameter of the cable.
12. Long and tortuous connections and, in particular, rack and installation wiring shall be labelled at each end with the code numbers or designation of the two panels which they connect.
13. End of metal braiding on screened leads shall be neatly finished off. Metal screening shall be terminated at an appropriate distance from the exposed conductor, to ensure adequate insulation resistance.
14. Plug and socket pairs shall be capable of mating only in the correct orientation and it shall be possible to mate those allocated only to one particular function on any one equipment.
15. The tags or terminals of fixed plugs and sockets shall be readily accessible for maintenance purposes. This does not preclude the use of protective sleeves over the individual connections.
16. Plugs and sockets shall, when necessary, be fitted with a locking device to prevent accidental disconnection.
17. The design of plugs and sockets shall be such that they are protected from mechanical damage and accidental shorting and from the ingress of moisture and dirt.
18. Mechanical making of the plug and socket shells shall take place prior to the making of the contacts to obviate damage to the electrical contacts.
19. The "live" portion of a parted plug and socket pair shall, unless both are "live", be the socket. In addition, where plug and socket couplings may be left unconnected they shall be covered with insulation sleeves.
20. They shall be provided with captive covers. Where the plug is unavoidably 'live' it shall be shrouded.
21. When multi-pole plugs and sockets are being wired, the individual completed connections shall be covered with insulating sleeves. These sleeves are always required when stranded conductors are used.
22. Plugs and sockets with low temperature softening-point insulation shall have a mating component inserted during soldering.

A. Mechanical Characteristics Equipment Racks

0. For rapid replacement of units, the cabinet shall contain equipment carriers, in which individual plug in units and modules shall be inserted. Drawers will not be accepted.

1. All the plug-in units and modules shall fit on slide rails and shall be removable from the front of the cabinet. Connectors shall be keyed to prevent insertion of units in the wrong way or into a wrong slot.
- B. Coatings
0. Printed circuits shall be coated by a photo solder- resistant material in order to increase the electrical resistance of the surface, and to decrease the surging effect of moisture and fungus on unprotected insulating surfaces.
  1. The printed circuit board coating shall permit the replacement of components by soldering techniques without destroying the coating or the board surface.
- C. In order to avoid wear and tear, no mechanically operating control elements shall be accepted for direct signal adjustment. There shall be no potentiometers in the direct path of signal generation. The use of potentiometers shall be limited to DC-alignments.
- D. Inter wiring of units within subassemblies shall be made via other boards (printed circuits).
- E. Cooling inside the cabinet shall be effected by convection exclusively and shall assure all components to operate well within their individual temperature ratings within the specified equipment ambient temperature range. Cooling by fans is not accepted. Heat sinks for power components and power circuits shall be separated from low-power circuits to avoid unnecessary heat stress to low-power circuits.

#### **1.14 PRINTED CIRCUITS AND WIRING**

- . Equipment design shall follow the best current engineering standards of practice.
- A. The preferred thickness of material shall be 2.5 mm.
  - B. The method of electrical connection of printed cards to the equipment shall be by means of an approved connector which will ensure reliability.
  - C. The connection shall be made in one way only, either dry or soldered, connectors, if mounted on a further printed card, shall be removable without requiring the use of multi-head or other special soldering irons. The use of the board as a lug with printed conductors as contact member is to be approved before use.
  - D. Where modular assemblies are used, these shall be completed electrical networks having measurable input/output characteristics.
  - E. Means shall be provided for the easy diagnosis of a fault to a particular card.
  - F. Facilities shall be included to provide access to individual cards for normal point-to-point testing. This testing shall be possible with the equipment functioning normally.
  - G. Circuit cards constructed with printed wiring and attached components shall be repairable or be completely replaceable.

## 1.15 LAYOUT AND ASSEMBLY

- . Components whose operational characteristics are likely to be affected by uneven or excessive heating shall be so sited that they do not receive pre-heated air.
- A. Components whose maximum ambient temperature ratings are below 70°C shall be sited as closely as is practicable to the cooling air intake.
- B. Wherever possible, the production of "hot spots" (local ambient temperature of 70°C and above) shall be avoided by providing adequate ventilating, regrouping of components etc. Any components that must be sited within a "hot spot" shall be suitably re-related in all relevant characteristics according to the maximum temperature reached by the "hot spot".
- C. Instrument dials and indicating devices shall be so fitted that they are readily visible from the operator's normal position.
- D. Light components, such as resistors and capacitors whose weight is of the order of 15 g or less, may be secured by their leads provided that the leads are arranged axially to the component.
- E. No component having wire terminations shall be soldered at less than 6 mm from the body of the component. To ensure that such components are free from harmful vibration the lead length shall not exceed 12 mm and be adequately secured by clamp or clips.
- F. Heat radiating components shall be adequately spaced from other components or parts or materials liable to suffer damage from the heat. Vitreous resistors shall be mounted vertically to secure maximum air cooling.
- G. Where neon lamps are used as fuse indicators they shall be adjacent to the fuses they monitor.
- H. Facilities shall be provided which will allow wire-in semi-conductors to be individually tested without disturbing other circuit elements or normal operation of the equipment.
- I. Semi-conductor leads shall be long enough for heat shunts to be used during soldering or unsoldering operations. Where this is not possible, suitable semi-conductor sockets shall be fitted.
- J. Where heat sinks are used, these shall function adequately with the equipment exposed for maintenance.
- K. 'Potted' (encapsulated) circuits shall be such that easy replacement is effected in the same way as for single components. Plug-in facilities may be provided. Components which are liable to require frequent replacement should not be included in 'potted' circuits unless their use is absolutely unavoidable.
- L. Sub-assemblies requiring infrequent replacement shall have soldered or wrapped connections, these being grouped or easily accessible.
- M. Component parts shall be so located, secured and disposed with respect to each other and structural members, that they can be inspected, removed and replaced without damaging or unduly disturbing other parts of wiring.

## 1.16 ACCESSIBILITY

- . Accessibility demands that consideration shall be given to the following features:
  0. The use of hinged doors, cradles and runners, or other approved devices, preferably without interfering with the operation of the equipment. Hinged doors shall be such that they can be lifted off their hinge pins and do not have to be held manually in the open position.
  1. The use of screws to secure frequently used cover plates shall be avoided. If their use is unavoidable the screws shall be captive.
  2. Access should be such as to permit the replacement of components and the use of tools, at the same time allowing for observation of the work.
  3. Parts which have to be removed for inspection or adjustment shall be provided with easily accessible connection and fixing points.
  4. Replaceable parts shall be located and secured so as to permit inspection, servicing and replacement without damage to, or interference with, adjacent parts of wiring.
  5. Equipment layout shall be so arranged that components wiring or cable-forms cannot be damaged in the process of assembly or removal of covers or the opening of inspection doors.
  6. Cabinets, panels, units or chassis shall be provided with suitable handling devices such as handles, lifting eyes, jacking points, etc. The design of panels, units, chassis etc. shall be such that they can be rested on any face, or rolled from any face to any other face, without damage to the components. These items shall be made such that personnel are protected from sharp edges or points and from heat.
  7. Fragile components shall not be positioned in exposed places, but should be protected in the best way possible. Guardrails may be used.

## 1.17 COMPONENTS

- . Components shall conform to the highest engineering specifications and lists of standards. Equipment shall be designed to make use of these components, using the widest tolerances possible for the circuit conditions.
- A. Space shall always be provided corresponding to the maximum dimensions of the components and not to those of individual specimens.

## 1.18 PRE-SET AND VARIABLE COMPONENTS

- . Pre-set controls shall not be unduly critical or interdependent and should have an adjustment range adequate for alignment purposes. After the initial setting there shall be at least 1/3 of the total travel left at either end. They shall remain stable at their pre-set value and have locking devices which are positive, as to apply and release and which do not affect the setting.
- A. Slot ended control spindles for screwdriver operation may be used, but care must be taken to ensure that the head is robust enough to stand constant adjustment without damage. Controls for resetting up an item of equipment for action, although of pre-set character, should be provided with knobs and locking devices.

- B. Controls which are solely the concern of the maintenance staff shall not be readily accessible to any other person. All such controls shall be labeled clearly that they are to be used by maintenance staff only. In particular those controls, if maladjusted, might increase the interfering potentiality of the equipment, shall not be accessible to operating personnel.
- C. User pre-set controls required for the initial setting up of units should be located on the front panel. Their position shall be such that when adjustments are made the indicating devices can be easily read.

### **1.19 ELECTRONIC COMPONENTS**

- . Electronic components such as relays, transistors, resistors, capacitors, integrated circuits etc. applied in electronic systems shall be of the latest design.
- A. The components shall be operated within the ratings stated in their individual specifications.
- B. It is essential to ensure that the spread of electrical characteristics and the tolerance on physical dimensions allowed by the specification for any component can be accommodated in the equipment being developed.
- C. The components used should be provided capable of an operational life appropriate to the equipment in which they are used. This operational life should be retained over the temperature range nominated in the equipment specification.
- D. Circuit designs shall be such that satisfactory operation is obtained with any component which conforms to the appropriate system specification.
- E. The components shall not be loaded at more than their maximum rating, nor shall they be operated beyond their environmental ratings.
- F. No circuits shall be employed which, when associated with its components and dependence for satisfactory operation on device parameters, which are not defined in the component specification.
- G. Facilities shall be provided which will allow wire-in devices to be individually tested under operational conditions without disturbing other circuit elements or normal operation of the equipment.
- H. The electronic components shall be preferably mounted on standard printed circuit boards.

### **1.20 ELECTRONIC DEVICES**

- . The method of connection of an equipment to power supply shall be possible in one way only. Alternatively, connection to a supply of incorrect polarity should not damage the equipment.
- A. Satisfactory circuit performance shall not require selection of semi-conductors or associated components.
- B. Circuit design shall be such that subsequent damage is minimized should any one element fail.

- C. Where CMOS-IC's are used, provisions shall be made so that generation of transients during normal testing will not damage the IC's.

### **1.21 ELECTROLYTIC CAPACITORS**

- . The use of electrolytic capacitors shall be avoided wherever possible. If the equipment design is such that these have to be used, then consideration should be given to the use of tantalum types. When the dry aluminium foil variety is used, these shall be readily accessible for replacement and test. Before assembly the date coding of electrolytic capacitors shall be checked to ascertain whether reforming is necessary.

### **1.22 BATTERIES AND ACCUMULATORS**

- . Preference is given to maintenance free sealed batteries and accumulators. Every effort shall be made to avoid using dry batteries or accumulators in equipment. Where they must be used the design of the equipment shall provide for maintaining them at a temperature that will not affect their performance or cause deterioration when they are not operating.
- A. Attention shall also be paid to the possible action of the electrolyte on adjacent materials.

### **1.23 PLUG-IN COMPONENTS**

- . Plug-in components or assemblies shall be fitted with retaining devices.

### **1.24 FUSES**

- . Glass bodied fuses shall be avoided wherever possible. Ceramic bodied fuses are preferred.

### **1.25 PROTECTIVE DEVICES**

- . Overload dashpots shall have the overload current settings, the delay times, and the type and grade of the control liquid clearly marked.
- A. An instantaneous current tripping device shall be incorporated in their design. They shall be so constructed and assembled on equipment that they may be easily cleaned and refilled in site or be easily removable and replaceable.
- B. Thermal overload relays shall trip at a stated current for a particular setting and shall not be affected by changes in ambient temperature.
- C. Overload settings shall be adjustable to conform to the reduced currents allowed when equipment is used under high altitude and/or high temperature conditions.
- D. Fuses or other protective devices shall be provided and circuits shall be so connected that in the event of circuit failure:
  - 0. Fire risk is reduced to a minimum.
  - 1. The power supply to other associated equipment is not affected.
  - 2. Other component parts of the equipment are not damaged.
  - 3. The operation of the protective device does not isolate from earth parts of other circuits which are normally connected thereto.

## 1.26 SAFETY REQUIREMENTS

### . Electrical

0. Automatic locking of cabinet mounted panels is desirable both in the normal and in the withdrawn positions.
1. Where points of dangerously high potential are exposed, locks and catches shall be interlocked with electrical safety switches in addition to the usual warning notices. The design of the safety switch and its associated circuits shall be such that it is impossible to re-assemble completely striped equipment unless the safety switch is fully operative.
2. High-potential circuits shall have short time constants so that such potentials do not remain for long periods after switched off and where this is not possible automatic earthing devices shall be fitted which come into operation when the compartment door is opened.
3. Provisions shall be made for the adequate earthing of the exposed metal work of all panels, chassis and components which are supplied with power at voltage dangerous to personnel.
4. Pre-set components which have to be adjusted under "live" conditions, shall be kept to an absolute minimum. They shall be so positioned that no danger to personnel will exist due to the proximity of tools (used for making adjustments) to live parts.
5. Where dangerous high energy radiofrequency fields or ionizing radiations are present, adequate protection shall be provided for personnel engaged in maintenance.
6. Accidental contact with dangerous voltages shall be guarded against when equipment is in use under operational conditions. For safety during inspection of equipment or changing of components, it will be sufficient with small metal-cased apparatus to ensure that the removal of the case will involve breaking the supply circuit when this is provided by a connector from a separate unit. If inspection panels or doors are provided, interlocked switches shall be incorporated to open the supply circuits when such panels or doors are open, unless the use of a special tool is necessary to get access to the interior of the equipment. The interlock switches shall operate as soon as the panels or doors begin to open. Means shall be provided for restoring the power supplies for test purposes.

## 1.27 TOXIC OR RADIOACTIVE MATERIALS

- . Toxic or radioactive materials which require special handling or disposal shall be listed.
- A. Warning labels shall be fitted to all devices containing such materials (Attention is drawn to the fact that some semi-conductor devices contain Barilla).

**END OF SECTION: 20010 CODES OF PRACTICE**

## SECTION 20120

### DISTANCE MEASURING EQUIPMENT (DME)

#### PART 1 - GENERAL

##### 1.10 SUMMARY

- . This section shall consist of the design, manufacturing, fabrication, supply and installation, testing and commissioning and putting into operation of a Distance Measuring Equipment (DME).
- A. The DME shall have a coverage of 250 NM.
- B. Each DME system shall consist as a minimum of the following subsystems:
  - 0. Dual DME transponders, with associated modulation/demodulation, encoding/decoding, control and changeover equipment.
  - 1. Omni-directional antenna with associated cabling, monitor pick-up probe (or loop).
  - 2. One DME monitor and test group consisting of dual parallel monitors and special type test equipment for equipment.
  - 3. Remote monitoring of the equipment.
  - 4. Shelters with associated equipment.
- C. The equipment shall be solid state. The reliability and availability shall be maintained by using redundant configuration. The hardware shall be based on the latest market developments.
- D. Cables between the equipment shelter and antenna are included in the works. All cables shall be installed by the Contractor.
- E. The Contractor shall provide foundations for the shelters and the antennas.

##### 1.11 APPLICABLE CODES AND SECTIONS

- . The following sections include requirements which relate to the work of this section:
  - 0. Section 16050 Basic Electrical Requirements
  - 1. Section 16075 Electrical identification
  - 2. Section 16100 Grounding
  - 3. Section 16129 Indoor cables and wires
  - 4. Section 16178 Underground cabling
  - 5. Section 20100 Codes of practice

## **1.12 QUALIFICATIONS**

- . The Manufacturer shall be specialized in manufacturing products specified in this section with minimum five years documented experience in the production of Navigational Aids.
- A. Quality Assurance: The Manufacturer shall be an ISO 9000 certified manufacturer. The production of the proposed Navigational Aids shall fall under the ISO 9000 certificate.

## **1.13 DELIVERY, STORAGE AND HANDLING**

- . Protect equipment from extreme temperature and humidity and store in a conditioned space. Prevent corrosion and contamination. Keep all electrical equipment dry at all times.
- A. Protect equipment from rodents, dust and debris by wrapping unit in transparent dust tight cover and storing away from construction activity.
- B. Handle equipment and materials in accordance with the Manufacturer's recommendations.

## **1.14 MAINTENANCE SERVICE**

- . Provide service and maintenance of system during the entire defects liability period.

## PART 1 - PRODUCTS

### 1.10 GENERAL

- . The DME Operational Requirements:
  - 0. The DME subsystem shall provide for continuous and accurate distance information to a suitably equipped aircraft from a ground reference point.
  - 1. The radiation from the DME antenna group shall consist of pulse pairs of RF energy in response to interrogations by pulse pairs from airborne interrogators.
  - 2. The DME subsystem shall provide accurate distance information to within 0.2 NM or better.
- A. Operational Radio Frequencies:
  - 0. The DME subsystem shall be frequency paired with the DVOR in accordance with ICAO Annex 10, Volume I, Aeronautical Telecommunications.
  - 1. To alter the frequency of the DME, only modular substitution and field level adjustments shall be required. Channel assignment shall be coordinated with authorized organization.
- B. The DME subsystem shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation with the transmitter reduced to one-half the rated output. The rated power, however, shall not be at such a level as to cause receiver overload at the aircraft. The radiation shall be omni-directional. The requirements of ICAO Annex 10, Volume 1, Part I, Paragraphs 3.5.3.1 and 3.5.3.2 apply.
- C. The radiation from the DME antenna shall be vertically polarized in the frequency band 960 MHz to 1215 MHz.
- D. The DME reply signals shall consist of radio frequency (RF) energy bursts with modified Gaussian distribution spaced 12 microseconds apart. The pulses shall be 3.5 microseconds duration at the half amplitude points with 95 percent of energy maximum occurring at nominally 2.5 microseconds.
- E. Transponder Accuracy Transponder Accuracy shall be  $\pm 30$  m for interrogation pulse rise time from 2 to 3 microseconds with an over all transponder service conditions with an interrogation power at the transponder antenna connector input from  $-39$  dBW to  $-109$  dBW and a delay variation of  $\pm 0.2$  micro seconds.
- F. The handling capacity shall be 100 aircraft.
- G. DME transponder group
  - 0. The transponder group shall be composed of equipment necessary for the reception and decoding of DME interrogation pulse pairs, and the generation and transmission of reply pulse pairs. The constituent transmitters and receivers shall be interchangeable in main or standby configurations. While the designated main equipment is operating into the antenna group, the designated standby equipment shall be operating, under monitor control, into the dummy load. Immediate changeover shall

be effected immediately on command of the monitor system or by manual override.

1. The accuracy of the transponder shall comply with the following specifications:

***The accuracy of the transponder shall not contribute more than plus or minus 0.5 microsecond (75 m) to the over-all system error.***

***The transponder reply efficiency shall be at least 70 per cent at all values of transponder as defined per ICAO Annex 10.***

H. Receiver Performance

0. The receiver centre frequency shall be the interrogation frequency appropriate to the assigned DME channel. The receiver shall perform over the environmental service conditions. When adjusted under normal test conditions for optimum performance, changes in the following parameters of the service conditions shall not exceed:

***Sensitivity :at least -103 dBW/m<sup>2</sup> at 70% efficiency***

***Bandwidth :± 100 kHz t -3 dB***

***Overload protection gain :0 to 50% gain or not less than 45 dB available gain reduction***

***Pulse spacing :X-mode 12 ± 0.10 micro seconds***

***Y-mode 30 ± 0.10 micro seconds***

***Pulse shape Pulse width :3.5 ± 0.5 micro seconds (half-amplitude)***

***Decoding :Decoding of single pulse does not occur.***

***Frequency stability per channel: ± 20 kHz of assigned channel***

***Echo Suppression :Shall be provided for long and short range***

***Dynamic range :22 dBW/m<sup>2</sup> – 103 dBW/m<sup>2</sup>***

***Spurious rejection :75 dB ( minimum)***

***Adjacent channel rejection :80 dB (minimum)***

***IF Frequency rejection :80 dB (minimum)***

***Bandwidth :400 Hz between 3 dB points***

***Input impedance :50 Ohm***

I. Transmitter Performance

0. The transmitter frequency shall be the reply frequency for the assigned DME channel. The transmitter shall perform as follows over the environmental service conditions. When adjusted under normal test conditions for optimum performance, changes in the following parameters over the service conditions shall not exceed:

**RF frequency stability :0.001%**

**Pulse shape :Rise time: 2.5 to 3.0 microseconds. Width (half-amplitude) :3.5 ± 0.5 microseconds (10% to 90% of trailing edge)**

**Decay time: :2.5 to 3.0 Microseconds (90% to 10% of trailing edge).**

**Effective peak radiated power :1000 W**

**Pulse spectrum: The spectrum of the pulse modulated signal shall be such that during the pulse the effective radiated power contained in a 0.5 MHz band centred on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel frequency in each case shall not exceed 200 mW, and the effective radiated power contained in a 0.5 MHz band centred on frequencies 2.0 MHz above and 2.0 MHz below the nominal channel frequency in each case shall not exceed 2 mW. Any lobe of the spectrum shall be of less amplitude than the adjacent lobe nearer the nominal channel frequency.**

**Pulse spacing :X-mode: 12 ± 0.10 microseconds**

**Y-mode: 30 ± 0.10 microseconds**

**Pulse amplitude difference :Less than 1.0 dB**

**Duty cycle :Not less than 700 pulse pairs per second**

**Identification :Associated**

**Spurious radiation :More than -80 dB below peak ERP**

1. Stabilization Time:

**After initial adjustment under normal test conditions, changes from the initial room temperature reading occurring between 3 seconds and 15 minutes after initial application of power, shall not exceed the limits tabulated below. The readings for each parameter shall be taken at 3 seconds after being energized and on a continuous recording basis for 15 minutes after being energized.**

**Peak power at transmitter** *:+ 10%*

**Transmitter frequency** *:+ 0.002%*

**Receiver sensitivity** *:+ 0.5 dB*

**Reply pulse width** *:+ 0.5 microseconds*

**Reply pulse spacing** *:+ 0.10 microseconds*

**Reply efficiency** *:+ 1.0%*

**Station delay** *:+ 0.1 microsecond*

2. A switch shall be provided to turn the transponder on and off. In addition, it shall be possible to select either local or remote control of this function.
3. The equipment to be supplied shall employ phase locked loop (PLL) frequency synthesis technique.
4. The time delay between the receipt of a valid interrogation and the transmission of a reply pulse pair shall be adjustable over the range of 30 to 80 microseconds. The station delay shall be continuously adjustable over the specified range. If the adjustment is realized in digital technique, step width of 0.0625 microseconds are acceptable.
5. A switch and control shall be provided to optionally cause receiver blanking for a period of 35 to 150 microseconds after the receipt of a valid interrogation.
6. The decoder shall trigger the transmitter encoder only by detected pulse pairs from the receiver having  $12 \pm 0.25$  microsecond interval. This duration shall be measured between the half voltage points on the leading edges of the pulses. In addition, the constituent pulses shall meet the shaping criteria specified.
7. The encoder shall provide properly spaced pulse pairs with shaping specified in for the transmitter. The encoder input shall be identification pulses, reply pulses and filler pulses (squitters). A priority circuit shall be incorporated to establish which input to the encoder shall predominate in the following order:

### **Identification**

### **Reply**

### **Squitters**

8. Changeover circuits shall be used to connect the antenna group to the main or standby transponder on command of the control unit. Directional coupler shall be used to sample and detect power to and reflected from the antenna group and dummy load. Changeover and test performance shall be as follows over the environmental service conditions:

**Impedance shall be a nominal 50 Ohm at all RF ports.**

**Insertion loss shall not exceed 0.5 dB**

***Switching time to disconnect radiating transponder and connect standby from/to the antenna shall not exceed 300 milliseconds after command from monitor control.***

***Voltage standing wave ratio (VSWR) shall not exceed 1.2:1.***

#### **1.11 ENVIRONMENTAL REQUIREMENTS**

- . The DME equipment shall function through a temperature range of 0° to 70° C indoors.

#### **1.12 CONTROL AND MONITORING**

- . Monitoring General Requirements
  0. The DME subsystem shall be equipped with a high integrity monitor group for fault detection. Automatic switchover or shutdown shall be initiated on command of the monitor group when critical parameters exceed specified limits. The DME shall be capable of operation in conjunction with a remote indicator/control unit providing visual and audible (including indent) indication of subsystem status and complete, positive control over this subsystem.
  1. The DME subsystem shall have dual monitors such that each specified parameter radiated is examined by two identical channels. An out-of-tolerance condition shall exist in both monitors before transfer or shutdown action is initiated. An out-of-tolerance condition of a single monitor or loss of the standby transponder shall produce indications of abnormal operation with no interruption of service.
- A. Built-in Test Equipment: BITE
  0. As maintenance will be greatly reduced by the provision of built-in test equipment a suitable arrangement shall be included in the equipment. For this purpose plug-in units and modules shall provide logic signals for verification of correct operation within the tolerance limits.
  1. Along the flow of navigation and control signals, test points shall be installed for automatically /sampling, via through the equipment data processing for Go/No Go decisions and read out and display of actual signal values via connected PC + supervisor program.
  2. It shall be possible to read out manually, by interrogation, the results of the fault-locating BITE programs via PC even when used at the remote site.
  3. The BITE function must be kept completely independent from the monitoring operation. Any of the following conditions shall cause shutdown, or transfer, as appropriate:

***Reduction of peak radiated power to 50% or less.***

***Reply efficiently to less than 70% (or greater if receiver suppression is less than 60 microsecond).***

***Station delay + 0.5 microseconds from established value.***

***A change in pulse width of + 0.5 microseconds.***

***A change in reply pulse width of + 0.5 microseconds.***

***Antenna VSWR of 1.5:1.***

- B. DME Monitoring Fail-Safe
  - 0. The DME monitor shall be fail-safe such that failure of any part of the monitor shall either result directly in an alarm condition, or as a minimum, shall not alter any alarm threshold level in the direction of tolerating greater deterioration of the transponder characteristics than permitted in the absence of such failure.
  - 1. For such parts as electronic or electromagnetic switching devices where it is not possible to provide fail-safe operation under both modes of failure (open and short circuit), fail-safe protection shall be provided for the mode of failure having the higher probability.
- C. Provision shall be made for meter indications and status indicating lights for all parameters monitored.
- D. The control unit shall provide selection of either transponder 1 or transponder 2 as the main transponder.
- E. Interface requirements between the DME subsystem and the remote indicator and control unit shall be provided.
- F. The indication and control unit shall have an override switch that disables monitor action during periods of adjustment and maintenance.
- G. An abnormal condition indicator at the control unit shall light if any one or more of the following conditions occur:

***Standby transmitter on the air.***

***Monitor mismatch.***

***Monitor locally bypassed.***

**1.13 REMOTE CONTROL**

- . The following functions of the DME system shall be remote controlled:
  - 0. Status of transponder 1 – on/off/fault
  - 1. Status of transponder 2 – on/off/fault
  - 2. Monitor mismatch
  - 3. Monitor bypassed
  - 4. Power supply DME unit on/off

- A. The functions shall be monitored in the Visual Control Room of the control tower.
- B. Wires shall be provided as described in section 16129, Indoor cables and wires and section 16178, Underground cables.

#### 1.14 CABLING

- . All cabling between the shelters and antenna shall be part of these specifications. All outdoor cables shall be direct buried as specified on the drawing, which will be provided by the Contractor.
- A. All power cables between the shelters and antenna shall be part of the specifications. The power cable shall be connected to the main switch in the power shelter.
- B. All control cables shall be part of the specifications. The control cable shall be connected to the marshalling box in the power shelter.
- C. Radio Frequency connections within the electronic equipment shall be effected by means of coaxial connectors, throughout. RF cabling and interconnections between plug-in units and modules shall be located at the rear of the cabinet or subtrack by plug-in type connectors for the RF-modules. RF connections to the transmitting antenna system shall be accessible on RF output connectors located on a separate panel inside the cabinet.

#### 1.15 ANTENNA GROUP

- . The DME antenna shall consist of appropriate elements to provide vertically polarized directional radiation pattern. The array shall be protected by a suitably low loss radome and shall incorporate a probe for sampling transmitted energy.
- A. The DME antenna shall be designed to provide a vertically polarized RF pattern whose main lobe is not less than  $6.0^\circ$  wide at the half power points. The main lobe should be as near the horizon as feasible and in the horizontal plane should cover a sector of  $\pm 35^\circ$ . The power density variation about the antenna in the horizontal plane shall not exceed 4 dB. The antenna group shall be broadband and shall not require adjustment for changes of frequency over the DME band. The antenna group shall meet the following requirements:
  - 0. The gain of the antenna shall be such that the required signal strength along glide path to coverage limits shall be met.
  - 1. The design centre impedance shall be 50 Ohm.
  - 2. The input VSWR of the antenna shall not exceed 1.5:1 over the entire DME band under test conditions with the antenna fed from a 50 Ohm line and source.
- B. The DME antenna shall be mounted in a way such that the radiation shall clear all major obstructions and the main lobe meet coverage requirements in paragraph above the antenna mast shall be constructed of such material as to meet the required structure specifications. In addition, the antenna installation shall meet the following criteria:
  - 0. The radome shall be constructed of type II fibre base plastic material. All performance requirements shall be met with the radome installed

1. The antenna shall be installed in such a way as to meet the performance requirements of paragraph 2.6B and the obstruction criteria of ICAO Annex 14.
  2. Obstruction lighting shall be required provided in accordance with ICAO Annex 14.
- C. Antenna elements shall be protected by glass fibre-reinforced polyester covers.

#### **1.16 POWER SUPPLY**

- . A battery system shall be provided to maintain the operation of the system during a power failure of the airport power supply system. The battery system shall be powered by float charge.
- A. The capacity shall be sufficient to maintain the system operations for at least 4 hours at full load.

## **PART 1 - EXECUTION**

### **1.10 GENERAL**

- . Verify the conditions and the availability of the sites prior to commencing the installation.
- A. The Contractor shall coordinate the installation of the equipment with the Project Manager.
- B. Verify foundations when constructed and obtain approval from the Project Manager before installation of equipment.
- C. Contractor will provide power cables between power shelter and navigational aids shelter. Connect power cable to distribution board in navigational aids shelter.
- D. Install cables between equipment shelter and antenna. Cable splices shall not be used. Cables shall be direct buried.
- E. Provide temporary obstruction lights on shelters and antennas during construction.

**END OF SECTION: 20120 DME**

## SECTION 20210

### DOPPLER VHF OMNI DIRECTIONAL RADIO RANGE (DVOR)

#### PART 1 - GENERAL

##### 1.10 SUMMARY

- . This section shall consist of the design, manufacturing, fabrication, supply and installation, testing and commissioning and putting into operation of a Doppler VHF Omni Directional Radio Range (DVOR).
- A. The System to be supplied shall be in full compliance with the ICAO Annex 10, Volume I, Chapter 3, Paragraph 3.3, latest edition and other applicable ICAO documents.
- B. The DVOR shall have coverage of 250 NM.
- C. Each DVOR shall, as a minimum, consist of the following subsystems:
  - 0. Dual carrier and side band transmitters including modulators, control and changeover equipment between main and standby.
  - 1. Antenna array with associated cabling, monitor pick-up probe (or loop).
  - 2. Dual monitor to provide continuous monitoring of the performance.
  - 3. Remote monitoring of the equipment.
  - 4. Standby battery power.
- D. The equipment shall be solid state. The reliability and availability shall be maintained by using redundant configuration. The hardware shall be based on the latest market developments.
- E. Cables between the equipment shelter and antenna are included in the Works. All cables shall be direct buried.
- F. The Contractor shall provide foundations for the shelters and the antennas.

##### 1.11 RELATED SECTIONS

- . The following sections include requirements which relate to the work of this section:
  - 0. Section 16050 Basic Electrical Requirements
  - 1. Section 16075 Electrical identification
  - 2. Section 16129 Indoor cables and wires
  - 3. Section 16178 Underground cables
  - 4. Section 16200 Grounding
  - 5. Section 16210 Uninterruptible power system
  - 6. Section 20100 Codes of practice

## **1.12 QUALIFICATIONS**

- . The Manufacturer shall be specializing in manufacturing products specified in this section with minimum five years documented experience in the production of Navigational Aids.
- A. The Manufacturer shall be an ISO 9000 certified manufacturer. The production of the proposed Navigational Aids shall fall under the ISO 9000 certificate.

## **1.13 DELIVERY, STORAGE AND HANDLING**

- . Protect equipment from extreme temperature and humidity and store in a conditioned space. Prevent corrosion, contamination. Keep all electrical equipment dry at all times.
- A. Protect equipment from dust and debris by wrapping unit in transparent dust tight cover and storing away from construction activity.
- B. Handle equipment and materials in accordance with manufacturer's recommendations.

## **1.14 MAINTENANCE SERVICE**

- . Provide service and maintenance of system during the entire warranty period.

## PART 1 - PRODUCTS

### 1.10 GENERAL

- . Operational Requirements:
  - 0. The DVOR shall provide for continuous bearing information to aircraft equipped with VOR receiver's equal clockwise angular deviation, degree for degree from magnetic north as measured from the location of the DVOR.
  - 1. The DVOR shall radiate a radio frequency carrier with which are associated two separate 30 Hz modulations. One of the modulations shall be phase independent of the azimuth of point of observation and refers to reference phase. The second modulation signal, variable phase and shall be as such that its phase of the point of observation differs from the reference phase signal by an angle to the bearing of the point of observation with respect to the DVOR station.
- A. The DVOR shall operate in the Radio Frequency band 111.975 MHz to 117.975 MHz. The channel separation shall be in increments of 50 kHz referred to the highest assignable frequency. The frequency tolerance of the radio frequency carrier shall be plus or minus 0.002%.
- B. The DVOR shall provide signals as to permit satisfactory operations of a typical aircraft installation at the levels and ranges required for operational reasons, and up to an elevation angle of 40°. The required field strength to permit satisfactory operation of an aircraft receiver at the minimum service level at the maximum specified service radius should be 90 microvolt per meter or 107 dB W/m<sup>2</sup>.
- C. The emission from the antenna system shall be horizontally polarized. The vertically polarized component of the radiation shall be as small as possible.
- D. The beacon shall consist of carrier and sideband transmitters to generate the Reference Phase Signal and the Variable Phase Signal.

### 1.11 SYSTEM CHARACTERISTICS

- . The DVOR transmitters shall have the following characteristics.
  - 0. The transmitter shall be in redundant configuration. Each transmitter shall consist of the following functional units:

***A frequency synthesizer providing unmodulated very pure (clean spectrum) carrier signals for the carrier and the sideband transmitters.***

***A modulator unit for modulation of the carrier with the amplitude modulated 30Hz-reference signal, the identity tone and voice.***

***Power amplifier for providing carrier output power up to 100 Watts.***

***A precision "control coupler" at the output of the transmitter for amplitude and phase control of the radiated radio frequency signal. The***

***“control coupler” shall be designed to measurement instrument quality signal measurements.***

***Duplicated sideband transmitters to generate upper and lower 9960Hz-  
pared sideband centred in respect to the carrier.***

***Carrier and sideband modulation signal generation shall be controlled  
by the carrier signal generator-control.***

- A. The System criteria shall be as follows:
  - 0. Azimuth accuracy :better than  $\pm 1^\circ$  on ground measurement
  - 1. Azimuth stability :better than  $\pm 0.5^\circ$  measured at the monitor
  - 2. Coverage :250 NM
- B. Carrier Transmitter
  - 0. Carrier Frequency

***The equipment shall operate on a carrier frequency, which shall be of  
any predetermined channel in the range of 111.975 to 117.975 MHz***

***The channel spacing shall be provided by a frequency synthesizer in  
increments of 50 kHz. In order to change the transmitter frequency, there  
should be no adjustment necessary.***

***The frequency synthesizer shall provide an output frequency stability  
within  $\pm 10$  ppm over environmental service conditions and AC supply  
voltage variations of  $\pm 10\%$ .***

- 1. Carrier Power

***The output power shall be programmable in increments of 0.5 or 1 Watt  
to meet specific operational coverage requirements. A power range of 25  
to 100 W is required.***

***The power amplifiers shall be broadband and designed to operate into a  
50 Ohm carrier antenna. They shall be capable of withstanding an  
infinite “Voltage Standing Wave Ratio” (VSWR) without damage. To keep  
it a temporary effect a warning indication shall be provided.***

***Related to the synthesizer reference phase the stability of the RF carrier  
shall be within  $\pm 5^\circ$  measured at the transmitter output.***

- 2. Carrier Modulation

***The carrier transmitter has to be modulable at least up to 75% at a low  
distortion rate. The shift in mean carrier level for any modulation depth  
up to 75% shall not exceed 5% with respect to the unmodulated carrier.***

***Amplitude modulated carrier***

The amplitude modulation with 30 Hz on the carrier shall be normally 30% servicing for the omni directional information and shall be programmable in the range from 3 to 39.9% in steps of 0.1%.

The 30 Hz modulation signals shall be digitally generated, amplitude controlled by values stored in memories and within  $\pm 0.01\%$  of the nominal frequency.

To set the station bearing information the phase of the 30 Hz modulation shall be programmable between  $0^\circ$  and  $359.9^\circ$  in steps of  $0.1^\circ$ .

### 3. Tone-identification

**Generation of 1020 Hz +/- 10 Hz Morse code characters as required for DVOR station identification shall be digitally controlled and be programmable in modulation depth via PC.**

**The keyer type shall be solid state. The keying rates shall remain with +/- 0.01% of the design centre value under the environmental service conditions of temperature and humidity.**

**Keying pulses shall start and stop without undesirable transients. Peaks during keying shall not exceed 1% of the audio frequency amplitude. It shall be possible to select either keyed or unkeyed modulation and to remove all modulation from the carrier. The dot length shall be 0.125 seconds. The dash length shall be 0.375 seconds. The time duration between dots and dashes shall be equivalent to one dot. The time duration between dots shall be equivalent to one dot. The time duration between letters shall be 0.375 seconds.**

**The identification signal shall consist of 2, 3 or 4 letters.**

**The modulation depth shall be programmable in steps of 0.2% between 0% and 20%.**

### 4. Voice Modulation

**The equipment shall be capable of accepting voice modulation within the frequency band 300 Hz to 3000 Hz.**

**The amplitude variation in the band shall be less than 3 dB related to 1020 Hz.**

**The operation of the voice channel shall in no way interfere with the navigational performance of the DVOR or the operation of the monitoring system.**

**The modulation depth shall be programmable from 0% to 39.8% in steps of 0.2%.**

**For stabilization and linearization of the carrier modulation feedback loops for envelope and RP phase have to be foreseen.**

***The harmonic components of modulation shall be less than 3%. Carrier modulation, envelope and RF phase shall be stabilized and linearized by feedback loops controlled by the carrier signal generator control processor.***

C. Sideband Transmitters

0. The sideband transmitters shall provide the frequency  $9960 \text{ Hz} \pm 1 \text{ Hz}$  from carrier
1. The sidebands have to be locked to the carrier to obtain in space an amplitude modulated signal.
2. A control loop has to be provided for alignment of the virtual sideband centre derived from lower and upper sideband to be in phase with the carrier and to correct it continuously if deviations exist.
3. The RF Phase adjustment range shall be designed to allow additionally adjustment range for the sideband RF phase from  $0$  to  $359^\circ$  in steps of  $1^\circ$  for alignment purposes.
4. The sideband phase stability shall be within  $\pm 5^\circ$  from preset nominal.
5. The output power must be programmable between  $0$  and  $30$  Watts in steps of  $0.5\%$  to achieve the required modulation depth in space.
6. The sideband transmitter producing the sideband  $\pm 9960 \text{ Hz}$  of the carrier shall be dualized.

D. RF Distribution Unit

0. RF distribution unit shall be provided feeding the sideband antennas in correct sequence to simulate the  $30 \text{ Hz}$ -rotation within the antenna circle. The distribution unit shall be designed for two sideband inputs and at least  $48$  outputs.
1. To obtain the smoothest velocity during rotation and the lowest amplitude modulation on the  $9960 \text{ Hz}$  sub carrier in space the sideband antenna have to be decoupled to obtain very low interactions.
2. To prevent interactions within the antenna system between radiating and non-radiating elements the source resistance looking backwards in the distribution unit shall be constant  $50 \text{ Ohms}$  (VSWR less than  $1.1$ ) Absorber modulation using variable resistance pin diodes network for generating the blending function is preferred.
3. The blending function shall be  $\sin/\cos$  and generated by D/A conversion. To control the  $30 \text{ Hz}$  rotation two switching frequencies of at least  $720 \text{ Hz}$  have to be provided and phase locked to the  $30 \text{ Hz}$  amplitude modulation on the carrier.
4. The RF phase deviation from one sideband input to the  $48$  or so outlets shall not differ more than  $\pm 5^\circ$  from the mean value. The attenuation from one sideband input to each output in the "on" conditions shall be less than  $0.8 \text{ dB}$ . In the "off" condition the attenuation has to be greater than  $50 \text{ dB}$  for this path.
5. For test purposes a manual selectable computer controlled stepwise phase shift of the rotating sidebands against the  $30 \text{ Hz}$  reference altitude modulations has to be provided. A continues feeding of each side band antenna pair for test and measurement shall be possible.

## 1.12 ANTENNA SYSTEM

### General Requirements

0. The antenna shall radiate carrier and both 9960 Hz-sidebands simultaneously. To provide for low amplitude modulation on the 9960 Hz sub carrier the system shall use at least 48 sideband antennas.
1. The sideband antenna have to be decoupled to obtain isolations greater 20 dB for low interactions.
2. Each radiating element shall have a high radiation efficiency and high stability to obtain coverage requirements given in ICAO Annex 10. Carrier and sideband antennas have to be mounted at a circular counterpoise of approx. 30 m diameter.
3. The counterpoise construction shall be adequate to have a very homogenous conductivity on the surface for the used radio frequency. The height of the counterpoise shall at least 3 m and shall be increasable using other supports.

### A. Electrical Requirements

0. The antenna system shall operate in the frequency range 108 to 118 MHz.
1. The horizontal pattern of the antennas shall be omni directional with tolerances of less than 0.5 dB in amplitude and less than 5° phase deviation from the mean value measured under low elevation. The radiated co-polarization shall be horizontal whilst the vertical cross polarization component in the horizontal plane shall be at least 40 dB below the co-polarization component.
2. The carrier antenna at the centre and at least 48 antennas mounted on an antenna ring of adequate size to produce a modulation index of 16 + 1 have to be provided for sideband radiation. Sideband antennas have to be decoupled by a coaxial network near the elements for lowest interaction and to avoid frequency sensitivity within the compensation by thermal change of length of antenna feeder cables.
3. The amplitude modulation the 9960 Hz sub carrier due to interactions when measured at more than 300 m from the station shall not exceed 30% peak to peak for elevation angles up to 5° above the horizon. Each element shall have an input impedance of 50 Ohms and a VSWR of less than 1.1:1.
4. The modulation depth of the subcarrier under elevation angels up to 20° shall be between 25 and 35% and within 20 to 40% for elevations from 20 to 40°.
5. The frequency modulation deviation in the 9960 Hz subcarrier decreases with the elevation angle due to the Doppler principle and shall be not less than 367 Hz at 40° related to station.
6. Peak values in the horizontal plane where the nominal value is 480 Hz shall not exceed 600 Hz.
7. The systematic bearing error shall be less than 0.5° measured at 300 m distance and an elevation angle of 3° above horizontal and flat terrain.
8. The azimuth accuracy has to be better than +/- 1° measured over flat ground at 3° elevation in more than 300 m distance.

9. The azimuth stability shall be better than  $\pm 0.5^\circ$  measured at the monitors.

B. Antenna Mounting

0. Each radiating element shall be enclosed by a fibreglass reinforced specification for weather protection.
1. The sideband radiating elements shall be equally spaced on the antenna ring and shall have a nominal height of 1.4 m above the counterpoise surface.
2. The counterpoise height shall be selectable in steps between 3 and 10 m. The counterpoise shall be of rigid construction. The antenna shall include all cable supports and shall have a fixed stair for access. The counterpoise antenna shall be mounted on concrete foundation to be constructed by the Contractor.
3. The antenna shall be installed in such a way that the performance requirements are met.
4. Obstruction lighting:

***The antenna shall meet the obstruction requirements of ICAO Annex 14. Obstruction lighting shall be mounted in accordance with the requirements.***

***A dual obstruction light shall be provided. The light shall be controlled by a photo electric cell.***

C. Environmental requirements

0. Each element of the antenna and the counterpoise shall withstand an temperature range of  $-10^\circ$  to  $+60^\circ$  C without decreasing performances.
1. Each element of the antenna and the counterpoise shall function up to a wind speed of 160 km/h without a decrease in performance and shall withstand wind speeds up to 200 km/h.

## 1.13 MONITOR GROUP

General Requirements

0. The integrity of the radiated navigation signals requires their continuous monitoring. Redundancy in the signal evaluation and action decision electronics must safeguard against false signal radiation or erroneous action of equipment in case of a monitor fault.
1. The monitoring system shall employ digital signal processing methods in combination with numerical tolerance evaluation and with fully redundant processing hard- and software.
2. Monitoring signal evaluation shall be carried out by "Discrete Fourier Analysis" Signals from the monitor receiving antenna in the field containing modulation components as well as DC levels equivalent to the carrier. As these components are individually available by the result of the Fourier Analysis they have to be mathematically linked to the relevant signals. They shall be used as specific-to-system monitor parameters.

3. Logic soft- and hardware circuits shall be provided to ensure correct decisions for warning, changeover or shutdown of the transmitting equipment, besides proper failure recognition and evaluation.
4. Failure of one monitor assembly shall not affect the operation of the DVOR but shall provide a warning.
5. The monitors shall be capable of operation with the local or remote control and status board arrangements providing visual and audible indications of the DVOR status or status change.
6. Provisions shall be made to switch a DVOR test generator to the monitors for calibration checks, correct functioning verification and integrity checks via PC operation.

A. Monitoring parameters and alarm limits

0. The monitor measurement range shall be  $0^{\circ}$  to  $359.9^{\circ}$  for installation of the monitor dipole in any azimuth of the station. The accuracy of each of the two monitors must be within  $\pm 0.15^{\circ}$ .
1. The upper and lower azimuth alarm limits must be programmable and settable from  $0^{\circ}$  to  $359.9^{\circ}$  in steps of  $0.1^{\circ}$ .
2. The upper and lower 30Hz AM alarm level must be settable from 0% to 39.9% in steps of 0.1%.
3. The upper and lower 9,960 Hz AM alarm level must be settable from 0 percent to 39.9% in steps of 0.1%.
4. The 30 Hz FM deviation (modulation index) has to be monitored and upper and lower alarm limits shall be settable around the nominal value of 16 in steps of 0.1.
5. The identity shall be monitored and alarm has to be given if keying at 1020 Hz is not present.
6. The carrier level has to be monitored. Alarm must be generated if power is outside lower or upper limit related to nominal. Limits have to be settable in steps of 1%.
7. Sideband antenna function has to be monitored. A warning shall be given if a failure exists in one or more antennas not leading to azimuth failure in space. Warning limits shall be programmable.
8. The RF phase of sidebands related to carrier shall be monitored and warning shall be initiated if the actual value is outside programmable limits. Both limits shall be selectable between  $0^{\circ}$  and  $180^{\circ}$  in steps of  $1^{\circ}$ . Monitor agreements shall be selectable between AND and OR configurations for alarm actions. Monitor have to be prepared to be fed with RF signals from an antenna in the far field.

B. Test Generator

0. In order to facilitate ground checks, a DVOR test generator shall be an integral part of the equipment. Its high accuracy navigation signal outputs shall be connected to the monitors for correct performance verification.
1. The generation of the test signals shall be such as to make unnecessary any further calibration and/or adjustments.
2. Monitor checks via the test generator shall not affect normal DVOR operation.

C. Built-in Test Equipment: BITE

0. As maintenance will be greatly reduced by the provision of built-in test equipment a suitable arrangement shall be included in the equipment.
1. For this purpose plug-in units and modules shall provide logic signals for verification of correct operation within the tolerance limits.
2. Along the flow of navigation and control signals, test points shall be installed for automatically/sampling, via through the equipment data processing for Go/No Go decisions and read out and display of actual signal values via connected PC + supervisor program.
3. It shall be possible to read out manually, by interrogation, the results of the fault-locating BITE programs via PC even when used at the remote site.
4. The BITE function must be kept completely independent from the monitoring operation.

D. Control and Indications

0. General Requirements

The control and status board unit associated with the transmitter cabinet shall provide all basic controls i.e. on/off, change transmitter and display the main status of the system.

Monitor data shall be maintained to indicate the existence of an out-of-limit condition, to transfer automatically after a programmable delay to the standby transmitter or to shutdown all radiation in case of malfunction.

In addition any indication given or action taken shall be memorized.

Means shall be provided to disable monitor and control function actions during equipment calibration (monitor bypass, local or remote controlled).

Local or remote control and status functions shall be selectable by a switch "Local/Remote"

Remote control: The information transfer via ordinary telephone line shall use a digital format. Necessary modems shall be included in both transmitter and remote control cabinets. The main status display shall be at control tower shall provide a status indication of the equipment.

Five (5) visual indications shall be provided continuously at the main status display in the control tower as follows:

i. Normal

**Warning**

**Alarm**

**Maintenance**

**Mains Off**

***In case of warning or alarm indication, the relevant data of the corresponding DVOR beacon shall be available at the remote control unit for read-out via PC + supervisor program.***

***The following printouts shall be generated on command:***

- ii. Transmitter data indication and recording

Monitor data indication and recording

Documentation of controls

Automatic recording of external

Transmitter parameter changes

***The remote control system shall be capable of reading all parameters of the transmitter BITE, providing therefore the possibility of remote trend analysis and remote fault analysis via PC.***

- 1. Equipment Change over and Measurement Requirements

Changeover circuits shall be provided to connect the reference carrier antenna and the RF distribution unit and the sideband antennas to transmitter 1 or 2 initiated either by the monitors or by local/remote control and status board operations.

Measurement functions shall be built into the transmitter circuitry to check waveforms and power levels of the DVOR signals for alignment and maintenance purposes. RF dummy loads shall be provided to terminate the unused transmitter outputs.

#### **1.14 CABLING**

- . All outdoor RF cabling shall be part of these specifications. All outdoor cabling shall be direct buried which will be provided by the Contractor.
- A. All power cables between the power shelter and equipment shelter shall be supplied by the Contractor. The power cable shall be connected to the main switch in the power shelter.
- B. All control cables shall be part of the specifications. The control cable shall be connected to the marshalling box in the shelter.
- C. Radio Frequency connections within the electronic equipment shall be effected by means of coaxial connectors, throughout. RF cabling and interconnections between plug-in units and modules shall be located at the rear of the cabinet or subrack by plug-in type connectors for the RF-modules. RF connections to the transmitting antenna system shall be accessible on RF output connectors located on a separate panel inside the cabinet.

#### **1.15 POWER SUPPLY SYSTEM**

- . A static Uninterruptible Power Supply (UPS) system shall be provided to maintain the operation of the system during a power failure of the airport power supply system. The airport power system is backed up by a diesel driven emergency generator.
- A. The UPS equipment shall comply with the requirements as defined in section 16210 – Uninterruptible power system and shall be installed in the navigational aids equipment shelter.

#### **1.16 FOUNDATIONS AND DUCTING**

- . Shelter foundations: the Contractor shall construct shelter foundations. The Navigational Aids contractor shall prepare drawings indicating the foundation requirements.
- A. Radial wire: the contractor shall provide radial wire mesh and grounding rods. The wire mesh shall be handed over to the Contractor before construction of foundation starts.
- B. Antenna Foundations: the Contractor shall construct the antenna foundations. Anchor bolts shall be handed over before construction starts.

## **PART 1 - EXECUTION**

### **1.10 GENERAL**

- . Verify the conditions and the availability of the site prior to commencing the installations.
- A. Coordination: The Contractor shall coordinate the installation of the equipment with the Project Manager.
- B. Provide construction drawings of the foundations to the Contractor. When foundations are completed verify foundations.
- C. Install equipment shelters and antenna on foundations. Obtain approval from the Project Manager before installation of shelters.
- D. The Contractor will provide power cable between the AGL building and navigational aids shelter. Connect power cable to distribution board in the AGL building.
- E. Install cables in duct system between the equipment shelter and the antenna. Cable splices shall not be used. Cables shall be installed in duct in a manner to prevent harm full stretching of the conductors.
- F. Provide temporary obstruction lights on shelters and antennas during constructions.

**END OF SECTION: 20210 DVOR**

## SECTION 20310

### SHELTER

#### PART 1 - GENERAL

##### 1.10 SUMMARY

- . The navigational equipment shall be installed in a prefabricated shelter. The shelter shall be furnished by the Contractor complete and in accordance with all requirements herein. The shelters shall be placed on concrete foundations to be provided by the Contractor.
- A. The equipment shelter for the Navigational Aids equipment shall be fully furnished as specified hereafter including equipment and shelter facilities.
- B. The contractor shall design and provide all conduit, power wiring, electrical power distribution panels, junction boxes, ground fault interrupters, and supporting hardware required to provide a complete operable interface between the shelter and the antenna group.
- C. The shelter shall accommodate all DME, DVOR and power equipment.

##### 1.11 RELATED SECTIONS

- . The following sections include requirements which relate to the work of this section:
  0. Section 16050 Basic Electrical Requirements
  1. Section 16075 Electrical identification
  2. Section 16129 Indoor cables and wires
  3. Section 16178 Underground cables
  4. Section 16200 Grounding

##### 1.12 QUALIFICATIONS

- . Contractor specializing in construction of shelters specified in this section with minimum five years of documented experience.

##### 1.13 DELIVERY, STORAGE AND HANDLING

- . Protect equipment from extreme temperature and humidity and store in a conditioned space. Prevent corrosion, contamination. Keep all electrical equipment dry at all times.
- A. Protect equipment from dust and debris by wrapping unit in transparent dust tight cover and storing away from construction activity.
- B. Handle equipment and materials in accordance with manufacturers recommendations.

##### 1.14 MAINTENANCE SERVICE

- . Provide service and maintenance of system during the entire defects liability period.

## **PART 1 - PRODUCT**

### **1.10 GENERAL**

- . The shelters described herein shall be installed on the locations as indicated on the drawings and shall house the following equipment:
  0. Contractor furnished electronic equipment.
  1. Ancillary electrical, mechanical and support items furnished by the Contractor.
  2. Additional items to be installed by the Contracting Authority at a later date.
- A. The shelters shall be designed for an intended useful life of 30 years, and shall be structurally capable of relocations without major repair.
- B. Exterior maintenance for the first 30 years shall be limited to minor repair and caulking. Interior maintenance shall be limited to cleaning, minor repairs, and light bulb replacement during the normal functional operation of the facility for the duration of a 30 years life. Repainting and re-roofing shall not be required. The structural design, material selection, foundation design, and protective finishes shall comply with current good engineering standards and, in addition, meet or exceed the engineering requirements stated.
- C. The Contractor shall lay out, design, fabricate, and furnish shelters suitable to house all the components, including electronic equipment, electrical/mechanical equipment, storage facilities, work surfaces, batteries, etc. required for the complete system.
- D. The shelter and electrical/mechanical equipment with or without installed electronic equipment shall be designed for transportation from the equipment Contractor's plant to the installation site and future transportation to different locations as indicated on the drawings. Electronic equipment, the air conditioners and wall opening hood covers may be packed in separate cartons and stored in the shelter for shipment. If any wall openings are exposed, they shall be tightly covered and sealed with suitable materials for shipment and possible long-term storage. Other long-term storage provisions, as required, including appropriate instructions shall be provided.

### **1.11 LAYOUTS**

- . Navigational Equipment Shelter
  0. The Contractor shall propose a layout with final equipment configuration and state-of-the-art technology. The following shall be provided:

***The Navigational Aids equipment shelter shall be equipped with the following electrical and mechanical systems:***

#### **Lighting fixtures and switches**

Socket outlets

Distribution board

Obstruction lighting with photocell

Lightning protection

Grounding System

Shelter

Terminal box for remote control system

***Working space: A 80 cm work clearance area shall be maintained in front of all electronic equipment, as well as benches, storage cabinets and electrical and mechanical equipment.***

***Fire Extinguishers: Space shall be provided near the building door for placement of a wall mounted ABC type and 7 kg CO<sub>2</sub> fire extinguisher.***

***Work benches and storage cabinets: The work benches shall be provided with laminated maple-top, steel frame, work bench with minimum dimensions of 60 x 90 x 90 cm and a steel storage cabinet with a minimum storage capacity of at least six cubic feet. The other shelters shall be provided with a laminated maple-top, steel frame, work bench with minimum dimensions of 60 x 120 cm and a steel storage cabinet with adjustable shelves.***

#### **1.12 SERVICE CONDITIONS**

- . The shelters and the equipment therein shall sustain the maximum stresses caused by service conditions without permanent deformation, damage or degradation of operation.

#### **1.13 SHAPE AND SIZE**

- . The shelters shall be rectangular in shape with nominal exterior dimensions of 2400 mm by 3500 mm to facilitate over the road transportation.

#### **1.14 DESIGN CRITERIA**

- . The shelters shall be skid mounted and designed to withstand subsequent relocations, with all equipment in place, after initial field installation. The shelter, including roof, shall be designed and connected to the floor structure so the structure as a whole shall be capable of resisting twice the overturning moment resulting from wind uplift forces encountered with the floor structure anchored to the foundation. The structural design shall incorporate all requirements for openings and support made necessary by equipment installed in, on, or through the structure.
- A. Floor, wall, and roof surface materials shall not be used for support, restraint, or alignment of installed equipment. The floor system shall be designed to support

a uniform live load based upon the maximum loads imposed by the equipment and personnel to be supported, recognizing that electronic equipment may be relocated within the shelter in the future. In no case shall the floor be designed for less than 250 kg/m<sup>2</sup>. The floor deflections due to equipment loading and live loads of 600 kg/m<sup>2</sup> shall not exceed 1/350 of the spans. The ceiling shall be designed to support a uniform live load based upon the maximum loads imposed by equipment mounted or suspended from the ceiling. Design loads shall be based on the environmental conditions. The shelter shall be designed to withstand the dynamic loads resulting from sudden starting and stopping during transportation and movement over bumpy roads with all equipment in place. The dead load of the shelter and all installed equipment shall be included in the dynamic design. The minimum vertical shock loading shall be 3g and the minimum lateral and longitudinal shock loads shall be 1g. Shock loads shall be considered to have a maximum frequency of 20 Hz.

### **1.15 MATERIALS AND MATERIAL APPLICATION**

- . Materials of construction shall be suitable for the intended application considering the shelter life, service conditions, and transportation loads. The ultimate sites for these shelters may range from coastal environments with salty atmosphere to mountainous areas. Provisions shall be made for the prevention of corrosion; avoidance of unprotected surfaces, moisture traps; and galvanic couples due to contact between dissimilar metals; and proper selection and application of protective finished shelters with required periodic maintenance inspection or activity normally necessary not more than once every three months.

### **1.16 FIRE RESISTANCE**

- . Materials used for shelter construction (hidden and exposed) shall be non-combustible or fire retardant. Fire retardant treatment shall not be subject to degradation due to weathering or custodial operations such as cleaning, washing, etc. Plastic materials (including foam insulation and sandwich panel rigid foam) shall be processed to impart self-extinguishing characteristics to the material.
- A. Bolts, nuts, washers, screws and other metal connectors shall be made of material that will not rust or corrode for the life of the building. Steel skids or framework under the shelter shall be hot-dipped galvanized.
- B. The materials selected shall have been proven as suitable for the intended service life of the structure, service conditions to which it will be exposed, transportation stresses that are expected, and the minimum maintenance that is required. Special provisions shall be taken for the prevention of corrosion and avoidance of unprotected surfaces, moisture traps, and galvanic couples due to dissimilar metals.

### **1.17 HEAT TRANSMISSION**

- . The maximum heat transmission coefficient value throughout the roof, walls, floor, and door shall for the shelters be 2.9 Btu/hr/m<sup>2</sup>/°C. Calculations of the actual heat transmission coefficient shall be submitted for the approval of the Project Manager. The calculations shall be in accordance with the methods and values shown in the latest issue of the Heating, Ventilating, and Air conditioning Guide and Data Book (ASHRAE Guide).

## **1.18 FLOOR**

- . The floor for the shelters shall be covered with vinyl tiles. The floor adhesives shall resist degradation from exposure to solvents and oil.

## **1.19 ROOF**

- . There shall be no roof-mounted equipment on the shelters. The roof shall sustain a 100 kg live load, concentrated on 0.1 m<sup>2</sup> placed at the centre of the roof simultaneously with a 200 kg/m<sup>2</sup> load with a maximum deflection 1/360 of the length of the spans. The roof of the glide slope shelter shall sustain the DME antenna load.

## **1.20 OPENINGS**

- . All openings for conduit, duct work, etc., shall be provided in the shelters as necessary for field installation of the system. Weatherproof covers shall be provided for each opening and provision shall be made to maintain the insulation rating of the shelter if the opening is not in use.
  - A. A weatherproof closure shall be provided to seal around each conduit, or cable that passed through an opening in the shelter. Hoods (with filter holders for intake air) and insect screens shall be provided for all air intake and exhaust openings. Hoods shall be detachable for transportation. Hoods shall be galvanized steel or other materials with equal strength and corrosion resistance properties.

## **1.21 DOORS**

- . The shelters shall be provided with an air lock to avoid the humidity of the outside air entering the shelter. The exterior door shall be a minimum of 900 mm wide and a minimum of 2050 mm high. The door shall be structurally sound, impervious to the weather and shall be insulated. A minimum of three hinges of the "non-rising" pin type, are required on each door. The door shall open out and be equipped with a brass or bronze threshold and weather stripping to prevent dust and moisture entry. A rain hood shall be provided for installation over the door opening. The hood shall be detachable during periods of transportation.
  - A. The exterior door shall be provided with a cylindrical lockset. The lockset shall be one that is adaptable to the existing key locking system.
  - B. The interior door shall be of a similar size to the outside door. The doors shall be made of aluminium with three hinges and be provided with draught excluding strips.

## **1.22 FOUNDATION DESIGN**

- . The shelters shall be designed for installation on a concrete slab, piers, or grade beam at a minimum of 300 mm above the finished site grade. Hardware required for tie down of the shelter shall be furnished. Anchor bolts shall be handed over to the Contractor. The Contractor shall design and prepare standard foundation construction drawings and specification.

## **1.23 STEPS**

- . Metal steps with an integral safety handrail and a 1200 by 1500 mm top landing shall be provided at each door for personnel access to the shelter. The steps shall be removable for transportation and shall be designed for anchoring to a poured concrete pad (not provided as a part of this specification) in accordance with instructions to be furnished by the Contractor.

#### **1.24 AIR CONDITIONING**

- . The contractor shall select and furnish 2 window type air conditioners with automatic switch-over and temperature control. The system shall be sized to maintain the conditioned space at 20 °C dry bulb and less and 50% relative humidity with normal design conditions at 37 °C dry bulb and 24 °C wet bulb, with not less than 20% spare capacity of the design load. The air conditioning load shall be calculated in accordance with the ASHRAE Guide and Data Book and based on the internal heat loads of the electronic equipment in the normal mode of operation as well as any mechanical heat loads that might be within the conditioned space. Included in the air conditioning load shall be all lighting fixtures illuminated, one occupant, and transmission gains through roof, wall and floor areas including solar load.

### **PART 1 - EXECUTION**

#### **1.10 GENERAL**

- . Verify the conditions and the availability of the site prior to commencing the installations.
- A. Coordination: The Contractor shall coordinate the installation of the equipment with the Project Manager.
- B. Install shelters on foundations. Obtain approval from the Project Manager before installation of shelters on the foundations commenced.
- C. Connect in and outgoing communication cables.

### **END OF SECTION: 20310 SHELTER**

## **SECTION 20320**

### **FLIGHT TEST**

#### **PART 1 - GENERAL**

##### **1.10 SUMMARY**

- . This section shall consist of the flight testing and commissioning and putting into operation of the navigational aids facilities. The flight tests shall be performed on all navigational aids included in the contract.
- A. Four weeks before the assumed date of Final Acceptance the Contractor shall submit his intended date of flight test. The Contractor shall make all arrangements for the flight tests in accordance with ICAO Annex 10, latest edition.
- B. The Contractor shall also provide all data to establish the correct guidance information of the facilities. Flight test sheets shall be made available. After final adjustments have been made to satisfy the requirements of the Employer they shall be submitted for approval. The sheets shall be signed by the inspection Supervisor of the Airways Navigation Services (ANS) and the Test Pilot.
- C. In order to provide suitable support equipment for the flight test team two VHF transceivers (108 - 137 MHz, 25 Watt) including incidentals shall be provided.
- D. The flight tests shall be successfully completed prior to the handover and acceptance of the complete systems.

##### **1.11 SUBMITTALS**

- . The following documents shall be provided:
  - 0. Flight Check Recordings
  - 1. Program of flight test

##### **1.12 QUALIFICATION**

- . The flight test shall be performed by a company specialized in calibrating Navigational Aids.

**END OF SECTION: FLIGHT TESTS**

**SECTION 20410**  
**DEMOLITION AND REMOVAL**

**PART 1 - GENERAL**

**1.10 SUMMARY**

- . Section includes demolition of designated structures; demolition of foundations and slabs-on-grade; disconnecting and capping, demolition of identified utilities; removing demolished materials from the site; protection of items to remain as indicated.
- A. Before any demolition works start a joint measurement of the item shall be performed between a representative of the Contractor and the Project Manager
- B. Contractor shall coordinate with the Contractor of Civil Works
- C. Prior to the activities above a NOTAM shall be issued decommissioning of the old NDB system including temporary measures. The Contractor shall inform the Authorities at least two weeks before the demolition works starts.
- D. All equipment identified by the Contractor shall be handed over to the Project Manager.
- E. All temporary measures shall be approved by the Project manager.

**1.11 SUBMITTALS**

- . Indicate demolition and removal sequence and location of salvageable items; location and construction of barricades, fences and temporary work.

**1.12 SCHEDULING**

- . Describe demolition and removal procedures and schedule.

**PART 1 - PRODUCTS**

- . Not applicable

## **PART 1 - EXECUTION**

### **1.10 EXAMINATION**

- . Identify utility services and obstructions to be removed or abandoned during progress of the work.

### **1.11 PREPARATION**

- . Provide, erect and maintain temporary barriers and security devices at locations indicated, including warning signs and lights, and similar measures, for protection of the public and Contractor's employees and existing improvements to remain.
- A. Protect existing landscaping materials, trees, appurtenances, and structures, which are not to be demolished.
- B. Mark location of utilities.

### **1.12 DEMOLITION REQUIREMENTS**

- . Conduct demolition to minimize interference with adjacent structures.
- A. Cease operations immediately if adjacent structures appear to be in danger. Notify Project Manager having jurisdiction. Do not resume operations until directed.
- B. Conduct operations with minimum interference to public or private accesses. Maintain protected egress and access from adjacent structures at all times.
- C. Obtain written permission from adjacent property owners when demolition equipment will traverse, infringe upon or limit access to their property.
- D. Sprinkle Work with water to minimize dust. Provide hoses and water connections for this purpose.

### **1.13 DEMOLITION**

- . Disconnect remove and cap and identify designated utilities within demolition areas.
- A. Remove materials to be re-installed or retained in manner to prevent damage. Store and protect in accordingly.
- B. Continuous clean-up and remove demolished materials from site. Do not allow materials to accumulate in the building or on the site.
- C. Do not burn or bury materials on site. Leave site in clean condition.

## **END OF SECTION: DEMOLITION AND REMOVAL**