CV0425-Metro Systems and Engineering

Unit-4: Electrical Engineering Aspects

POWER REQUIREMENTS

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signalling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following requirements:-

(i) Specific energy consumption of rolling stock – 75KWh/1000 GTKM

(ii) Regeneration by rolling stock – 20%

(iii) Elevated/at –grade station load – initially 250KW, which will increase to 400 KW in the year 2043

(iv) Underground station load – initially 2000 KW, which will increase to 2500 KW in the year 2043

(v) Depot auxiliary load - initially 2000 KW, which will increase to 2500 KW in the year 2043.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2018, 2021, 2031 and 2043 are summarized The high voltage power supply network of city was studied in brief. The city has 220, 132 and 66kV network to cater to various types of demand in vicinity of the proposed corridor. Series of meetings were held with M/s Torrent Power AEC Limited (Licensee of the area) and various sub-stations sites were inspected to finalize the Input Power Supply sources & Supply Voltage.

Keeping in view the reliability requirements, Four Receiving Sub-stations (two for N-S line and Two for E-W line) are proposed to be set up. This is an economical solution without compromising reliability. Based on the discussions with M/s Torrent AEC Ltd., it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132 or 66kV voltage through cable feeders: -

The summary of expected power demand at various sources is given:

***** Incase of failure of other source of power

The 132 kV power supply will be stepped down to 33 kV level at the RSS's of metro authority. The 33kV power will be distributed along the alignment through 33kV Ring main cable network for feeding traction and auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct and tunnel.

Interconnection of 33kV power supply between the two corridors has been planned at the Interchange station of Old High Court which can be used for transfer of power from One corridor to other in emergency situations. In case of tripping of One RSS of either corridor on fault or input supply failure, train services can be maintained from stand-by source of the same line or by feed extension from RSS of other line. But if one more RSS fails, only curtailed services can be catered to. However, in case of total grid failure, all trains may come to a halt but station lighting, fire and hydraulics & other essential services can be catered to by stand-by DG sets. However, no train services can be run with power supply received from DG Sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well,

except for the train running.

Typical High Voltage Receiving Sub-station

The 132 kV cables will be laid through public pathways from Torrent Power AEC Substations to RSS of Metro Authority. RSS at Gyaspur and Ranip/Sabarmati RSS shall be provided with 2nos. (one as standby) 132/33 kV, 30 MVA (ONAN) three phase Transformers for feeding Traction as well as auxiliary loads and RSS near Thaltej and Apparel park RSS shall be provided with 2nos. (one as standby) 132/33 kV, 45 MVA (ONAN) three phase Transformers. The capacity of transformers may be reviewed considering the load requirement/distribution of both the corridors at the time of detailed design. Conventional Outdoor type 132 kV Switchgear is proposed for all the RSS to be located in approx. 80 X 60 m (4800 sq. m) land plot as the availability of Land in this area may not be a constraint. If Gas Insulated Switchgear (GIS) type Switchgear will be planned in future due to less space and reduced maintenance the capital cost need to be enhanced.

750V dc Third Rail Current Collection System

For the 750V dc Third Rail Current Collection System, Bottom current collection with the use of composite Aluminum steel third rail on main lines is envisaged from reliability and safety considerations (figure below). Low carbon steel third rail available indigenously is proposed for the depot because of reduced current requirements.

6mm thick

Aluminium

sliding surface : stainless steel

Concrete Sleeper

Third Rail support

Third Rail

Insulated Protective Shrouds

Insulator

Track

Composite Aluminum Third Rail

750V dc Third Rail Current Collection System

The cross-section of third rail will be about 5000 mm2. The longitudinal resistance of composite and steel third rail is about 7 and 20 milli-ohm/km respectively. The life of composite and steel third rail is expected to be 25-30 years.

Special Arrangements in Depot

A separate traction sub-station (TSS) shall be provided for the depot so as to facilitate isolation of depot traction supply from mainlines in order to prevent the leakage of return currents to depot area. Tracks of Depot area shall also be isolated from mainline through insulated rail joints (IRJ). Remote operated sectionalizing switches shall be provided to feed power from depot to mainline and vice-versa in case of failure of TSS. The prescribed limit of highest touch potential in depot is 60V as per EN50122-1 and therefore Track Earthing Panels (TEP) shall be provided at suitable locations to earth the rail in case the rail potential exceeds this limit. In areas, where leaky conditions exist (e.g. washing lines, pit wheel lathe etc.), insulated rail joints (IRJ) shall be provided with power diodes to bridge the IRJ to facilitate passage of return current.

A detailed scheme shall be developed during the design stage.

Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)

AC traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. However, dc traction currents do not cause electromagnetic induction effect resulting in induced voltages and magnetic fields.

The rectifier-transformer used in dc traction system produces harmonic voltages, which may cause interference to telecommunications and train control/protection systems. The rectifier-transformer shall be designed with the recommended limits of harmonic voltages, particularly the third and fifth harmonics. 12-pulse rectifier transformer has been proposed, which reduces the harmonics level considerably. Detailed specification of equipment e.g. power cables, rectifiers, transformer, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc.

A detailed EMC plan will be required to be developed during project implementation stage.

Auxiliary Supply Arrangements for Stations & Depot

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. A separate ASS is required at each depot. The ASS will be located at mezzanine or platform level inside a room. Wherever TSS is required, ASS & TSS will be housed together inside a room. The auxiliary load requirements have been assessed at 400 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415kV) of 500kVA capacity are proposed to be installed at the stations (one transformer as standby). Both the Depot ASSs will also be provided with 2x2500 kVA auxiliary transformers. For Underground station, the auxiliary load requirements have been assessed at 2500 kW, accordingly, two dry type cast resin transformers (33/0.415kV) of 3200kVA capacity are proposed to be installed at the stations (with one transformer as standby).

Typical Indoor Auxiliary Sub-station

2 x 2.5MW transformer-rectifier set shall be provided in each TSS with space provisions for an additional set to be accommodated in future as and when train composition is increased. Self-cooled, cast resin dry type rectifier-transformer is proposed, which is suitable for indoor application. From the traction sub-stations, 750V dc cables will be laid up to third rail and return current cables will be connected to running rails.