Domestic service line - IE rules

Objectives: At the end of this lesson you shall be able to
- **explain the domestic service connection with bare and insulated conductors**
- **state the method of laying the service cable from the pole to the consumer premises**
- **state the safety precautions to be followed in domestic service connections**
- **list out the IE rules pertaining to domestic service connections**
- **explain the methods of taping service connections.**

Service connections

The distribution networks ends at consumer premises either single phase or three phase connections. The category of connections either single phase or three phase depends as the maximum load demand by the consumer and the wiring of the house or the premises. The decision of power allocation by the electricity officials after surveying the wiring and load demand by the consumer.

Once the power requirement finalised and arrived the connection to the consumer the point from where the service line to be connected. It is also decided the drawing of line from the pole cross arm structure to the consumer mains panel either in over head or through UG cable. If the distance from over head pole terminal to consumer panel board is more than 50 Mtrs separate pole should be erected and OH line to be drawn from the distribution pole cross arm structure.

Service connection with bare conductor: Any of the following methods shall be adopted as specified.

The bare conductors shall be strung with shackle insulators fixed to the cross arms on both ends. The feeding end cross-arms shall be fixed to the support and the one at the receiving end shall be mounted on a G.I. pipe of a maximum diameter of 5 cm. The bare conductors shall be kept at a height of atleast 2.5 m from the top of the structure in accordance with Rule 79 of I.E. rules.

The G.I. pipe shall be provided with double bends at the top. The pipe shall be secured by alteast 2 clamps made of 50 mm X 6 mm. with M.S. flats fixed firmly to the wall in the vertical position. It shall in addition be provided with a G.I. stay wire of 7/3.15 mm size anchored to the building with one eye bolt. Service connection shall be given with weather proof/PVC insulated cable through this G.I. pipe. Wooden/PVC pushings shall be provided at both ends of this G.I. pipe.

The bare conductors shall be strung with shackle insulators as above except at the receiving end where the insulators shall be fixed to a bracket made of an angle iron, of a size not less than 50 mm x 50 mm x 6 mm. The ends of the bracket shall be cut and split and embedded in the wall with cement mortar. The bare conductor shall be kept atleast 1.2 m away from the edge of the structure, in accordance with Rule 79 of I.E. Rules.

The service connection shall be given with weather proof/ PVC insulated cable through GI pipe of a minimum diameter of 4 cm. fixed to the wall. The GI pipe shall be bent downwards near the service entry. Wall fitting wooden/ PVC bushes shall be provided at both ends of the G.I. pipe.

Service connection with insulated conductors: Service connection may be given by weather-proof/PVC insulated cable on a GI bearer wire. The cables shall be supported by the bearer wire by means of suitable link clips spaced 30 cm apart or by wooden/porcelain cleats 50 cm. apart. The GI bearer wire shall be of a minimum 10 SWG size.

One end of the GI bearer wire shall be attached to a clamp which is fastened to the nearest pole carrying distribution lines from where the service connection is intended to be given. The other end of the GI bearer wire shall be fastened to a 5 cm. dia. GI pipe for a span up to 4.5m which is fixed to the wall with guy etc.

The GI pipe shall be fixed to an angle iron of size 40 mm x 40 mm x 6 mm with a suitable guy for high supports and for a span exceeding 4.5 m. Alternatively when the height of the structure permits minimum ground clearance, the other end of this GI bearer wire may be fixed to a hook, eye bolt or bracket embedded with cement mortar in the wall.

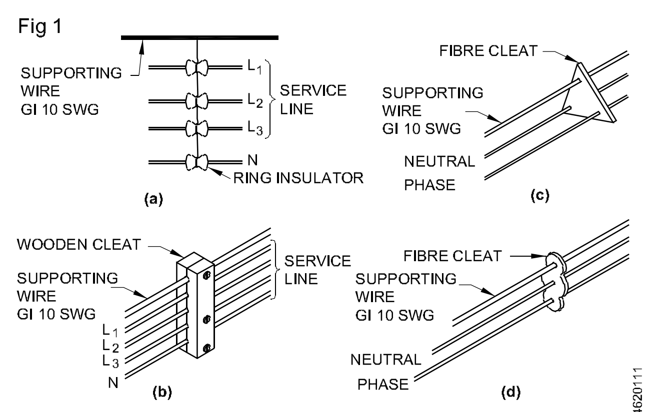
The weather proof/PVC insulated cable shall pass through a GI pipe of minimum diameter 5 cm, which is bent downwards. Wall fittings wooden/PVC bushes shall be provided at both ends of the GI pipe.

Method of laying the service cable from the pole to the consumer main: In practice either a glass or porcelain ring insulator or wooden fibre cleats are used to lay the overhead service line from the pole to the consumer mains as in Fig 1.

Safety Precautions to follow while connecting pole to consumer premises

1 The cable conductor size must be as per the IE rule standard either single phase or three phase.

2 If the service line crosses public road the clearance must be as per IE rule.



LAYING OF SERVICE LINES

3 The conductor slag should not exceed as per the IE rules.

4 If UG cables are providing the depth of cable in ground should be as per IE rules.

5 Do not keep much more cable unused and buried in soil in the coil form in case of UG cable laying.

6 The excess cable should not be kept by making coil and kept on the pole cross arm. Use only required cable for connection.

7 If the cable passing through excess heat producing areas in near to chimney, kitchen etc; adequate protection from heat to be provided.

8 Service cable run along with stay wire tightly tied with stay wire to avoid tension on service cable.

9 No rain water flows along with service cable and reach to consumer main panel. Necessary looping of cable to be provided either side.

10 The connection to main line is to be made so tight and clean surface, so that loose contact, sparking and formation of oxide coating can be avoided.

I.E. Rules pertaining to domestic service connection

Rule 10. Construction, installation, protection, operation and maintenance of electric supply lines and apparatus

All electric supply lines and apparatus shall be sufficient in power and size and of sufficient mechanical strength for the work they may be required to do, and so far as practicable, shall be constructed, installed, protected, worked and maintained in accordance with standards of the Indian Standards Institution so as to prevent danger.

Rule 30. Service lines and apparatus on consumer's premises.

1 The supplier shall ensure that all electric supply lines, wires, fittings and apparatus belonging to him or under his control which are on a consumer's premises are in a safe condition and in all respects fit for supplying energy, and the supplier shall take due precautions to avoid danger arising in the premises from such supply lines, wires, fittings and apparatus.

2 The consumer shall also ensure that the installation under his control is maintained in a safe condition.

Rule 31. Cut-out on consumer's premises.

The supplier shall provide a suitable cut-out in each conductor of every line other than an earthed or earthed neutral conductor, or the earthed external conductor of concentric cables within a consumer's premises, in an accessible position. Such cut-out shall be contained within adequately enclosed fire-proof receptacle.

Where more than one consumer is supplied through a common service line, each such consumer shall be provided with an independent cut-out at the point of junction to the common service.

Rule 33. Earthed terminal on consumer's premises.

The supplier shall provide and maintain on the consumer's premises, for the consumer's use, a suitable earthed terminal in an accessible position at or near the point of commencement of supply as defined under Rule 58.

Provided that in the case of medium, high or extra high voltage installation the consumer shall, in addition to the afore-mentioned arrangement provide his own earthing system with an independent electrode.

Rule 48. Precautions against leakage before connecting.

1 The supplier shall not connect with his works the installation or apparatus on the premises of any applicant for supply unless he is reasonably satisfied that the connection will not at the time cause a leakage from the installation or the apparatus exceeding five thousandth part of the maximum current supplied to the premises.

2 If the supplier declines to make connection under the provisions of sub-rule(1) he shall serve upon the applicant a notice in writing stating his reason for so declining.

Rule 54. Declared voltage of supply to consumer.

Except with the written consent of the consumer or the previous sanction of the State Government, a supplier shall not permit the voltage at the point of commencement of supply as defined under Rule 58, to vary from the declared voltage by more than 5 percent in the case of low or medium voltage or by more than 12½ percent in the case of high or extra high voltage.

Rule 77. Clearances above ground of the lowest conductor.

1 No conductor of an overhead line, including service lines erected across a street shall at any part thereof be at a height less than :-

a) for low and medium voltage lines 5.791 m

b) for high voltage lines 6.096 m.

2 No conductor of an overhead line including service lines erected along any street shall at any part thereof be at a height less than:

a) for low and medium voltage lines 5.486 m

b) for high voltage lines 5.791 m.

3 No conductor of an overhead line including service lines, erected elsewhere than along or across any street shall be at a height less than:

a) for low, medium and high voltage lines upto and including 11,000 V if bare 4.572 m

b) for low, medium and high voltage lines upto and including 11,000 V if insulated 3.963 m.

Rule 79. Clearances from building of low and medium voltage lines and service lines.

1 Where a low or medium voltage overhead line passes above or adjacent to or terminates on any building, the following minimum clearances from any accessible point, on the basis of maximum sag, shall be observed.

a) for any flat roof, open balcony, verandah, roof and lean-to-roof.

i) when the line passes above the building, a vertical clearance of 2.439 m from the highest point.

ii) when the line passes adjacent to the building, a horizontal clearance of 1.219 m from the nearest point.

b) For pitched roof

i) when the line passes above the building, a vertical clearance of 1.219 m immediately under these lines.

ii) when the line passes adjacent to the building, a horizontal clearance of 1.219 m.

2 Any conductor so situated as to have a clearance less than that specified in sub-rule (i) shall be adequately insulated and shall be attached by means of metal clips at suitable intervals to a bare earthed bearer wire having a breaking strength of not less than 517.51 kg.

3 The horizontal clearance shall be measured when the line is at maximum deflection from the vertical due to wind pressure.

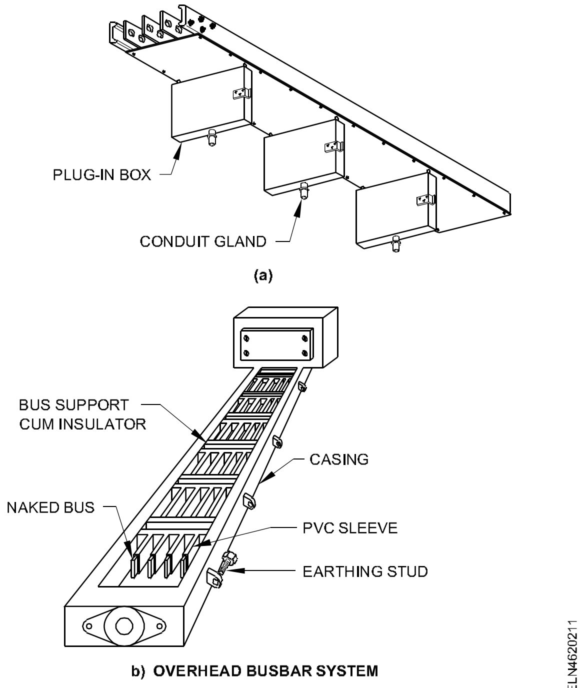
Tapping service connections: No service connection line should be tapped from an OH line from any point mid span, except at the point of support. When a service connection is taken overhead with a bare conductor, it should be provided with guard wires.

Bus-bar system - power tariff terms and definitions

Objectives: At the end of this lesson you shall be able to
- **explain the bus-bar system and the method of installation**
- **state the advantages of the bus-bar system**
- **determine the rating of the bus-bar**
- **state the use of plug-in boxes and their construction**
- **state the method of cable or conduit termination in plug-in boxes.**

In industrial workshops and factories, a number of machines are installed in the shop floor closely but apart from each other. connecting these machines to electrical supply through underground cables or overhead wires or cables may involve cumbersome methods resulting in shock hazards. For such places, an overhead enclosed bus-bar system as in Fig 1a and 1b is recommended.

Fig 1



This bus-bar system is sometimes referred to as bus way or bus duct.

Bus-bar assembly should be installed at a height of 2.75metre from ground, suspended by M.S. angles or flats from ceiling/roof or supported by framed structure from ground as in Fig 2.

Bus coupler

The bus-bars are either of high conductivity, high purity copper or alloy aluminium having rectangular sections mounted on insulating supports enclosed in standard length of metal trunking. The bus-bar sections are available in standard lengths (3.65metre for 200 ampere and 2.44metre for 400 ampere) which can be connected to another bus-bar by blowing the respective bus-bar ends thus forming a continuous bus-bar along the entire length of the workshop. Method of coupling two bus-bars is in Fig 3.

Fig 2

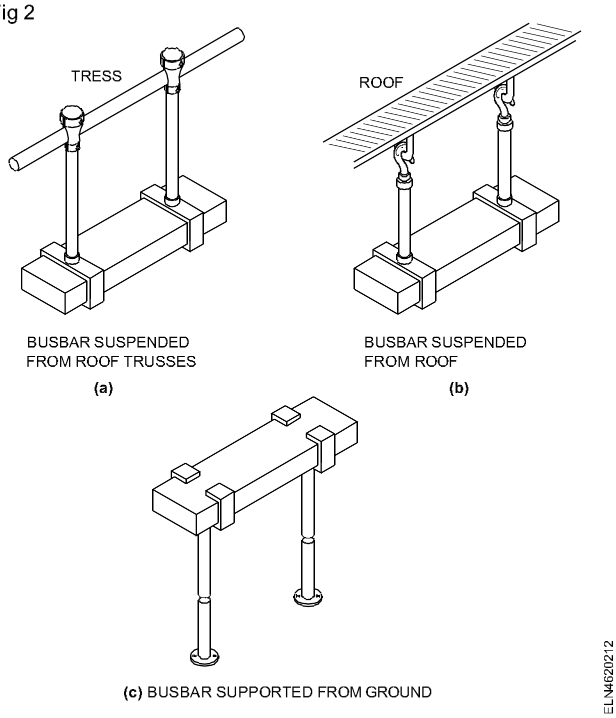
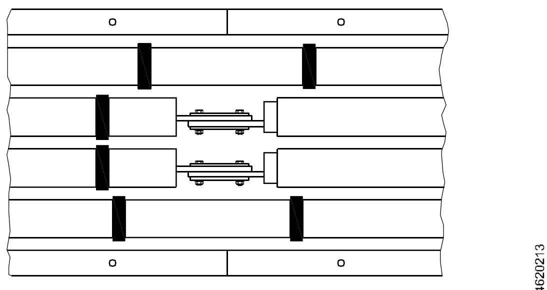


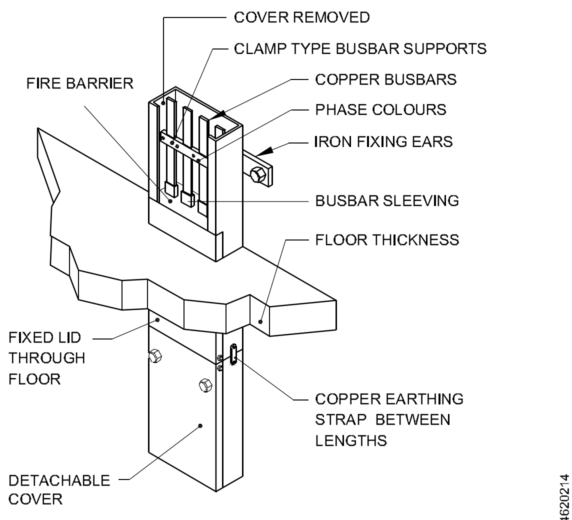
Fig 3



TWO SECTIONS OF 400 AMPS BUSBARS COUPLED TOGETHER

The standard rating of bus-bar are 100, 200, 400, 600, 800, 1200, 1600, 2000, 2400 and 3600 ampere with rated voltage of 500V. These bus-bars also available for indoor or outdoor use as point to point feeders or as plug-in take off points for power. These bus-bars are used in generating stations, sub stations, in metal industry and textile industry. These bus-bars are also used in multi storied flats to facilitate connection to various stories from the mains by using vertically mounted bus-bars as in Fig 4. These vertical bus-bars are provided with a fine barrier made up of high grade fire-resisting material positioned at the top of each fixed section of the trucking passing through the floors. This barrier is the collecting points for dirt, dust and moisture which could be removed at intervals.

Fig 4



VERTICALLY MOUNTED BUSBAR

Recommended current density for a copper bus-bar which is not enclosed should not exceed 165A/sqcm and for aluminium 118A/sqcm.

Recommended section of aluminium and copper bus-bars and their respective ratings are in Table.

Earthing continuity is provided by two strips of aluminium or copper running throughout the bus-bar assembly. When extending the bus-bar lengths, these earthing strips also to be connected to have earth continuity.

Note:

1 **Above rating is for rectangular cross-section of E-91 E-WP grade as per IS : 5082-1969 in still unconfined air without enclosure, presuming longer section vertical.**

2 **Denting factor of 0.88 may be applied for ambient of 30°C and temperature rise of 35°C. Similarly in outdoor application denting may be done for 0.85 to 0.9. Indoor well ventilated 0.6 to 0.8 and partly ventilated areas 0.5 to 0.6.**

Bus-bar size in mm	**Rating at 50Hz AC current at average ambient of 35°C and 40°C maximum and temperature rise of 50°C.**				
	Aluminium				**Copper**
	Single bar	**Two bars**	**Three bars**	**Four bars**	**Single bar**
12.5 x 3	—	—	—	—	160
25 x 3	—	—	—	—	290
50 x 3	335	650	850	950	525
75 x 3	475	875	1150	1300	750
100 x 3	600	1075	1400	1600	970
12.5 x 4.5	125	260	315	370	205
25 x 4.5	225	525	635	750	365
32 x 4.5	320	660	800	940	510
50 x 4.5	500	970	1270	1425	650
25 x 6	350	700	950	1000	430
50 x 6	675	1300	1700	1925	760
75 x 6	950	1750	2300	2600	1080
100 x 6	1225	2150	2800	3200	1380
125 x 6	1500	2500	3200	3700	1680
25 x 10	—	—	—	—	540
50 x 10	85	1500	1950	2250	960
75 x 10	1180	2050	2650	3000	1350

Bus-bar size in mm	Rating at 50Hz AC current at average ambient of 35°C and 40°C maximum and temperature rise of 50°C.				
	Aluminium				Copper
	Single bar	Two bars	Three bars	Four bars	Single bar
100 x 10	1500	2475	3150	3550	1710
125 x 10	1850	2925	3600	4200	2070
150 x 10	2100	3325	4000	4606	2430
250 x 10	2750	4100	4900	5700	—
25 x 12.5	—	—	—	—	650
50 x 12.5	—	—	—	—	1120
75 x 12.5	1350	2250	800	3200	1570
100 x 12.5	1750	2700	3350	3900	2050
125 x 12.5	2100	3100	390	4500	2420
150 x 12.5	2400	3500	4450	5100	2820
200 x 12.5	3050	4500	5300	6100	—

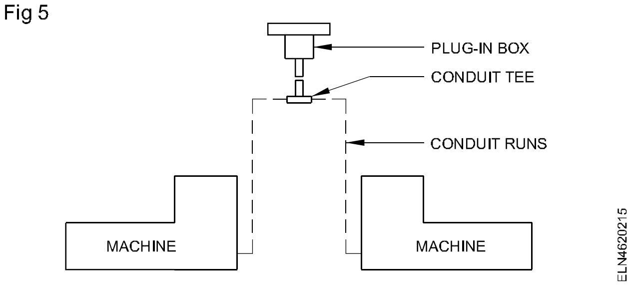
Advantages of Bus-bar system

Following are the advantages of bus-bar system

1 **Reduced cost:** Simple rapid installation with complete elimination of expensive floor chasing (cutting) reduces cost at the initial period of installation and needs no expenditure for maintaining the bus-bar system while in regular use.

2 **Maximum flexibility:** As plug-in-points are provided at intervals of 60.96cm (2 feet) along every length of bus-bar the connections can be taken for machines installed on either side. Refer Fig 5.

Fig 5



3 **Complete safety:** As the plug-in-point are completely insulated, safety is ensured for operating and maintenance personnel.

4 **'Live' connection:** As the plug-in-boxes could be connected to 'live' bus-bars quickly and safely without shut down and the time is saved without disturbing the normal work of the factory.

5 **Guaranteed protection:** As the fuse in the plug-in boxes of HRC type the circuit is protected positively and reliably against short circuit.

6 **Easily extended for layout modification in the factory:** As the bus-bars can be extended in straight lengths or at an angle to suit the layout with the help of standard accessories, the bus-bars can be remounted or rearranged within a short time.

7 **Saving of time while initial erection:** The advantages of this system are that the trucking and bus-bars can be erected before the installation of the machinery, and the latter can be connected up and set to work as soon as they are installed.

8 **Reduction of voltage drop in feeders:** By bringing the heavy main feeders near to the actual loads, the circuit wiring is reduced to a minimum and voltage drop is lower than would otherwise be the case.

9 **Addition and alterations:** Subsequent additions and alterations to plant layout can be easily accomplished, and where bus-bar sections have to be removed they can be used again in other positions.

10 **Internal grid for welders:** The overhead bus-bar system is especially advantageous where a large number of electric welders have to be fed with heavy currents from a step down transformer.

11 **Branching from plug-in-boxes for small loads:** If a large number of small machines are to be fed it is usual to fix a distribution box near the trucking system and to protect this with a tap-off fitted with HRC fuses of suitable capacity.

12 **Durable and trouble free service:** Normally bus-bars give much durable service than U.G. Cables and give many years of trouble free service.

Method of determining the ratings of the bus-bars

In a small factory, ten motors having each of 5 HP ratings to be installed. The total load is approximately 10 x 5 i.e. 50 HP Assuming 5 HP motor takes approximately full load current at 7.5A. The total current in the factory load will be 75A and has to be supplied through a single bus-bar. Normally the ratings of bus-bar is 200A or 400A. Hence a 200A rating bus-bar is selected for this case as the same bus-bar also could be used when there is expansion of load in the factory in future. Considering the overload, bus-bars are manufactured in standard sections of 3.65m (200A) and 2.44m (400A). We can decide the number of bus-bars to meet the entire length of machine layout.

Technical Data

Rating	Overall dimensions in mm	No.of plug
200A	3658 x 248 x 76	6
400A	2440 x 248 x 108	4

Bus-bar length can be increased by providing mechanical coupling and any length at run in multiples of the standard length may be thus achieved.

Plug-in-Boxes

Plug-in-boxes (Fig 6) are compact sheet steel boxes with hinged doors housing the HRC fuse holders, which are solidly connected to high conductivity copper clip on contacts reinforced by spring steel strips. These clip on contacts plug directly to the bus-bars at the plug-in-points.

Two earth pins are located at the two ends of these boxes which also serves to mount the plug-in-boxes on bus-bars.

Fig 6

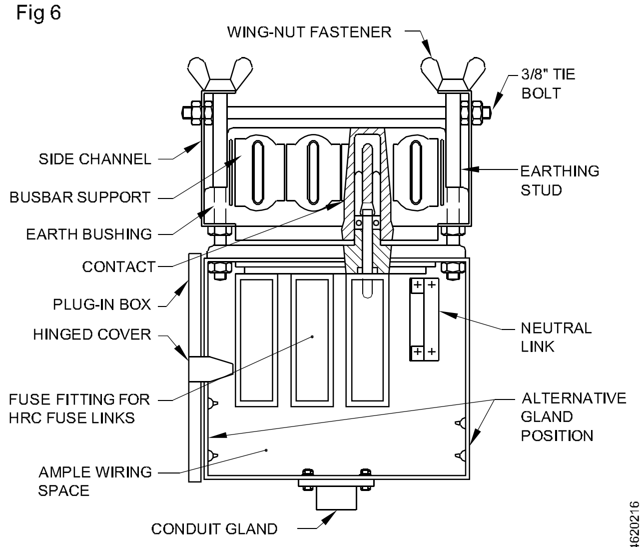


DIAGRAM SHOWING MAIN FEATURES OF PLUG-IN BOXES FITTED TO BUSBARS

Rating of plug in boxes

Plug in Boxes must be able to withstand faults current capability of bus-bars. There are rated in 16, 32, 63 and 100Amp at 415/500V (TPN).

Cables (or) conductors with termination connection to plug-in-boxes for outgoing supply by using conduit pipe to conduit glands supplied with plug in boxes either vertically down or on to either side.

However remember to use oxide inhibiting grease at all aluminium joint to maintain conductivity.

Power tariff - terms and definitions

Objectives: At the end of this lesson you shall be able to
- **state the term maximum demand**
- **explain the concept of average demand**
- **explain load factor**
- **state the term of diversity factor and its application**
- **explain the importance of plant utility factor.**

Introduction

The alternators in the power station should run at their rated capacity for maximum efficiency and on the other hand, the demands of the consumers have wide variations from time to time due to uncertain demands of the consumers. This makes the design of a power station highly complex. We shall focus our attention on the problems of variable load on power stations.

Maximum Demand

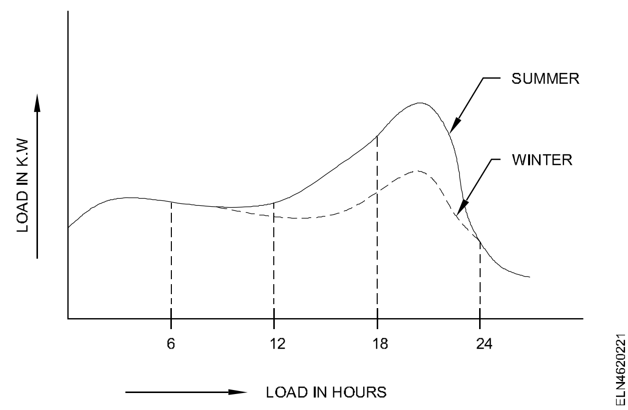
It is the highest level or greatest electrical demand monitored in a particular period or a month.

The maximum demand is in between 18 hours and 24 hours in the night during summer as well as in winter seasons as in Fig 1. All other times the maximum demand falls very low to the connected load. However the maximum load demand less than the connected load because all the consumers do not switch 'ON' their connected load of the system at a time.

The importance of the maximum demand knowledge is very important as it helps in determining the installed capacity of the stations, and the station must be capable of meeting the maximum demand.

The ratio of maximum demand as the power station to its connected load is known as demand factor; Mathematically

Fig 1



$$\text{Demand factor} = \frac{\text{Max.Demand}}{\text{Connected load}}$$

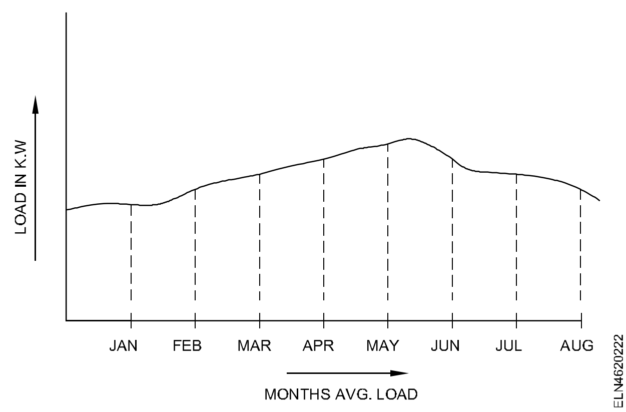
Usually it always less than one. The knowledge of demand factor is vital in determining the capacity of the plant equipment.

Average demand

It is the total demand in a month divided by number of days in that time period.

The average demand in a month taken to find the load requirement for a certain period is in Fig 2. It is evident that average load requirement is not uniform among all the months consumption as it depend on the environmental conditions; such as Winter, Summer, Monsoon seasons.

Fig 2



Load factor

In electrical engineering the load factor is defined as the total load divided by the peak load in specified time period. It is a measure of the utilization rate, or efficiency of electrical energy usage; a low load factor indicates that load is not putting a strain on the electric system, whereas consumers or generators that put more of a strain on the electric distribution will have a high load factor.

$$f_{Load} = \frac{\text{Total load}}{\text{Maximum load in given time period}} \text{ or } \frac{\text{Total load}}{\text{Peak load.}}$$

An example, using a large commercial electrical bill:

- peak demand = 436 KW
- use = 57 200 kWh
- number of days in billing cycle = 30

Hence:

- load factor = { 57 200 kWh/ (30 d x 24 hours per day x 436 kW) } x 100% = 18.22%

It can be derived from the load profile of the specific device or system. Its value is always less than one because maximum demand is always higher than average demand, since facilities likely never operate at full capacity for the duration of an entire 24 hours day. A high load factor means power usage is relatively constant. Low load factor shows that occasionally a high demand is set. To service that peak, capacity while remaining idle for long periods, thereby imposing higher costs on the system. Electrical rates are designed so that customers with high load factor are charged less over all per kWh.

The load factor is closely related to and often confused with demand factor.

$$f_{Demand} = \frac{\text{Maximum load in given time period}}{\text{Maximum possibe load}}$$

The major difference to note is that the denominator in the demand factor is fixed depending on the system. Because of thiss the demand factor cannot be derived from the load profile but needs the addition of the full load of the system in question.

Diversity factor

Diversity factor (Or simultaneity factor K_S) is a measure of the probability that a particular piece of equipment will turn on coincidentally to another piece of equipment. For aggregate system it is defined as the ratio of the sum of the individual non - coincident maximum loads of various sub divisions of the system to the maximum demand of the complete system.

$$\text{Diversity factor} = \frac{\text{Sum of individual max Demands}}{\text{Maximum Demand}}$$

The diversity factor is almost always larger than 1 since all components would have be on simultaneously at full load for it to be one. The aggregate load is time dependent as well being dependent upon equipment characteristics. The diversity factor recognizes that the whole loads does not equal the sum of its parts due to this time interdependence (i.e. diverseness). For example, we might have ten air conditioning units that are 20 tons each at a facility. We typically assume that the average full load equivalent operating hours for the units are 2000 hours per year. However, since tha units are each thermostatically controlled, we do not known exactly when each unit turns on. If the ten units are substantially bigger than the facility's actual peak A/C load, then fewer than all ten units will likely come on at once. Thus, even though each unit run a total of 2000 hours a year, they do not all come on at the same time to affect the facility's peak load. The diversity factor gives us a correction factor to use, which results in a lower total kW load for the ten A/C units. If energy balance we do for this facility comes out within reasons, but the demand balance shows far to many kW for the peak load, then we can use the diversity factor to bring the kW into line with facility's true peak load. The diversity factor does not affect the kWh; it only affects the kW.

Plant utility factor

The utility factor or use factor is the ratio of the time that a piece of equipment is in use to total time that it could be in use. If is often averaged over time in the definition such that the ratio becomes the amount of energy used divided by the maximum possible to be used. These definitions are equivalent.

The utility factor, K_u, is the ratio of the maximum load which could be drawn to rated capacity of the system. This is closely related to the concept of load factor. The factor is the ratio of the load that piece of equipment actually draws (time averaged) when it is in operation to the load it could draw (which we call full load.

$$\text{Utility Factor} = \frac{\text{Ratio of maximum power}}{\text{Plant capacity}} \times 100$$

For example, an oversized motor - 15 kW - drives a constant 12 kW load whenever it is on. The motor load factor is then 12/15 = 80%. The motor above may only be used for eight hours a day, 50 weeks a year, The hours of operation would then be 2800 hours, and the motor use factor for a base of 8760 hours per year would be 2800/ 8760 = 31.96%. With a base of 2800 hours per year, the motor use factor would be 100%.

In power plant utility factor various according to the demand on the plant from the electricity market.