**APPENDIX C - CIRCUIT ARRANGEMENT (Informative)**

**C1 Scope**

This appendix provides guidance on the following: (a) Determination of the circuit current for consumer mains, submains, and final subcircuits.  
(b) Cable selection based on current-carrying capacity and voltage drop.  
(c) Coordination of current ratings of circuit cables and protective devices.  
(d) Division of installation into circuits supplying single and multiple items of equipment, as necessary, to provide satisfactory performance of circuits for the intended purpose.  
(e) Cable installation.

These factors determine the arrangement of circuits in an installation that is deemed to meet the design, equipment selection, and installation criteria of this Standard.

**C2 Maximum Demand**

**C2.1 After Diversity Maximum Demand**

As indicated in Clause 2.5.3, the current in a circuit is not permitted to exceed the current rating of the circuit protective device, which, in turn, must not exceed the current-carrying capacity of the circuit conductors.

**NOTE:** Paragraph B3.2 of Appendix B provides further explanation.

For circuits supplying a single item of equipment, the circuit current is simply the nominal load current of the equipment (e.g., a 10,000 W, 230/400 V three-phase heater has a full per-phase load current of 14.5 A). The circuit conductors and protective device are required to have a current-carrying capacity of not less than 16 A (nearest standard rating).

Where more than one item of equipment is connected, the circuit current can be assessed as the sum of the individual equipment load currents. While this provides a safe and conservative solution, it doesn't account for normal operating conditions where not all equipment operates simultaneously at full load or for long periods (e.g., submains to a distribution board associated with multiple socket-outlet circuits).

Under such conditions, the circuit current is estimated using diversity factors, often described as the "after diversity maximum demand."

**C2.2 Calculation of Maximum Demand in Consumer Mains and Submains**

As specified in Clause 2.2.2, maximum demand current may be determined by one of four methods: calculation, assessment, measurement, or limitation. The following paragraphs provide examples of applying the calculation method for determining maximum demand in consumer mains and submains.

**C2.3 Domestic Installations**

**C2.3.1 Method**

Table C1 provides an allocation of load for different types of equipment connected to consumer mains or submains in a single or multiple domestic installation. The load current is calculated for each equipment load group, and these contributions are summed to achieve the maximum demand current.

**NOTES:**

1. See Clause 2.2.2 for circumstances where the maximum demand for consumer mains, submains, and final subcircuits may be determined by assessment, measurement, or limitation.
2. For multiphase connections, divide the number of living units by the number of supply phases (e.g., 18 units on a three-phase supply would be 18/3 = 6 units on the heaviest loaded phase).
3. Where only part of the units in a multiple domestic installation is equipped with permanently connected or fixed appliances, the number of appliances is divided over the number of phases, and the maximum demand is determined accordingly.

**C2.3.2 Examples of Calculation**

**NOTE:** These examples assume a supply voltage and equipment rating of 230 V.

**Example 1:**

**Problem:**  
Determine the maximum demand for a single domestic electrical installation supplied at single-phase with the following load:

* 24 lighting points
* 10 m of lighting track
* 9 single 10 A socket-outlets
* 8 double 10 A socket-outlets
* 50 W exhaust fan
* 1000 W strip heater
* 15 A socket-outlet
* 10,000 W electric range
* 4800 W water heater
* 3000 W tennis court lighting

**Solution:**  
Using Table C1, the method to determine the demand is as follows:

1. **Load group (a)(i):**
   * 24 lighting points
   * 10 m of lighting track
   * 50 W exhaust fan  
     **= 3 + 2 + 2 = 7 A**
2. **Load group (a)(ii):**
   * 3000 W tennis court lighting  
     **= 13 A × 0.75 = 9.8 A**
3. **Load group (b)(i):**
   * 9 × 10 A single socket-outlets
   * 8 × 10 A double socket-outlets (count as 25 points)
   * 1000 W strip heater (1 point)  
     **= 10 + 5 = 15 A**
4. **Load group (b)(ii):**
   * 15 A socket-outlet  
     **= 10 A**
5. **Load group (c):**
   * 10,000 W electric range  
     **= 43.48 A × 0.5 = 21.7 A**
6. **Load group (f):**
   * 4800 W water heater  
     **= 20.9 A**

**Total demand**  
Sum of load group demands:  
**(a)(i) + (a)(ii) + (b)(i) + (b)(ii) + (c) + (f)**  
**= 7 + 9.8 + 15 + 10 + 21.7 + 20.9 = 84.4 A**

**C2.3.2.2 Example 2:**

**Problem:**  
To determine the maximum demand of the heaviest loaded phase in a domestic electrical installation comprising:

* 26 lighting points
* 24 × 10 A single-phase single socket-outlets
* 1 × 15 A single-phase socket-outlet
* 1 × 16,600 W three-phase electric range consisting of two 5000 W hotplates and one 6600 W oven
* 1 × 4000 W single-phase air-conditioning unit
* 1 × 12,960 W three-phase instantaneous water heater
* 1 × 3600 W single-phase clothes dryer

And arranged for connection across a three-phase supply as follows:

**Red Phase:**

* 15 A socket-outlet
* 5000 W hotplate
* 4000 W air-conditioner
* 4320 W instantaneous water heater

**White Phase:**

* 5 × 10 A socket-outlets
* 5000 W hotplate
* 4320 W instantaneous water heater

**Blue Phase:**

* 9 × 10 A socket-outlets
* 6600 W oven
* 4320 W instantaneous water heater
* 3600 W clothes dryer

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C2.4 Non-0omestic installations C2.4.1 *Method*

= 114.8A

Example Solutions: Maximum Demand Calculations

# C2.3.2.2 Example 2

Problem:  
To determine the maximum demand of the heaviest loaded phase in a domestic electrical installation comprising:  
- 26 lighting points  
- 24 × 10 A single-phase single socket-outlets  
- 1 × 15 A single-phase socket-outlet  
- 1 × 16,600 W three-phase electric range consisting of two 5000 W hotplates and one 6600 W oven  
- 1 × 4000 W single-phase air-conditioning unit  
- 1 × 12,960 W three-phase instantaneous water heater  
- 1 × 3600 W single-phase clothes dryer  
And arranged for connection across a three-phase supply as follows:

Red Phase:  
- 15 A socket-outlet  
- 5000 W hotplate  
- 4000 W air-conditioner  
- 4320 W instantaneous water heater  
  
White Phase:  
- 5 × 10 A socket-outlets  
- 5000 W hotplate  
- 4320 W instantaneous water heater

- 3600 W clothes dryer

Blue Phase:  
- 9 × 10 A socket-outlets  
- 6600 W oven  
- 4320 W instantaneous water heater

## Solution

The method of determining the demand in the heaviest loaded phase, in accordance with Table C1, is as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| Equipment | Load Group | Column | Red (A) | White (A) | Blue (A) |
| Lighting | (a)(i) | 2 | | | 5 |
| 10 A socket-outlets | (b)(i) | 2 | | 10 | 10 |
| 16 A socket-outlet | (b)(ii) | 2 | 10 | | |
| Range | (c) | 2 | 10.9 | 10.9 | 14.4 |
| Air-conditioner | (d) | 2 | 13.0 | | |
| Water heater | (e) | 2 | 6.3 | 6.3 | 6.3 |
| Clothes dryer | (c) | 2 | | 7.8 | |

Total loading, heaviest loaded phase = red phase, 40.2 A.

# C2.3.2.3 Example 3

Problem:  
To determine the maximum demand of the heaviest loaded phase of a block of 80 units comprising the following loads:  
- Lighting: 80 units  
- 10 A single-phase socket-outlets: 80 units  
- Single-phase electric ranges: 17 units  
- 2500 W (10.9 A) permanently connected single-phase strip heaters: 80 units  
- Single-phase quick recovery water heaters: 80 units  
Loading not associated with the individual units (communal services):  
- 90 × 60 W lighting points  
- 21 × 100 W lighting points (total lighting: 7500 W)  
- 20 × 10 A single-phase socket-outlets  
- 10 × 3600 W single-phase clothes dryers  
- 2 × 12,000 W three-phase lift motors (22 A per phase nameplate rating)  
- 5500 W three-phase pump motor (10.4 A per phase nameplate rating)  
- 4000 W three-phase water supply motor (8.3 A per phase nameplate rating)

## Solution

|  |  |  |  |
| --- | --- | --- | --- |
| Equipment | Load Group | Column | Calculation | Result (A) |
| Lighting | (a)(i) | 5 | 27 × 0.5 = 13.5 A |
| Socket-outlets | (b)(i) | 5 | 50 + (27 × 1.9) =101.3 A |
| Electric ranges (6 units) | (c) | 4 | 6 × 2.8 = 16.8 A |
| Strip heaters | (d) | 5 | 27 × 10.9 × 0.75 = 220.7 A |
| Water heaters | (f) | 5 | 100 + (27 × 0.8) = 121.6 A |

Total units loading for heaviest loaded phase = 473.9 A

**Communal Services:**

The lighting is taken as being evenly balanced over the phases, i.e.,  
**7500 W / 3 = 2500 W per phase.**  
[Should the lighting load be arranged for connection to one phase, the loading for load group (h) would be 7500 W.]

The 20 socket-outlets are taken as connected, seven over each of two phases and six on the other phase.

The 10 clothes dryers are taken as connected, three over each of two phases and four on the other phase—loading on the heaviest loaded phase = **14,400 W**.

The two **12,000 W lift motors** = 22 A per phase (nameplate rating).

**Motors:**

* **5500 W motor** = 10.4 A per phase (nameplate rating)
* **4000 W motor** = 8.3 A per phase (nameplate rating)

|  |  |  |  |
| --- | --- | --- | --- |
| Equipment | Load Group | Column | Calculation | Result (A) |
| Lighting | (h) | 5 | 2500 / 230 = 10.9 A |
| Socket-outlets | (i) | 5 | 7 × 2 A = 14.0 A |
| Clothes dryers | (j)(i) | 5 | 0.5 × (14,400 / 230)= 31.3 A |
| Lift motors | (k) | 5 | (22 × 1.25) + (22 × 0.75) = 44.0 A |
| Pump & water supply motors | (l) | 5 | 10.4 + (8.3 × 0.5) = 14.6 A |

Total communal services loading for heaviest loaded phase: 114.8 A

Total loading for heaviest loaded phase: units loading + communal services loading = 473.9 A + 114.8 A = 588.7 A

**Table C2: Load Allocation for Non-Domestic Installations**

Table C2 provides an allocation of load for different types of equipment connected to consumer mains or submains in a non-domestic installation.

The load current is calculated for each equipment load group in the installation, or the affected part thereof, and these contributions are then added together to achieve the maximum demand current. The accompanying notes provide clarification of certain provisions, and the ensuing examples demonstrate how the calculation is made.

**NOTES:**

1. See Clause 1.4.3 for where the maximum demand for consumer mains, submains, and final subcircuits may be determined by assessment, measurement, or limitation.
2. In the calculation of the connected load, the following ratings are assigned to lighting:
   * (a) **Incandescent lamp**: 60 W or the actual wattage of the lamp to be installed, whichever is greater, except if the design of the luminaire associated with the lampholder only permits lamps of less than 60 W to be inserted in any lampholder. In that case, the connected load of that lampholder is the wattage of the highest rated lamp that may be accommodated. For multi-lamp luminaires, the load for each lampholder is assessed on the same basis.
   * (b) **Fluorescent and other discharge lamps**: Full connected load, i.e., the actual current consumed by the lighting arrangement, considering auxiliary equipment such as ballasts and capacitors.
   * (c) **Lighting tracks**: 0.5 A/m per phase of track, or the actual connected load, whichever is greater.
3. A socket-outlet installed more than 2.3 m above the floor for the connection of a luminaire may be included as a lighting point in load group (a). An appliance rated at not more than 150 W, which is permanently connected or connected by means of a socket-outlet installed more than 2.3 m above the floor, may also be included as a lighting point in load group (a).

**NOTES TO TABLE C2 (continued):**

1. Load group (b)(i) applies to an electrical installation, or portion of an electrical installation, incorporating permanently installed heating and/or cooling equipment specifically provided to render unnecessary the use of socket-outlets for portable electric space heating or cooling appliances. Whether heating or cooling, or both, is deemed necessary to avoid the use of portable heating or cooling equipment will depend on the location and climate involved.
2. For the purpose of determining maximum demand, a multiple combination socket-outlet is regarded as the same number of points as the number of integral socket-outlets in the combination.

# C2.4.2 Examples of Calculation

## C2.4.2.1 Example 4

1. Problem:  
   To determine the maximum demand of the heaviest loaded phase of a 30-unit motel complex supplied by three-phase with the following load:  
   - 200 × 60 W lighting points  
   - 30 × 50 W single-phase exhaust fans (permanently connected)  
   - 10 × 10 A single-phase single socket-outlets (non-permanently heated or cooled area)  
   - 90 × 10 A single-phase single socket-outlets (permanently heated or cooled area)  
   - 4 × 15 A single-phase socket-outlets  
   - 1 × 16,600 W three-phase electric range consisting of two 5000 W hotplates and one 6600 W oven  
   - 1 × 750 W three-phase sewerage pump motor (2.0 A per phase nameplate rating)  
   - 1 × 6000 W single-phase sauna heater  
   The load is arranged for connection across the three-phase supply as follows:

## Phase Connections

|  |  |  |  |
| --- | --- | --- | --- |
| Phase | Red Phase | White Phase | Blue Phase |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| Lighting | 70 lights | 70 lights | 60 lights |
| Exhaust fans | 10 exhaust fans | 10 exhaust fans | 10 exhaust fans |
| Socket-outlets | 5 × 10 A (b)(i) 30 × 10 A (b)(ii) | 5 × 10 A (b)(i) 30 × 10 A (b)(ii) | 30 × 10 A (b)(ii) |
| Other loads | 1 × 15 A socket-outlet 6600 W oven 750 W pump | 2 × 15 A socket-outlets 5000 W hotplates 750 W pump | 1 × 15 A socket-outlet 5000 W hotplates 750 W pump 6000 W sauna |

## Solution

|  |  |  |  |
| --- | --- | --- | --- |
| Equipment | Load Group | Calculation | Red (A) | White (A) | Blue (A) |
| 70 light points | (a) | (70 × 60 W / 230 V) x 0.75 | 13.7 | 13.7 | |
| 60 light points | (a) | ((60 × 60 W )/ 230 v) x 0.75 | | | 11.74 |
| 10 exhaust fans | (a) | ((10 × 50 W) / 230v) x 0.75 | 1.63 | 1.63 | 1.63 |
| 5 × 10 A socket-outlets | (b)(i) | 1000 + (4 × 400 W) = 2600 W / 230 V | 11.3 | 11.3 | |
| 30 × 10 A socket-outlets | (b)(ii) | 1000 + (29 × 100 W) = 3900 W / 230 V | 16.96 | 16.96 | 16.96 |
| 1 × 15 A socket-outlet | (b)(iii) | Full current rating | 15.0 | 15.0 | |
| 2 × 15 A socket-outlets | (b)(iii) | 15 A + (15 A × 0.5) | | 22.5 | |
| 6600 W oven | (c) | Full connected load | 28.7 | | |
| 5000 W hotplates | (c) | Full connected load | | 21.74 | 21.74 |
| 750 W sewer pump | (d) | Full load (nameplate rating) | 2.0 | 2.0 | 2.0 |
| 6000 W sauna heater | (g) | Full-load current | | | 26.09 |

## Total Loading

|  |  |
| --- | --- |
| Phase | Total Load (A) |
| Red Phase | 89.29 A |
| White Phase | 89.83 A |
| Blue Phase | 95.16 A |

1. Total loading, heaviest loaded phase = Blue Phase, 95.16 A.

**C2.4.2.2 Example 5:**

**Problem:**  
To determine the maximum demand of the heaviest loaded phase of a factory electrical installation supplied by three-phase with the following load:

* 30 × Twin 36 W power factor corrected fluorescent luminaires, each with a run current of 0.42 A or as specified by the supplier
* 10 × 10 A single-phase single socket-outlets (non-permanently heated or cooled area)
* 4 × 10 A single-phase double socket-outlets (permanently heated or cooled area)
* 1 × 20 A single-phase socket-outlet
* 1 × 15 A single-phase socket-outlet
* 1 × 4000 W single-phase air conditioner
* 1 × 5500 W three-phase rolling machine motor (10.4 A per phase nameplate rating)
* 1 × 4000 W three-phase lathe motor (8.3 A per phase nameplate rating)
* 1 × 3600 W single-phase storage water heater
* 2 × 250 A output three-phase arc welders (permanently connected) (10 A per phase primary current nameplate rating)
* 1 × 30,000 VA two-phase spot welder (permanently connected) - varying operation [Paragraph C2.5.2.3(a)(i)] (50 A per phase primary current nameplate rating)
* 1 × 15,000 VA two-phase spot welder (permanently connected) - specific operation at 20% duty cycle [Paragraph C2.5.2.3(a)(ii)] (25 A per phase primary current nameplate rating)

The load is arranged for connection across the three-phase supply as follows:

**Red Phase:**

* 15 lights
* 5 × 10 A socket-outlets (b)(i)
* 3600 W water heater
* 15 A socket-outlet
* 5500 W rolling machine
* 4000 W lathe
* 250 A arc welder
* 250 A arc welder
* 15,000 VA spot welder

**White Phase:**

* 4 × 10 A socket-outlets (b)(ii)
* 20 A socket-outlet
* 5500 W rolling machine
* 4000 W lathe
* 250 A arc welder
* 250 A arc welder
* 30,000 VA spot welder
* 15,000 VA spot welder

**Blue Phase:**

* 15 lights
* 5 × 10 A socket-outlets (b)(i)
* 4000 W air conditioner
* 5500 W rolling machine
* 4000 W lathe
* 250 A arc welder
* 250 A arc welder
* 30,000 VA spot welder