# Rated Diversity Factor

**A look at this perhaps little-known aspect of electrical component design.**

*The rated diversity factor (RDF) is a figure less than one which is specified by an assembly manufacturer to account for the mutual thermal effects between adjacent, continuously loaded circuits. It could be thought of as an assembly "grouping" factor and is similar to a cable grouping factor of which we are probably more familiar.*

*Although RDF has been around for a while, it is now starting to become more of an issue with continuous-load, high-current draw items like electric vehicle charging points and heat pumps which are now more common. During service, these circuit-breakers will heat up and cause problems by prematurely tripping adjacent breakers; the problem is exacerbated when other similar devices are loaded continuously up to or close to their maximum continuous current rating* $I_n$

*We will go on to see that it is the designer's responsibility to take the manufacturers limitations into account when designing an electrical installation.*

## Circuit breakers.

A circuit breaker to BS EN 61008 has two internal mechanisms which provide protection against different overcurrent situations: The ***thermal trip*** and the ***magnetic trip***.

The solenoid or "*magnetic trip*" operates only when a certain threshold of current is reached. It reacts extremely quickly and protects against earth fault currents and short-circuit currents. We make the assumption that the disconnection time is 0.1 seconds, in reality; however, it is even quicker than this. It is this very current that we use to calculated $Z_s$, thereby allowing a disconnection time of < 0.4 seconds as required by BS 7671.

The "*thermal trip*" consists of a bi-metallic strip. When current is passed through it, as with any conductor, it heats up. It operates relatively slowly and protects the circuit from overload currents. Depending on the level of current, it can take several minutes or seconds to disconnect. The bi-metallic strip works by converting heat into mechanical movement eventually tripping the breaker and protecting the circuit from overload. During normal service, the strip heats up, and this can affect other adjacent breakers.

The manufacturers are aware of this and apply a diversity factor to enable you to take this into account.

To take a simple example, let's say we have an RDF of 0.5. If we apply this to a 32A load then we would need 32/05= 64 A breaker, or alternatively de-rate the breaker to 16 A if it were surrounded by other heavily loaded breakers. There are other alternatives like situating the breaker next to low current draw services like lighting or even spacing either side with blanks!

The old habit of placing the largest breakers at one end is not always appropriate when RDF applies

## Rated diversity factor and BS 7671 part 5 requirements

## Regulation 536.4.202 Current ratings. (page 183) Amendment 3 2024.

The relevant design current shall not exceed the rated current of an assembly ($\mathbf{I}_{nA}$) or rated current of a circuit ($\mathbf{I}_{nc}$) of the associated assembly, having taken any applicable diversity/loading factors into account.

- The rated current of an assembly ($I_{nA}$) (A) is the maximum current that it is designed to manage and distribute
- The rated current of a circuit ($I_{nc}$ ) (A) is stated by the assembly manufacturer, taking into consideration the ratings of the devices within the circuits, their disposition and application.

Further to this:

## Regulation 132.16 Additions and alterations to an installation. (page 26)

*" No addition or alteration, temporary or permanent, shall be made to an existing installation, unless it has been ascertained that the rating and the condition of any existing equipment, including that of the distributor, will be adequate for the altered circumstances. Furthermore, the earthing and bonding arrangements, if necessary for the protective measure applied for the safety of the addition or alteration, shall be adequate."*

# Terminology:

$I_z$ is the current carrying capacity of the cable

$I_n$ is the rating of the protective device

$I_{nA}$ is the rating of the assembly

$I_{nC}$ is the rated current of the circuit (Usually this turns out to be the breaker rating that is chosen after the RDF has been applied)

$I_{ng}$ is the group rating factor.

**Continuous load**: A circuit that is either on more than it is off or is continuously loaded for more than 30 minutes. The demand will exceed RDF x $I_{nc}$ for > 30 minutes.

**Intermittent load:** A circuit that is off for longer than it is on or is off for more than 30 minutes. The demand will not exceed RDF x Inc for > 30 minutes.

Some examples of RDF:

**Scenario:**

**We wish to verify a heat pump with a continuous load of 32A which has been surrounded by other continuously loaded breakers. The RDF from the assembly manufacturer is 0.6.**

Current to be used to select a value of $I_n$ for the breaker ($I_b$ / RDF)= 32/0.6 = 53.3A

This is the ***nominal minimum*** value of $I_n$, so we simply choose the next available size of breaker which would be 63A.

63A becomes the circuit limit and is given the term $I_{nc}$

The group rating factor ($I_{ng}$) = ($I_{nc}$ x RDF) = 63 x 0.6 = 37.8A

This should be greater than the design current $I_b$

$$\left(I_b \leq I_{ng}\right) 32A < 37.8A$$

Our heat pump should thus be fitted with a 63A breaker, which will not be working as hard and therefore it will not get as hot as the original 32A breaker!

Another example

**Scenario:**

**We wish to verify a 7 kW electric vehicle charging point which has been previously installed using a 32A breaker using an RDF of 0.8!**

$$I_b = \frac{7000}{230} = 30.43A$$

Current used to select the breaker

$$\frac{I_b}{RDF} = \frac{30.43}{0.8} = 38.04A$$

The next available size is 40A which now becomes the $I_{nc}$ for the circuit.

The group rating factor ($I_{ng}$) = ($I_{nc}$ x RDF) = 40 x 0.8 = 32A

$$\left(I_b \leq I_{ng}\right) 30.43A < 38.04A$$

The breaker with a larger $I_n$ will not heat up so much, thereby mitigating the mutual effect of other adjacent continuously loaded circuits. There is a potential further problem with this if we examine the following:

$$I_z \geq I_{nc} \geq \frac{I_b}{RDF}$$

In the first scenario, our heat pump required a 63A breaker and this in turn would mean that a cable based on 63A would need to be installed!

This can only be the case when providing protection against overload current in accordance with **Regulation 433.1.1.** However, **Regulation 433.3.1 (ii)** states that we do not need to provide overload protection provided:

"For a conductor which, because of the characteristics of the load or the supply, is not likely to carry overload current, provided that the conductor is protected against fault current in accordance with the requirements of Section 434"

This is a discussion for another time, but it does allow the current carrying capacity of the cable to be lower than the $I_n$ of the breaker if the load is fixed and therefore, cannot draw overload current.

When determining a breaker based of the RDF, it is the mutual heating effects of the breaker that is in question rather than the current carry capacity of the cable. If compliance with Regulation 433.1 is necessary, then larger cable will then be required.