Voltage
Neutral earthing resistors or NERs are often described by the system voltage of the supply, eg an “11kV NER”.

The maximum voltage that the resistor actually experiences in service is the line voltage (phase to neutral voltage). Hence the rating plate of the resistor will bear the line voltage. Eg an “11kV NER” is rated at 6.35kV.

Current
Resistors are rated by current at line voltage. System impedances are ignored. This implicitly specifies the resistance value. There is usually a 10% tolerance on the current value.

Choice of current rating depends on the characteristics of the system and equipment. For example a generator manufacturer may specify a tolerable maximum value of earth fault current. Choice also depends on the type of protection relay system employed. Older systems need higher currents to operate. Newer systems can have the sophistication to operate reliably at lower currents. In the absence of specific information, the current is usually chosen to be equal to or lower than the rated current of the transformer or generator. Current values generally lie between tens of amps and thousands of amps.

Preferred current values can be conveniently selected from the ISO R’10 series, which is used across the electrical industry. Values are 10, 12.5, 16, 20, 25, 32, 40, 50, 63, 80 and 100 and multiples thereof. In addition multiples of 15, 30, 60 and 75 are also popular.

Time
Resistors are generally rated to carry their current for a time of 10 seconds. The current will actually flow for a much shorter time than this. The 10 second time is chosen to allow for the occurrence of multiple events. This can happen when auto-reclosers are used. It also allows for the operation of an upstream backup protection device, if the protection relay fails.

Times of 30 seconds usually indicate an old specification based on liquid resistors. The long duration reflects the extended cooling time associated with this old technology.

Continuous current
NERs are generally rated for occasional use and only have a limited capacity to handle continuous current. This limited capacity is typically 5 to 10% of the 10 second current rating.

Where necessary, NERs can be specified to handle significant continuous current. This may significantly increase size, weight and cost of the NER. Ingress protection requirements above IP54 can make such requirements especially difficult and expensive to achieve due to the restricted ability to lose heat.

Insulation levels
NERs never experience voltages in excess of line voltage. Insulation levels should therefore be specified based on line voltage. Despite this, some specifiers choose to specify insulation based on system voltage. This has minimal impact on size, weight and cost of the NERs designed for lower voltages. This has significant impact on size, weight and cost of the NERs designed for higher voltage levels.

Temperature rise
Temperature rise is limited to 760°C maximum, in strict accordance to ANSI/IEEE 32, 1972. This was based on the resistor alloy and insulation technology available in 1972. Current technology allows for a rise of 1000°C, maximum. The specification of a 1000°C design significantly reduces size, weight and cost.

Temperature coefficient of resistance (TCR)
Metallic resistors have a positive temperature coefficient of resistance (TCR). This means that the current flowing will not exceed the rated value. Current reduces as the NER warms up. In general the TCR should be limited to 3.5% per 100°C rise.

Excessively high TCR values are encountered where low cost stainless steels are used to make resistance elements and in the case of liquid resistors.

Element type
Metallic resistors are generally specified in preference to liquid types for a number of reasons. Metallic resistors do not do not suffer from evaporation, freezing, leakage and positive TCR. Metallic resistors contain no electrolyte and require minimal maintenance. Metallic resistors do not need ancillary supplies to power frost protection heaters.

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It is desirable to minimise the number of joints and connections within the resistor.

It is desirable to avoid thermal hot spots within resistor elements.

It is desirable to have a homogenous voltage distribution within a resistor element

All of these requirements can be met by the use of **oval edge wound metallic coils** or **coiled coils**.

The term grid is often used in connection with high power resistor elements. Historically the term referred to an element constructed from cast iron. This type of construction has largely been superseded. The term is now generally taken to mean a heavy duty metallic element.

Termination
NERs have three main terminals or connection points. The first terminal connects one end of the resistor to the neutral of the transformer or generator. The second terminal connects the remaining end of the resistor to earth. The third terminal provides enclosure earth bonding.

The enclosure earth terminal and resistor earth terminal should be separate to facilitate easy testing on site.

The resistor neutral terminal is typically in the form of a bushing rated for the line voltage.

The resistor earth terminal is typically in the form of a bushing rated for 1.2kV.

The enclosure earth terminal is usually in the form of a M12 stud. A second enclosure earth terminal may be added, in a location diagonally opposite to the first for ease of bonding.

Ingress Protection (IP) rating
NERs are typically specified to have an IP rating of IP23.

The materials used within a NER may include speciality resistive alloys, stainless steels, ceramics, galvanised steel and copper. All of these materials are durable in harsh environments. Hence the need for environment protection is low.

Were necessary, higher IP ratings can be specified. NER housings with an IP rating in excess of IP54 can significantly restrict the escape of heat from the resistor. This becomes especially important for NERs with high continuous current ratings. Such requirements can significantly increase size, weight and cost of the NER.

Specific parts of a NER such as the cable box may be specified to have a higher IP rating than the rest of the NER in order to protect equipment within. IP54 is the level of protection normally specified.

It should be noted that IP ratings only refer to ingress of water and dust in the context of NERs. NERs are high voltage electrical system components and may have exposed live parts such as bushing stems etc. NERs are hot during and after operation. The IP rating does not infer that it is safe to touch NERs.

Enclosure
Aluminised zinc treated mild steel enclosures may be specified and are suitable for most environments.

304 stainless mild steel enclosures may be specified and are more durable than aluminised zinc treated mild steel enclosures.

316 stainless steel enclosures may be specified for costal, marine and offshore environments.

Pre-galvanised steel enclosures may be specified for indoor and moderate outdoor environments.

Painted enclosures can also be specified but are generally not desirable due to the increased maintenance requirements and the possibility of discoloration following operation of the NER.

Safety
NERs are hot during and after operation.

NERs are high voltage electrical system components and may have exposed live parts such as bushing stems etc.

Site layout, NER labelling, operation and maintenance procedures should fully take account of these hazards.

Ancillary items
Items such as vacuum contactors, switchgear, current transformers, interlocks and neutral earthing transformers may be packaged as part of the NER.