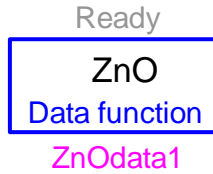


# ZnO Data Function device



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Jean Mahseredjian, 2/5/2018 9:46 PM

## 1 Generation of ZnO arrester model data

The ZnO arrester data function device is used to generate the model data needed for the EMTP ZnO arrester model (ZnO device). The model data is generated from the actual current-voltage characteristic of the arrester available from manufacturer tests.

This Model Data Calculation function uses the following form of the exponential describing the protective characteristic of a ZnO arrester:

$$i_{km} = p \left( \frac{v_{km}}{V_{ref}} \right)^q$$

where  $i_{km}$  (from k side to m side) is the arrester current,  $v_{km}$  is the arrester voltage and  $V_{ref}$  is an arbitrary reference voltage (arrester's MCOV, for example) used to prevent numerical overflow problems for large voltage values. The arrester current-voltage characteristic is fitted by one or more exponential functions, each valid in a particular range. The exponential segments are fitted on a log-log plane (straight line segments) to avoid numerical ill-conditioning of the exponential fitting. The resulting mathematical model of the arrester is shown in Figure 1-1. Each segment  $j$  is described by its own version of the above exponential function:

$$i_{km} = p_j \left( \frac{v_{km}}{V_{ref}} \right)^{q_j}$$

Below the first exponential start voltage  $V_{min_1}$  the arrester is assumed to be linear. The arrester may have a gap which changes its characteristic upon sparkover. It is possible to enter separate data for the characteristic after sparkover.

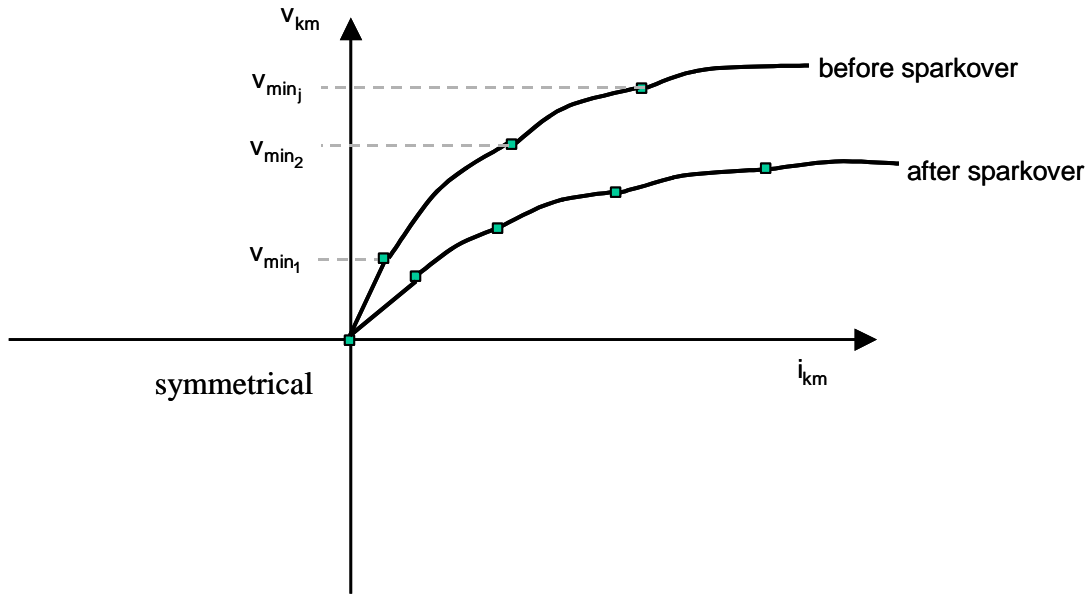


Figure 1-1 Zinc Oxide arrester characteristic

## 2 Input data

### 2.1 First data tab: Main Characteristic

The first tab allows entering current-voltage characteristic data before flashover.

The following parameters are entered for the current-voltage characteristic section.

- ❑ **Desired Voltage rating.** This is the desired voltage rating of the arrester in volts RMS. This variable can be used to:
  - Convert the arrester input data from pu to volts
  - Obtain the characteristic of an electrically similar arrester with a different voltage rating. The properties of similar arresters do not change with rating, providing a proportional number of blocks is used to obtain the new rating.
  - If  $V_{ref}$  is maintained proportional to this parameter, similar arresters will have identical parameters at all ratings
- ❑ **Data Voltage rating.** Voltage rating of the arrester upon which the input (arrester test) data are based in volts RMS.
- ❑ **Voltage multiplier.** Multiplier used in the additional scaling of voltage points. It can be, for example, used to obtain a minimum characteristic (maximum energy) from a maximum characteristic (maximum voltage). The value to be normally used is 1.0.
- ❑ **Current multiplier.** Multiplier used in obtaining characteristics of arresters with number of columns different from that of which the data points are known. An even current distribution is assumed.
- ❑ **Minimum current value.** Minimum value of current above which the first segment of the arrester characteristic begins. This value must be greater than zero.
- ❑ **Current (A) – Voltage (V) matrix.** This two column matrix area describes the arrester current-voltage curve. More than one segment data can be entered using blank lines to separate segment matrices. The keyword BLANK starting on column 1 is also acceptable. Current appears on the first column and voltage appears on the second column. A value field is limited to 12 characters. The number of spaces on each line is arbitrary. All values must be positive.

When the matrix area is unclicked or the data tab is closed, EMTWorks checks entered data and deletes illegal matrix lines. Here is a 3-segment example:

100.	187000.
500.	200000.
700.	203000.
1000.	208000.
2000.	218000.
4000.	228000.
5000.	233000.
BLANK	ENDS CHARACTERISTIC
8000.	246000.
10000.	251000.
15000.	266000.
20000.	279000.
30000.	299000.
BLANK	ENDS CHARACTERISTIC
40000.	316000.
50000.	336000.
60000.	354000.
70000.	372000.
80000.	387000.
90000.	402000.
100000.	414000.

When this matrix area is unclicked the BLANK keyword line is replaced by a white (blank) line.

The following data parameters are needed for the Fitting options section.

The Fitting options sections allows the user to select between two options for the determination of the number of exponential segments to be fitted:

- Automatic.** The program determines the number of segments depending on the maximum permissible relative error (Relative error input field) specified by the user.
- Manual.** The user specifies the number and the boundaries of the segments (blank line matrix separators used above).
- Number of exponential segments.** This data field is enabled only for when the Manual mode is selected. This number should correspond to the number of segments specified in the current-voltage matrix area. In this version it is not allowed to change this data field.
- Relative error.** This data field provides the maximum relative error permitted during the automatic determination of the number of segments. If  $i_1$  is a value of current specified by the user and  $i_2$  is the current calculated by the program using the fitted characteristic, then the Relative error is given by:

$$\frac{|i_1 - i_2|}{i_1}$$

The default value is 0.05.

- $V_{ref}$  is a reference voltage used to scale the voltage data points. The scaling is used to prevent a possible overflow during the EMTWorks simulation of the corresponding arrester model. The default value of  $V_{ref}$  is taken to be twice the Desired Voltage rating.

## 2.2 Second data tab: Gap

This tab allows entering parameters for the presence of an optional arrester gap.

The following parameters are required:

- $V_{flash}$  is the gap flashover (sparkover) voltage in volts (crest). This field is not accessible if the arrester is gapless. When  $V_{flash}$  is positive it is allowed to enter more data on its characteristic.
- Reuse main Current-Voltage characteristic.** This option indicates that the characteristic after flashover is similar to the characteristic before flashover. This option and the following Scale factor permit the representation of arresters with shunt passive gaps and arresters with series passive gaps. For the shunt case the shunted portion of the arrester can be of similar or dissimilar material. For the series case the arrester is inoperative before sparkover.

- **Scale factor** is a factor multiplied by the main Current-Voltage characteristic voltages. This value must be greater than 1.

### 3 Calculating model data

After entering data, the user can click the OK button and the device will request to generate (calculate) data. If the entered data is valid, the model data will be calculated and the Ready value will appear on this device. At this stage the device right-click menu Copy/Paste can be used to Copy and then Paste on any ZnO arrester (target) device using the Paste command of the target device.

The calculated data is also available in the ModelData attribute of this device.