Selection of Protective Fuses for Type 1 AC Surge Protectors

Abstract—Since years, the Surge Protective Devices (SPD) are widely used to protect the sensitive equipment connected to the AC distribution network against lightning or switching surge voltages. The international standard for SPDs (IEC 61643-11 [1]) are now widely spread and make the new generation of AC surge protectors more efficient and more secure.

In the standard, an important issue is the safety of operation in case of SPD end of life: for example, in order to withstand the short-circuit current test, the SPDs must be associated with overcurrent protective devices, as fuses or breakers. The selection of the relevant fuses or breakers must provided by the SPD manufacturers, or selected through some informative tables available on document as IEC 61643-12 [2]. For Type 1 AC SPD, the rating of fuses could reach huge values and a more specific selection could be necessary.

The target of this paper is to test the relevant models and accurate ratings of associated fuses in full compliance with the test standard.

Keywords—surge protectors; fuse; Iimp;

I. Introduction

Surge Protective Devices for AC networks are designed to operate without failure on high energy surge currents. Nevertheless in some conditions and there is a possibility for these SPDs to fail in short circuit: in order to manage this issue, the IEC 61643-11[1] standard ask for dedicated tests (Short-circuit current behaviour tests: 8.3.5.3) : to withstand successfully these tests, a dedicated overcurrent device is required to be installed on the branch of the SPD: it is mainly current breakers or fuses. but, in association with SPD, these devices must be able to withstand also, without operate, the surge currents declared by the SPD (Iimp, Imax or In). The manufacturer of the SPD must declare the overcurrent backup device to be installed with the SPD and which will be used during the qualification tests.

II. Fuse selection

The document IEC 61643-12 [2] (Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power distribution systems - Selection and application) gives useful information about the way to select the relevant fuse in relation with the discharge current of the SPD. The annex P of this document describes the calculation and propose a table with some average ratings of fuses.

Single shot 10/350 surge current withstand for fuses

The prospective single shot withstand of a fuse is calculated by comparing its $I^2t$ (1ms) given by the fuse manufacturer, and the energy of 10/350 impulse current ($I^2t$ (10/350)). The withstand is effective if:

$$I^2t (1ms) > I^2t (10/350)$$ (1)

For the 10/350 surge current, the energy calculation follows this rule:

$$I^2t (10/350) = 256.3 \times I_{\text{crest}}^2$$ (2)

with $I_{\text{crest}}$ in kA, and $I^2t$ in A²s
Example: following this calculation, to withstand a single shot of surge current of 5 kA@10/350, the backup fuse must have a minimum pre-arcing value greater than:

\[ I^2t = 256.3 \times 5^2 = 6407.5 \text{ A}^2\text{s} \]

Influencing Factors (reduction) for preconditioning and operating duty test

During the test procedure described in IEC 61643-11, the fuse has to withstand not only a single 10/350 surge current but a complete sequence of impulses, described on the following paragraphs:

- Operating duty test (8.3.4.3): 15 shots of In (8/20 surge current with peak value equal to Iimp)
- Additional operating duty test for test class I (8.3.4.4): 0.1, 0.25, 0.5, 0.75 and 1 x Iimp

These multiple surges will age the fuse and reduce its surge withstand capability. In order to comply the full operating duty tests, IEC61643-12 proposes a reduction factor from 0.5 to 0.9 to be applied on the \( I^2t \) (1ms) of the fuse to select the prospective multiple shot withstand value.

### III. Back-up fuses for Type 1 SPDs

In practical, the use of the protective fuses for Type 1 SPD is facing some issues: because the high rating required by the annex P, the dimension (NH format) and the cost of the fuses could be high. The present edition on IEC 61643-11 gives selection information about 10/350 withstand only for NH fuses.

Nevertheless, for “low power” Type 1 SPD with a limp rating of 12.5 kA, the use of cylindrical fuses in compliance with the IEC61643-11 standard is possible and the following tests shows this possibility.

### IV. Tests

The tests have been performed with a impulse current generator able to deliver 8/20 and 10/350 waveform up to 100 kA.

### TABLE I.

<table>
<thead>
<tr>
<th>Fuses</th>
<th>IEC 61643-12 Annex P</th>
<th>Manufacturer A</th>
<th>Manufacturer B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical rated current of the fuse [A]</td>
<td>Format and curve of fuse</td>
<td>Calculated 10/350 Peak current for multiple shots test [kA]</td>
<td>Tested and Declared Iimp [kA]</td>
</tr>
<tr>
<td>125 Cyl gG</td>
<td>No value</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>125 Cyl gG</td>
<td>No value</td>
<td>15</td>
<td>12.5=open</td>
</tr>
<tr>
<td>125 Cyl aM</td>
<td>No value</td>
<td>15</td>
<td>Not tested</td>
</tr>
<tr>
<td>125 NH gG</td>
<td>7</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>160 NH gG</td>
<td>10</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>200 NH gG</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>250 NH gG</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>250 NH gG</td>
<td>20</td>
<td>25=open</td>
<td>25</td>
</tr>
<tr>
<td>315 NH gG</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

### V. Conclusion

The tests shows the behavior of dedicated fuses is slightly different from the table P-1 of the IEC 61643-12 document and the use of cylindrical fuses is possible, in full compliance with standard: it is especially useful for the “low power” T1 SPDs to be able to use cylindrical SPDs, instead of NH size, to reduce cost and dimensions.

But because the results is variable for a same curve/rating couple, if the SPD manufacturer wants to declare fuse rating different from the table P-1 of IEC 61643-12, he must declare the model of the required fuse, not only the rating and the curve.

### References
