HRC fuse links are important and indispensable part of an electrical circuit. Proper selection of a fuse and its co-ordination with other protective devices in the circuit is very vital for foolproof protection of the circuit and its uninterrupted performance.

The basic functioning of a fuse calls for:

- continuously carrying the rated current without getting overhead
- instantaneously interrupting the circuit case of a fault.

These functions make fuse element design very critical.

The selection of a fuse link requires its proper co-ordination with other protective devices in the circuit to provide protection to a given motor. It necessitates study and plotting of characteristics of all protective devices like fuse, overload relay with respect to the motor.

With various manufacturers offering different types of fuses and overload relays, it becomes difficult for the ultimate user to match the actual characteristics of these equipments and ensure that they offer proper co-ordination. Hence, the best solution lies in getting a perfectly co-ordinated combination from a single manufacturer with an established system for motor protection. Yet, co-ordination is not the only consideration in fuse selection.

During the earlier days, emphasis was given to the ability of the fuse to interrupt the current on fault.

The power losses resulting in the fuse were not given due importance. Even the standards devised for fuses in earlier days (1952) did not cover this aspect. But, in reality, the power loss incurred in the fuse itself affected its performance very badly. It not only contributed to the overall loss in the system, but it also raised the temperature in the cubicles. Operating at higher temperature promoted deterioration of the fuse thereby reducing reliability of its operation. Higher temperatures accelerated deterioration of insulating materials exponentially. In addition, the overall rise in temperature added a burden to the ventilation system of the plant.

Thus, realising the importance of limiting power losses in fuse links, the next revision of standards for fuses in 1972 specified the permissible watt loss values for various types of fuses which have been further reduced in the latest revision of standards (1886).

The feature article in this issue details the important aspects that need to be considered while selecting proper fuse links for the protection of various motors running in the plant.
Selection of HRC Fuse-links for Motor Starting Applications

- K. S. Parthasarathi

Switchgear Design & Product Development

HRC fuse-links offer one of the best forms of protection for motor starting applications in view of very low short circuit stresses generated in case of a fault as compared to other protective devices. However, the best possible rating of a HRC fuse-link selected/recommended for such application depends on following requirements:

(a) Ability to withstand motor starting currents

The fuse-link selected should not blow during motor starting. Also the fuse-link should withstand repeated starting currents without any deterioration. The rating of fuse-link is decided by:

(i) The motor starting current and its starting time. This will depend on two factors:
   - Type of starter (e.g. DOL or Star-Delta)
   - Motor characteristics

(ii) The time current characteristic of the fuse-link.

(b) SCPD co-ordination

The fuse-link should meet the criteria for co-ordination as specified in the relevant National/International Standards. For example, as per the Standards IEC 947-4-1/IS 13947, part 4 section 1, for the Short Circuit Protective Device co-ordination, "two types of co-ordination are permissible 'Type 1 or 2'. Type '1' co-ordination requires that under short circuit conditions, the contactor or starter shall cause no danger to persons or installation and shall be suitable for further use. The risk of contact welding is recognised, in which case the manufacturer shall indicate the measures to be taken as regards the maintenance of the equipment."

It is very evident from the above that it is advantageous to have type '2' co-ordination with SCPD. The fuse-link selected should be able to provide type '2' co-ordination.

Thus the fuse-link selection will also depend on its short-circuit characteristics i.e. the Cut-off current and tI characteristics.

(c) Discrimination

There should exist discrimination between the overload relay and the SCPD i.e. the fuse-link. This means that for overload currents less than lc (lc—the current corresponding to the intersection point of overload relay and the fuse-link characteristics), the relay should operate and protect the device and not the fuse-link. Also there should be no damage to the starter. For overload currents more than lc, the fuse-link should operate before the starter and protect the circuit.

Here the fuse-link is selected based on its time-current characteristics and the time current-characteristics of the overload relay.

(d) Low Power-loss

One of the most important factors while selecting a HRC fuse-link is its Power-loss. The rated power-loss of the fuse-link is the power-loss value as stated by the manufacturer when the fuse-link is carrying its current under specified conditions. The fuse-link selected should preferably have low power-loss.

(i) Saving in power/energy
(ii) Lower temperature rise at fuse-switch terminals and fuse-knives.

Table 1 gives the power-loss value limits as recommended in the relevant National/International standards. It is evident that over a period of time the Standards recognised the importance of power-loss and revised to reduce the limiting values. More and more manufacturers in the country and abroad have reduced the

<table>
<thead>
<tr>
<th>Standard</th>
<th>100 A Size 00</th>
<th>160 A Size 0</th>
<th>250 A Size 1</th>
<th>400 A Size 2</th>
<th>630 A Size 3</th>
</tr>
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<tbody>
<tr>
<td>IEC 269, 1973/ IS 9224, 1979</td>
<td>12</td>
<td>25</td>
<td>32</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>IEC 269, 1986/87 IS 13703, 1993</td>
<td>7.5</td>
<td>16</td>
<td>23</td>
<td>34</td>
<td>48</td>
</tr>
</tbody>
</table>
power-loss values of their fuse-links and have started achieving power-loss values much lower than the values specified in the Standards.

Guidelines for selecting a suitable fuse for a given motor

Since various manufacturers offer different characteristics, they specify different fuses for the same rating of motor. It leaves the choice to the user. In the forthcoming discussion, we bring you the guidelines to be followed while selecting a fuse suitable for a given rating of motor.

Let us consider DOL starting of a 3 phase Induction Motor rated 50HP/37kW, 415V AC. Here two typical cases are considered where two different ratings of fuse-links are recommended for the same application. Our objective is to determine the appropriate rating of fuse-link suitable for this application meeting the requirements mentioned above. In both the cases, fuse-links recommended are DIN type, commercially available in the market (see fig. 2). In case A, a 125A fuse-link is recommended whereas in case B 100A fuse-link is recommended.

In both the cases the switch recommended is 125A and contactor 70A, which means that there is no significant saving in panel area.

To study the suitability of fuses for the application. It is required to study the (i) Time current characteristics of the use and, (ii) Motor starting characteristics (see fig. 1).

It is observed that 100A fuse-link (recommended in Case-B) characteristic curve lies very close to the starting characteristics of the Motor. This will result in premature blowing of the fuse.

In some makes of fuses, knee like characteristics are claimed. Such fuses are claimed to give necessary relief between motor starting characteristics and fuse time current characteristics.

However, it is found that the knee like region on fuse-link

(Contd. on pg. 4, col. 1)
Selection of HRC Fuse-links
(Contd. From pg. 3, col. 3)

characteristic occurs at much larger current (at about 9 × In) than the motor starting current (6 × In).

This means that ‘knee like region’ occurring on the fuse characteristic is in no way helping in selection of a lower rated fuse-link for the application.

In case 'A', the fuse-link recommended is 125A, size 00. The fuse-link characteristic lies much above the motor starting characteristics which means that the fuse-link can withstand better motor starting currents without any deterioration.

Also, in case of both fuses, it is expected that Type '2' co-ordination and discrimination is achieved, this means that in both cases, let through energy is well within the withstand capacity of contactor and overload relays, and there is no damage to the cables and motor. To ensure this co-ordination and discrimination, it is always recommended to use starter and fuse combination from the same manufacturer.

Power-loss in fuse-links
It can be seen that in Case A, the power loss in fuse is 9.8 watts at 125A i.e. 2.73 watts at 66A (full load current of motor). As against that, in Case B, the power loss in fuse is 10.3 watts at 100A i.e. 4.48 watts at 66A. Thus, in Case B, the power loss is almost 64% more as compared to that in Case A.

Since, the power loss in fuses results in higher temperature in cubicle and thereby affects the life of the equipment, it is recommended that the user should verify power loss figures indicated by the manufacturer before finalising a particular fuse rating. Reduction in power loss in fuses also results in direct saving of energy consumption.

Consumption
The selection of a HRC fuse-link for a Motor application should be done very carefully ensuring that the selected fuse-link meets all the following requirements:
- ability to withstand motor starting currents
- ability to offer Type 2 co-ordination and ability to offer discrimination with the overload relay.

L&T offers new generation HRC fuses type HN suitable for use in switch fuses type FA-C, fuse switches type FB/FB-C and fuse switches type FN.

The fuses have been specially designed to offer customer's greater advantages. The integral fuse knife and inner plate assembly of these fuses are manufactured by a cold extrusion process which eliminates joint resistance. The result: a watt loss lower than the standards specified by IS 13703. This gives you a two-fold benefit: lower temperature rise and saving in power. The table below speaks for itself:

| Permissible Watt-Loss Values & Rated Watt-Loss Values of HRC Fuse-Links Type HN (L&T) in 'W' |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Standard/Fuse type:             | 100 A Size 00                   | 160 A Size 0                    | 250 A Size 1                    | 400 A Size 2                    | 630 A Size 3                    |
| IEC 269, 1986/87 IS 13703, 1993 | 7.5                             | 16                              | 23                              | 34                              | 48                              |
| HN (L&T), Rated value           | 7.5                             | 12.5                            | 17.3                            | 24.9                            | 42.2                            |

For further information, please contact Larsen & Toubro Limited, Packing Division, Powai Works, Saki-Vihar Road, Mumbai 400 072.

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