Cost of Ownership

Fusible Equipment vs. Circuit Breaker Equipment

One of the basic requirements in designing an electrical distribution system involves the specification of overcurrent protective devices. Many technical issues must be resolved in order to properly specify fuses and circuit breakers. The following examines a key factor in the evaluation and design process: COST OF OWNERSHIP-FUSIBLE EQUIPMENT VS. CIRCUIT BREAKER EQUIPMENT. The evaluation includes:

1. The Initial Cost of the Equipment. (This includes the overcurrent devices as well as the switchgear.)
2. The Preventive maintenance costs of the equipment during its expected life.

Overcurrent Protection Requirements

Before performing the cost of ownership comparison, basic system requirements must be established. These requirements, relative to the overcurrent protective devices are based upon:

1. Voltage Rating
2. Current Rating
3. Interrupting Rating

For the systems in Figures 1 and 2, the following ratings are established.

Figure 1 — All switches are rated, with fuses, for use where 200,000 amps or less are available. Fuses, by themselves, are rated for 300,000 A.I.R.

**Fusible Board Ratings**

1. Voltage Rating-600V
2. Current Rating-3000 Amp Switchgear
3. Interrupting Rating: 300,000 Amps-Fuses, 200,000 Amps-Switchboard

Figure 2 — All feeder CBs have 65,000 A.I.R., insulated case, drawout feature and electronic sensing capabilities.

**Circuit Breaker Board Ratings**

1. Voltage Rating - 480V
2. Current Rating - 3000 Amp Switchgear
3. Interrupting Rating; (multi-pole) - 100,000 Amps - Main*, (multi-pole) - 65,000 Amps-Feeders*

*Consult manufacturers or Single Pole Interrupting Ratings.

Initial Cost of Equipment

The two industrial grade switchboards illustrated in Figures 1 and 2 represent state-of-the-art specifications for fusible design and circuit breaker design, respectively.

Prices from one major switchgear manufacturer, to the end user, would be as indicated below:

**Figure 1. Fusible Design: $26,000**
(Includes Spare Fuses and Acceptance Testing)

**Figure 2. Circuit Breaker Design: $47,500**
(Includes Acceptance Testing. Does not include additional bracing of structure if short time delay is used on main CB.)

**THE INITIAL COST OF THE CIRCUIT BREAKER EQUIPMENT IS 83% HIGHER THAN THE INITIAL COST OF THE FUSIBLE EQUIPMENT. AN ADDITIONAL COST OF $21,500 IS PAID BY THE END USER.**

**These costs are typical, and will vary with market conditions and manufacturer’s pricing.**
Preventive Maintenance

Preventive maintenance is a planned procedure of inspecting, testing, cleaning, adjusting and lubricating electrical apparatus. A good preventative maintenance program with planned shutdowns maximizes continuity of operation. Through such a program, troubles can be detected in the early stages, and corrective action can be taken before extensive damage occurs.

Field surveys of existing overcurrent protection systems have yielded rather alarming statistics. An IEEE paper reported a survey that indicated 40 percent of all breakers tested were found to be faulty. One manufacturer has stated in its field maintenance manual, that many circuit breakers over 5 years old are completely inoperative. Another manufacturer states that “Nine times out of ten, circuit breakers fail because of lack of maintenance, cleaning, and lubrication.” Only through a thorough, well planned, and well executed preventive maintenance program will overcurrent devices continue to provide optimum protection.

Three requirements will help assure a reliable overcurrent protection system. The first requirement in an optimum electrical maintenance program is good apparatus, properly installed.

Secondly, properly trained, adequately equipped maintenance personnel are needed. Preventive maintenance can be expensive; it requires shop facilities, skilled labor, keeping records and stock replacing parts.

The third requirement is scheduling outages for preventive maintenance and periodic testing of electrical apparatus. When preparing routine maintenance schedules, it must be recognized that too frequent testing is a waste of money, and that insufficient testing places vital equipment and operating personnel in jeopardy.

For more information see: www.cooperbussmann.com/apen/topics/reliability.

Preventive Maintenance Costs

An accurate analysis of Cost of Ownership must also compare the ongoing cost to maintain the equipment, over the life of that equipment.

Fusible Equipment - Annual Maintenance Requirements

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Maintenance Hours/Device</th>
<th># of Devices</th>
<th>Total Man Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Bolted Pressure Switches</td>
<td>1.5</td>
<td>3</td>
<td>4.5</td>
</tr>
<tr>
<td>4-Feeder Disconnects</td>
<td>0.5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Prep Work and Data Retrieval</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Annual Total Man Hours</td>
<td></td>
<td></td>
<td>12.5</td>
</tr>
</tbody>
</table>

Assume $80/hour by a qualified testing/engineering firm.

Maintenance Cost = $80/Hr x 12.5 Hrs/Year = $1000/Year

Fuse Replacement Costs

<table>
<thead>
<tr>
<th>Rating</th>
<th>Replace**</th>
<th>Fuse Cost*</th>
<th>Fuse Cost Over 20 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>800A &amp; 3000A</td>
<td>1/20 Yrs</td>
<td>$490</td>
<td>$480</td>
</tr>
<tr>
<td>400A &amp; 600A</td>
<td>2/20 Yrs</td>
<td>$135</td>
<td>$270</td>
</tr>
<tr>
<td>Total Replacement</td>
<td></td>
<td></td>
<td>$780</td>
</tr>
</tbody>
</table>

Fuse Replacement Cost/Yr = $780/20Yrs = $38/Yr.

Total Maintenance Cost - Fusible Equipment

= Fuse Replacement + maintenance costs
= $38 + $1000 + $1038/Year

*Circuit Breaker Equipment - Annual Maintenance Requirements

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Maintenance Hours/Device</th>
<th># of Devices</th>
<th>Total Man Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Main LVPCB*</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6-Feeder ICCB**</td>
<td>1.5</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Prep Work and Data Retrieval</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Annual Total Man Hours</td>
<td></td>
<td></td>
<td>19</td>
</tr>
</tbody>
</table>

Assume $80/Hour by a qualified testing/engineering firm.

Total Maintenance Cost - Circuit Breaker Equipment

= $80/Hr x 19 Hrs/Year = $1520/Year

*Low Voltage Power Circuit Breaker, Drawout
**Insulated Case Circuit Breaker, Drawout

Total Cost of Ownership

We can expect a minimum 20 year useful life for the fusible and circuit breaker equipment. Life Costs, or Total Cost of Ownership, would be:

Total Cost of Ownership* = Initial Cost + (total annual maintenance cost) 20 yrs.

Fusible Equipment Cost of Ownership

Initial Cost + (total Maintenance Cost) 20 = $26,000 + ($1038)(20 Yrs) = $46,760

Circuit Breaker Equipment Cost of Ownership

Initial Cost + (total Maintenance Cost) 20 = $47,500 + ($1520)(20 Yrs) = $77,900

The Cost of Ownership of the circuit breaker equipment is 67% greater than that of the fusible equipment, over the expected 20 year life of the equipment. Additional cost would be incurred if circuit breakers need to be replaced.

*These figures and calculations do not examine the effects of the Time Value of Money. These values can be calculated using a number of methods, i.e., Present Worth, Annual Costs, etc.

Other Considerations

This evaluation has not analyzed the other necessary engineering considerations associated with overcurrent protection. These include:

- Current Limitation
- Component Protection
- Selective Coordination
- Multipole vs. Single Pole interrupting Ratings
- Electrical Safety (for more information see www.cooperbussmann.com)

Conclusions

Cost of Ownership, which includes both initial costs and preventive maintenance costs, is an important part of an engineer’s decision making process. Good engineering and preventive maintenance is critical for adequate performance during the lifetime of the equipment. Fusible vs. Circuit Breaker design choices involve economic as well as engineering considerations.