Electrical System Basics

MV vs. HV - Definitions

• Differences between USA and the rest of the world

• IEC define a high voltage fuse as a fuse-link rated for 3 phase systems above 1kV to 72.5 kV

• IEEE define a medium voltage fuse-link as a fuse rated for single and 3 phase systems between 1kV and 38kV
Electrical System Basics

- Generation voltage
  10 kV-25kV **MV** (Medium Voltage)

- Transmission voltage
  **HV** (High Voltage) – 132kV to 475 kV
  Or **EHV** (Extra high voltage) – 500 kV to 800 kV

- Distribution voltage
  **MV** (Medium Voltage) – 1.1kV to 72.5 kV

- Low voltage
  **LV** 1 V to 1kV
Electrical System Basics
Why High Voltage

Power = Volts X Amps
If we increase voltage, we can decrease current
If we decrease current, we can use smaller conductors (less copper) and have lower losses (around 7% typical)

Transmit and distribute at high and medium voltages

Typically on overhead line systems
Why Overhead Line Systems

- Predominantly driven by cost
  For 1 kilometre of overhead line £5,000

- For 1 kilometre of underground cable £25,000

- Overhead systems susceptible to faults permanent & transient

- Need for protection and isolation
Urban and Rural System Statistics

Medium voltage accounts for 61% of ALL network faults.
MV Systems Protection - Objectives

• Protect equipment and people
• Provide fault discrimination
• Provide isolation points
• Cost effective and reliable
• Minimize customer outages
• Environmental considerations
Distribution Systems

Protection Options

• Circuit breaker based system – Far too expensive.

• Fuse based systems most widely used

• Cost effective and environmentally safe

• Can be easily combined with switches

• Variety of options

• In current-limiting form - the best solution for transformer protection
OHL Distribution Network Systems

Auto-Recloser

Transformer

Fuse link or Sectionaliser
Equipment on Overhead Systems

• **Fuse Link** - Usually an expulsion fuse-link mounted in a holder (cutout), opens on an overcurrent condition, “de-latches” and swings open to isolate the fault.

• **Auto Re-Closer** - A circuit breaker that opens and close rapidly to allow a temporary fault to clear

• **Cutouts, Fuse mounts, DOEF** - All mean the same thing – an expulsion fuse link holder

• **Sectionaliser** – Electronic device which replaces an expulsion fuse and holder, will “de-latch” on an over current condition - isolating the fault
Fuse Types

DIN

Air / Motor

VT (Voltage Transformer)

Oil Tight Fuses
# HV part numbers

## Part referencing system for current limiting fuse links

<table>
<thead>
<tr>
<th>kV</th>
<th>1st Letter General Type</th>
<th>2nd Letter Barrel Diameter (mm)</th>
<th>3rd Letter Barrel Length (mm)</th>
<th>4th Letter Striker (mm)</th>
<th>5th/6th letter and or digit - termination or fixing</th>
<th>Amps A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A / B / D / N</td>
<td></td>
<td></td>
<td>S = Striker to DIN43625, form C, 50N</td>
<td>A = No Tags. Ferrule diameter as the 2nd letter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V or W</td>
<td></td>
<td></td>
<td>E = Striker to DIN43625, 80N</td>
<td>B = Offset tag, single bolt fixing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>E, H, L = 63.5</td>
<td></td>
<td>C = 195</td>
<td>C and D = Tags to BS2692-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q</td>
<td>F, I, K = 76.2</td>
<td></td>
<td>D = 203</td>
<td>F = Offset tag, double bolt fixing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S</td>
<td></td>
<td></td>
<td>X = 88</td>
<td>H or M = Striker to BS2692-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T</td>
<td></td>
<td></td>
<td></td>
<td>N = None fitted</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>J = Ferrule to DIN 43625</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q = Tags to BS2692-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>G = Tags to BS2692-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M = 537</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I = 568</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>K = 914</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22 = 5/16-BSW stud one end only</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>02/03 double and triple barrel fuse link</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F2/F3 double and triple barrel variants</td>
<td></td>
</tr>
</tbody>
</table>
### MV Fuse Classification

<table>
<thead>
<tr>
<th>Fuse link types</th>
<th>Rated current of fuse link (I&lt;sub&gt;n&lt;/sub&gt;)</th>
<th>Minimum Fuse opening range (1.1I&lt;sub&gt;n&lt;/sub&gt; to 1.4I&lt;sub&gt;n&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back Up</td>
<td></td>
<td>3 I&lt;sub&gt;n&lt;/sub&gt;</td>
</tr>
<tr>
<td>General Purpose</td>
<td></td>
<td>1.7 I&lt;sub&gt;n&lt;/sub&gt; (1 hour current)</td>
</tr>
<tr>
<td>Full Range</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Minimum breaking current**

**Zone of uncertain operation. Fuse-link will open but cannot clear fault**
The Importance of the Striker

Back up and General Purpose Fuses

Rely on striker pin to trip fuse-switch for low level over currents where the fuse-links cannot clear the fault
Provides “full range” operation

Fuse opens and striker pin contacts trip bar

Trip bar in the switchgear trips all 3 phases
The Striker

Two types of Strikers
- Spring (Din fuses)
- Pyrotechnic (Oil fuses / Air fuses)

**Spring Striker**
- Pin
- Spring
- Retention wire

**Pyrotechnic “Gun Powder” Striker**
- Case
- Pin
- Gun powder
- Ignition wire
Back-Up Fuse Construction

- Outer cap
- Ceramic former
- Striker coil
- Silver elements
- Striker assembly
- Body
- Quartz filler
Expulsion Fuse Link and Cut-out

- Overhead line cut-out secures fuse-link
- Fuse-link melts during over current condition
- Fuse-link cutout de-latches and swings downward, extinguishing over current and isolating fault
- Inexpensive protection
Auto Re-Closer

• A pole mounted circuit breaker

• Or a ground mounted circuit breaker with an auto-reclose sequence relay fitted

• Open and closes rapidly to remove a temporary fault on an overhead line

• Usually set to O-C 3 times locks out on fourth
Sectionaliser

Applied in conjunction with auto-recloser (opens fault)

Contains Electronic circuit board and CTs to monitor current

After auto-recloser has opened a specified number of times, the sectionaliser actuator “de-latches”

Sectionaliser swings downward, isolating fault

Cost-effective protection
Urban Distribution Systems

Fused End Box

Ring Main Unit (RMU)

Primary Feeder

Transformer
Equipment Used In Urban Systems

RMU’s and fuse switches

Switchgear used to protect transformers and over-head lines on a network – R.M.U. – Ring Main Unit, consists of a fuse switch or circuit breaker, with two ring switches, very common and where 70% of MV current limiting powder fuses end up.

Fused End Boxes

– Fused end boxes contain current-limiting fuses but do not provide isolation or switching.
Ring Main Unit (RMU)

Non-Fused Switch - Provides power supply from either source

Fuse Switch/CB - Provides isolation and protection for load (transformer)

Earth Switch - Switches incoming cables to earth during routine maintenance
Fused Switch

1) Busbar compartment
2) Switching compartment
3) Cable compartment
4) Low voltage compartment

Current Limiting (CL) Fuse-links

11/22kV Switch

CL Fuse
Fused End Box

- Phase Barrier
- Mounting flange
- Full Range Current Limiting Fuse-link
- Cable Entry
- Fuse-link connection (bolted or DIN clip)
Summary

• All countries have a generation, transmission and distribution system to get electricity to facilities

• Medium and low voltage fuse-links are used mostly in the DISTRIBUTION part of the system

• Medium voltage non-current limiting fuse links and Sectionalisers mounted in cut-outs are used in overhead lines

• Medium voltage current limiting fuses are generally used in Ring main units (RMUs), fused switches and fused-end boxes in urban networks