

## *FUSES SAFE and RELIABLE*

### **Fuses against Circuit-breakers**

- Fuses / Circuit-breakers.
- Markets.
- Co-ordination test according to IEC 947-3.
- Comparison of motor starters.
- Current limiting and let through energy.
- Selectivity.
- Reliable isolation.
- Cost differences in use.
- Performance and life time costs.
- More power is needed.
- Cables protection.
- Conclusion

## *FUSES SAFE and RELIABLE*

### Fuses against Circuit-breakers

➤ **Relative advantages**

<b>CIRCUIT-BREAKERS</b> ("mechanical moving parts")		<b>FUSES</b> ("Nothing can prevent the fuse from blowing") (Joule effect)
Although dimensions are standardized, there are many different tripping characteristics and forms of arc dispersion to the outside which complicates selection and replacement. MCBs have non adjustable characteristics, but up to 4 different type are available.	International standardization means simplicity	IEC 60 269 have electrical unit dimensional characteristics which make them fully interchangeable
<ul style="list-style-type: none"> <li>- Low performances</li> <li>- Hot ionized gases can be emitted to the outside (safety area needed)</li> </ul>	<ul style="list-style-type: none"> <li>Fault current</li> <li>Current (<math>I_N</math>)</li> <li>Nominal voltage (<math>U_N</math>)</li> <li>Reliability</li> <li>Selectivity</li> </ul>	<ul style="list-style-type: none"> <li>-High performances</li> <li>-Safe operation               <ul style="list-style-type: none"> <li>Confined arcing</li> <li>Safely within the sealed cartridge.</li> </ul> </li> </ul>

## *FUSES SAFE and RELIABLE*

### Markets

➤ General market

User convenience ==> Domestic

- = *Circuit-breakers*
- Lower breaking capacity.
  - Normally tested with additional length of cable


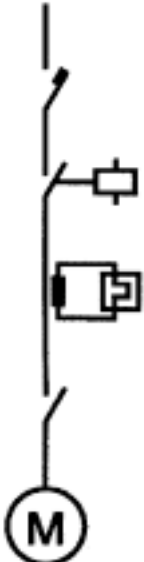
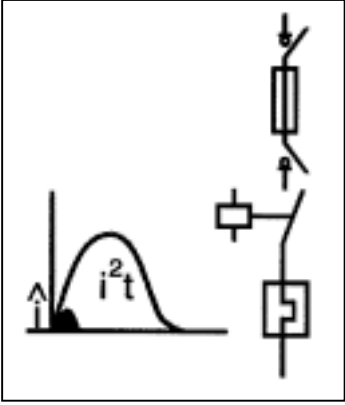
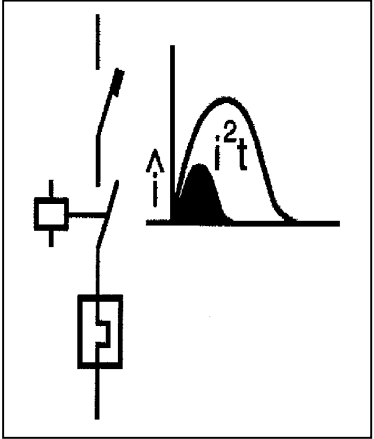
➤ Demanding market

Reliability ==> Industry

- = *Fuses*
- Have unrivalled ability to clear high fault currents safely. Breaking capacity up to 50 – 100 – 200 kA are common under the severest testing conditions.
  - This means that detailed fault level calculations are not necessary. The fuse can do it !

# FUSES SAFE and RELIABLE

## Comparison of motor starters

Fuse	Fonction	Circuit-breaker
 <p>Fuses</p> <p>Switch fuse isolation</p> <p>Contactor</p> <p>Overload relay</p> <p>Switch disconnecter</p> <p>Motor</p>	<p>Short-circuit protection</p> <p>Both polarities isolator of fuses</p> <p>Power control</p> <p>Overload protection</p> <p>Safety isolation (near Motor)</p> <p>Motor</p>	 <p>Circuit-breaker</p> <p>Contactor</p> <p>Current transformer</p> <p>Switch disconnecter</p> <p>Motor</p>
Type 2	Co-ordination (IEC947-4)	Type 1
		

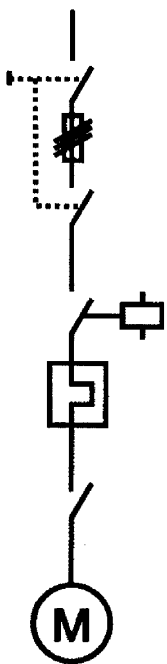
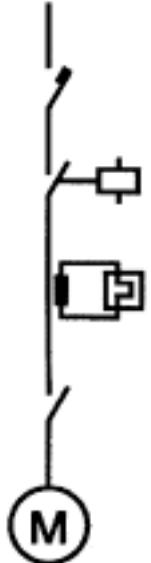
## *FUSES SAFE and RELIABLE*

### Comparison of motor starters

- ↪ Type 2 co-ordination shall be insured in order to comply with the safety rules (people and equipments). The fuse limits the peak current and let through  $I_t$  to levels below the withstand of the contactor and overload relay.
- ↪ In case of motor starters with circuit-breaker protection, the contactor shall be oversized to carry the peak current through limiting breaker.

## *FUSES SAFE and RELIABLE*

### Co-ordination test according to IEC 947-4

The tests for fuse protected starters	Possible consequences for wrong coordination	The tests for circuit breaker protected starters
<p>Test 1-30 kA Test 50 kA Test &lt; 10 I<sub>e</sub></p> 	<ol style="list-style-type: none"> <li>1. The peak let through current of the contactor leads to : <ul style="list-style-type: none"> <li>- light welding of the contactor contacts,</li> <li>- damages of the arc chambers.</li> </ul> </li> <li>2. The short circuit withstand current of the bimetal relay : <ul style="list-style-type: none"> <li>- exceeds maximum motor acceptable value</li> <li>- burns the bimetal relay</li> </ul> </li> <li>3. The peak let through current or I<sub>t</sub> in the circuit generates high electrodynamic compulsions, high temperature rise (joule effect)</li> </ol>	<p>Test 1-30 kA Test 50 kA</p> 

For both fuses and breakers

## *FUSES SAFE and RELIABLE*

### **Co-ordination test according to IEC 947-4**

#### **Co-ordination type 1 :**

- ↪ The starter and the contactor may be damaged.

#### **Co-ordination type 2 :**

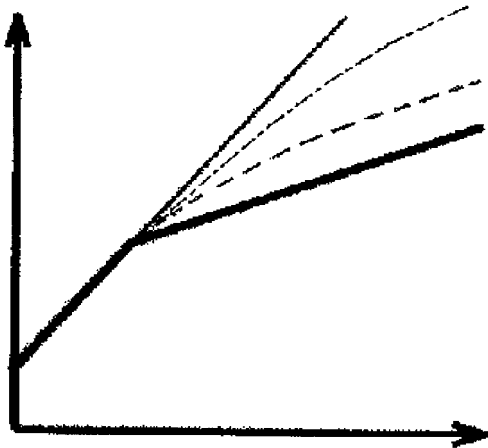
- ↪ The starter must be operable after the tests whatever high its prospective current may be.
- ↪ Only light welding of the contactor is allowed.
- ↪ Achievable with fuses whatever the contactor manufacturer is.
- ↪ With circuit-breaker, it is necessary to conduct tests and adjustments according to the manufacturer products.

#### **Co-ordination type 3 :**

- ↪ The starter must be faultless after the tests.

## *FUSES SAFE and RELIABLE*

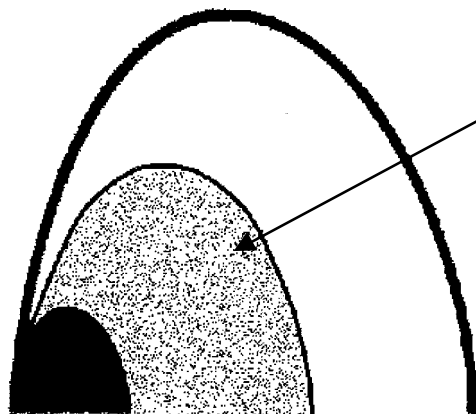
### Current limiting and let through energy



Current limiting with "standard" breaker.

Current limiting with "limitor option" breaker.

Natural current limiting with fuses.



High and wide peak let through current of the circuit-breaker

The size of the contactor and overload relay must be selected in proportion to the current limiting level of the breaker (Typical let through  $I_t$  levels are about 10 – 20 times higher than a fuse)

Short and low let through current and very low  $I_t$  of the fuse. The short circuit capacity of the contactor and overload relay is normally adequate for the let through energy.

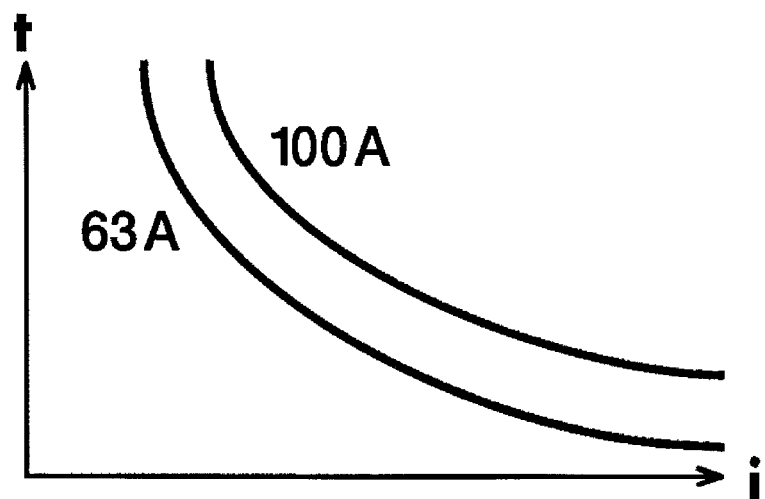
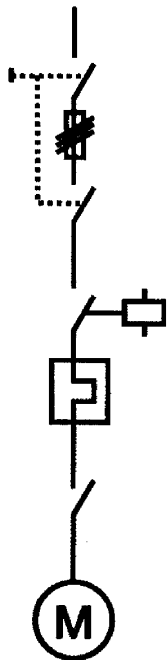
Current limiting fuses clear short-circuit fault in less than a half-cycle, improving the "power quality" in the system.

Current limiting breakers operate within one half cycle but the operating time is much longer than for a fuse and the improvement in "power quality" is less marked.

## *FUSES SAFE and RELIABLE*

### Selectivity

**Fuses** = Excellent discrimination (selectivity) for all currents

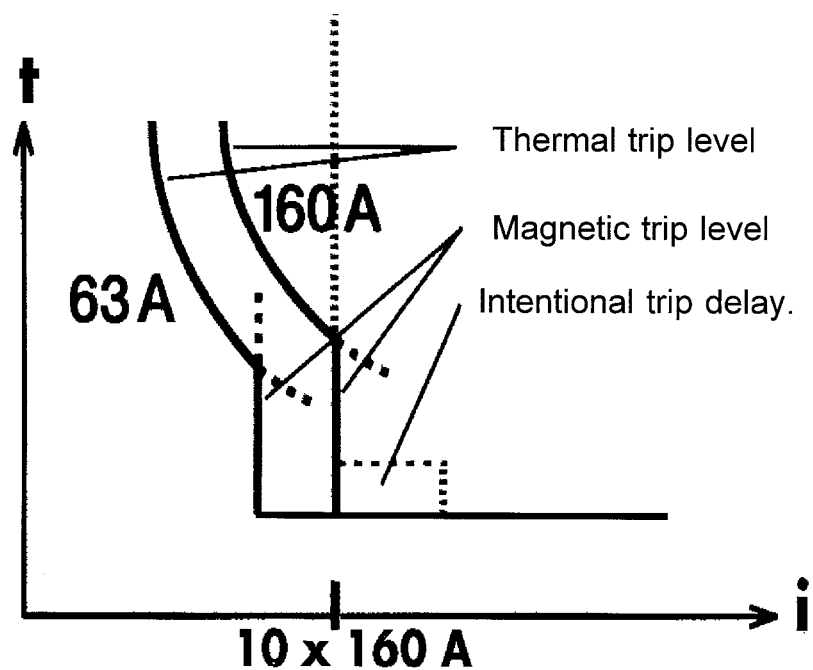
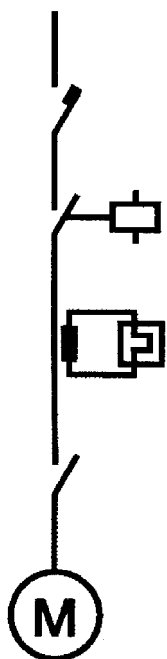


- ↑ Standard melting curve IEC 269-1 and 2.
- ↑ Selectivity ratio = 1.6 / 1 with gG fuses.
- ↑ Selective when rated current of the fuse on supply side is one or two sizes higher than on load size.
- ↑ Specific let through energy in high currents is small. Contactor and thermal relay are not critically stressed.

## FUSES SAFE and RELIABLE

### Selectivity

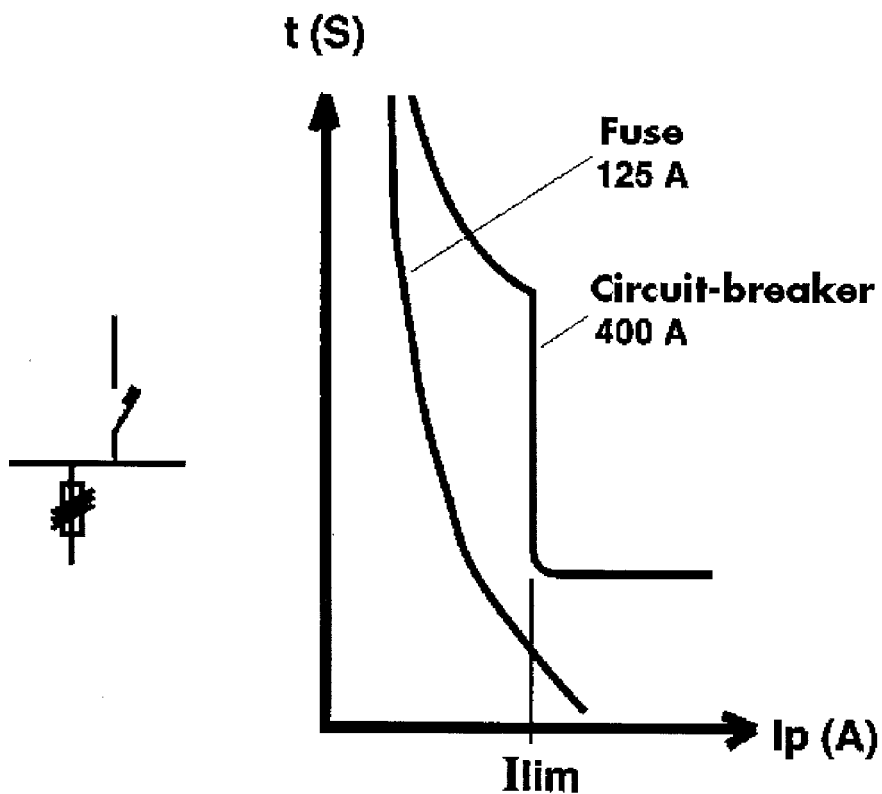
**Breakers** = Selectivity ensured for low currents



- ↑ Always mechanical delay.
- ↑ Selectivity for high currents require specific calculations (often impossible to achieve).
- ↑ Time delay device improves selectivity only up to 15 times the rated current of the supply side breaker (selectivity ratio  $> 2.5 / 1$  and usually  $4/1$  needed according characteristics).

## *FUSES SAFE and RELIABLE*

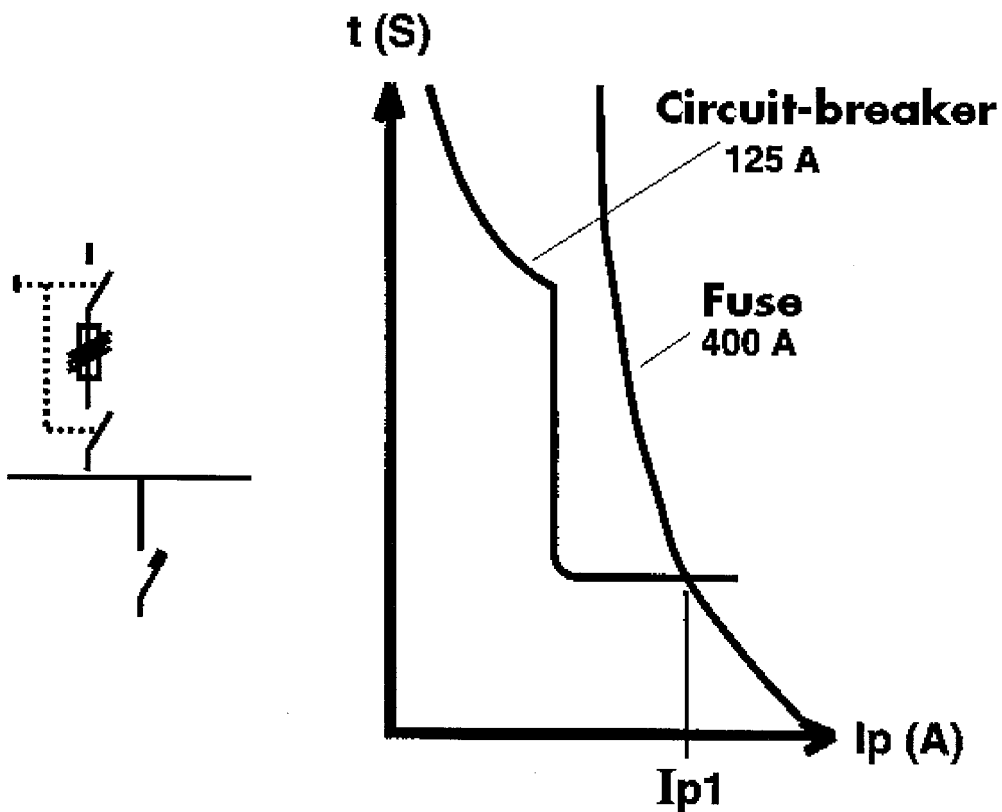
### Selectivity Fuses / Breakers



Require rated current higher for breaker than fuses (generally more than 3 times – to be controlled with instantaneous ( $I_{lim}$  triggering action)).

*FUSES SAFE and RELIABLE*

**Selectivity Fuses / Breakers**



In this case the selectivity is not possible on the full range of currents ; the fuse will blow for high prospective currents.

In some cases, the fuses will permit to use low breaking capacity breaker (all currents higher than  $I_{p1}$  will be eliminated by fuse which has a very high breaking capacity).

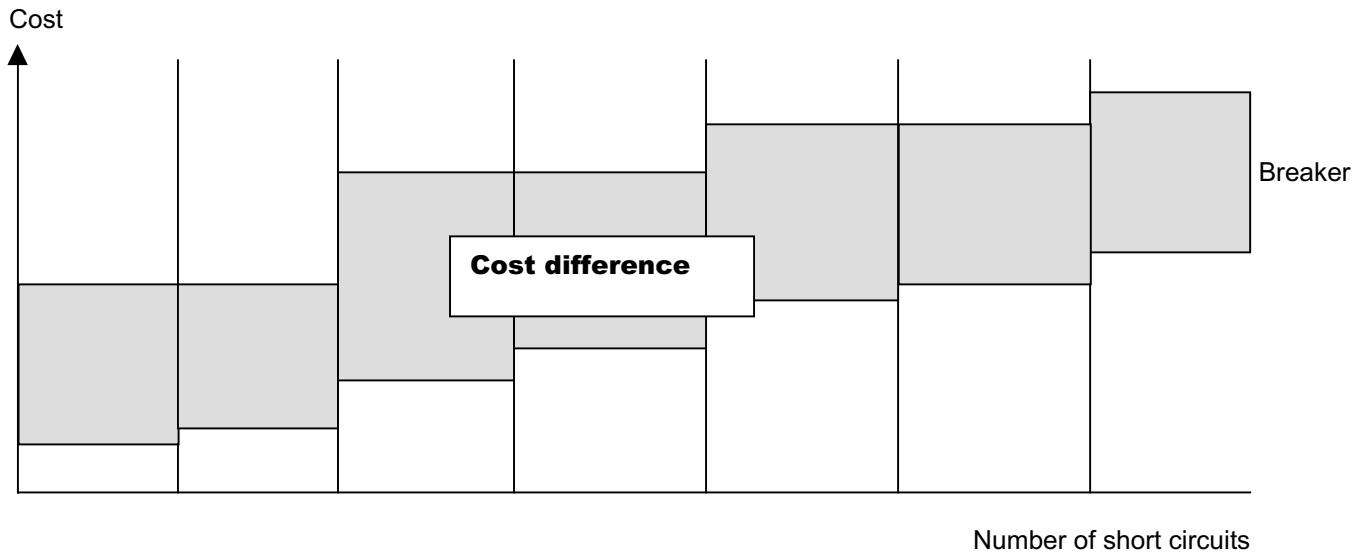
## *FUSES SAFE and RELIABLE*

### **Reliable isolation**

- When a fuse is removed from its holder or a switch fuse is operated "effective isolation" as required by IEC 364 (wiring regulations) is achieved. In each case, when the fuses are removed, the circuit is open and the tripping distance is high. So that it is safe for persons to work on the downstream circuit.
- In addition, some devices have reliable isolation on both sides of the fuse and the isolation has a visible point while fuses are removed.
- This increases safe operation for maintenance staff.
- Installation of a class AC22 or AC23 circuit-breaker, (break visible) or a class AC20 switch with a switching adjacent to the motor or the machine, with perfect security in the event of interference.
- The new machine regulations impose a switch with pe-breaking contact or a circuit-breaker to separate the energies (Clause R233-29), the electrical risks (Clause R233-25), the voluntary action of putting into operation (Clause 233-18).
- Only circuit breakers with a certain minimum contact separation will give effective isolation in accordance with the regulations. The case of reclosing a breaker increases the risk of accidental re-energisation of the circuit.

## *FUSES SAFE and RELIABLE*

### Cost difference in use



#### **Fuses**

- ↪ Quick replacement (always three fuses on one circuit).
- ↪ Low spare part costs.
- ↪ Ready for use after replacement.

#### **Circuit-breaker**

- ↪ Plug-in version is needed for quick replacement.
- ↪ More costly spare part stock.
- ↪ Require settings before use.

## *FUSES SAFE and RELIABLE*

### Performance and Life time costs

	Fusegear		Breaker	
	Costs	Performance en %	Costs	Performance en %
Investment	1.0	100 %	1.2	100 %
Failure n° 1	0.1	100 %	0	80 %
Failure n° 2	0.1	100 %	0	60 %
Failure n° 3	0.1	100 %	1.2	100 %
<p>★ Safe replacement after operation</p> <ul style="list-style-type: none"> <li>– The system protection is restored to its original state.</li> </ul> <p>★ Fuse totally closed :</p> <ul style="list-style-type: none"> <li>– Safe in minimum installation space</li> <li>– Long term protection perfect in various environmental conditions.</li> </ul> <p>★ . After a fault has occurred the cause of the fault must first be identified and then corrected. The fuse can be changed at this time.</p>		<p>★ Performance level drops in use</p> <p>★ Not totally closed :</p> <ul style="list-style-type: none"> <li>- space for overpressure needed</li> <li>- smooth functioning must be skiller regular testing</li> </ul> <p>★ Breaker must be changed after 2-3 major short-circuits with identical product (position of the venting on it not standardized).</p>		

## FUSES SAFE and RELIABLE

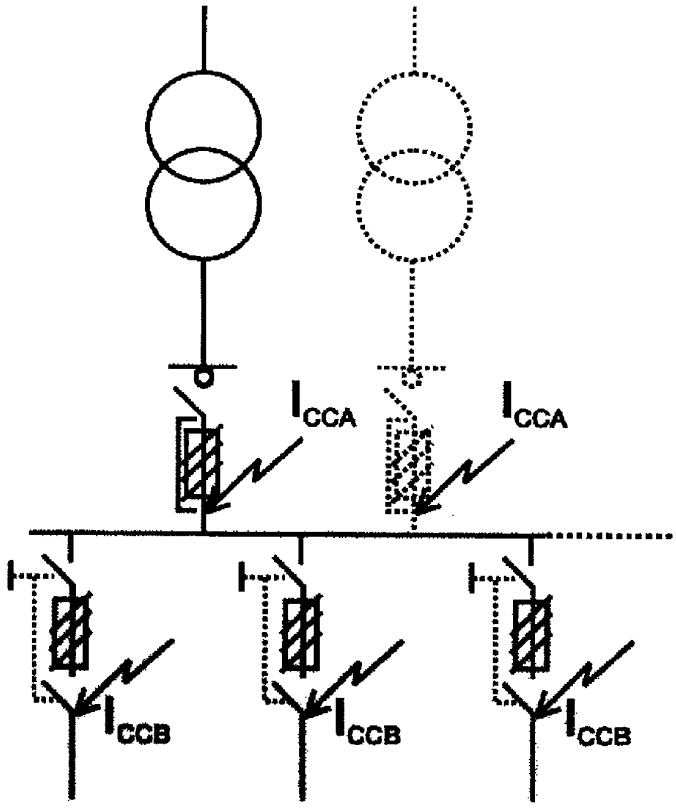
### Security if fault level increase

Electrical distribution net works grow with the addition of extra breakers and equipment :

eg. Second transformer is connected in parallel ==> required higher breaking capacity devices.

No problem with fuse system (breaking capacity between 100 and 200 kA).

The breaking capacity of the breaker itself can be exceeded. In either case the breaker needs to be replaced with a more suitable type, or a fuse must be fitted to provide back-up protection of the breaker.

Present Situation		Future Situation
PN = 1250 kVA $U_{CC} = 4\%$ $I_{CCA} = 36,1\text{ kA}$ $I_{CCB} = 36,1\text{ kA}$		PN = 1250 kVA $U_{CC} = 4\%$ $I_{CCA} = 72,2\text{ kA}$ $I_{CCB} = 72,2\text{ kA}$

## *FUSES SAFE and RELIABLE*

### Protection of Cables

gG fuses to IEC 60-269... give complete over-current protection of cables in accordance with the international wiring regulations (IEC 364)

- In accordance with IEC 364 the section of the cables wire protected by fuses must be increased by 10 % (in comparison with circuit breaker protection with adjustable current).

On the other hand, this difference of section disappears in the following cases.

- Variation higher than 4% on the voltage supply,
- Extensions,
- Power losses calculated in the longer cables :

Ex : 50 m of 10 mm<sub>2</sub> cable for 60 A circuit == >

R = 90 mohms == > power losses = 3900 kW / year

50 m of 16 mm<sub>2</sub> cable for 63 A fuses ==>

R = 56 mohms ==> power losses = 2400 kW / year

(depreciation in 4 years)

- Modern a fuses are tested at  $1,3 I_N$  in accordance with IEC 60269-2-1 standard Annexe ...and in order to have the same rating calculation than Circuit Breakers
- Circuit breakers can also provide low overcurrent protection of cables, but protection against short-circuit is only provided below a certain fault level

## *FUSES SAFE and RELIABLE*

### **Conclusion**

The advantages of fuses compensate the disadvantages of breakers and vice-versa.

Many industrials and utilities in Europe prefer fuses, but others industrials choose breakers.

The experience shows that the panel boards are reliable and safe with combination of breakers and fuses.

The most important is when you design the installation, you consider all the short-circuits current values, the selectivity for the motors starters and cables protections.