Major developments in distribution fusegear for public networks

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Abstract: Distribution on the low voltage side of transformers in public networks has until recently been by via the humble feeder pillar or fuseboard. For forty years or so, these units were of a very basic and static design, which in use, exposed operators to live conductors and relied on the manual insertion and removal of fuses for the switching of circuits.

In the last decade there have been substantial pressures for change and advancement. Inherent safety is now widely regarded as essential. Statutory obligations ensure it is no longer acceptable to expose operators to live conductors, or, to rely on their skill and diligence for their safety. Networks demand more flexible designs of equipment in order to facilitate different loads and applications. Pressures to improve security of supply, whilst increasing system utilisation, mean more monitoring, and at times on line monitoring, is essential.

These, in some instances conflicting pressures, have had, and continue to have, considerable influence on the equipment on the low voltage side of transformers. The feeder pillar for today is more akin to a modern low voltage switchboard. It offers more flexibility in use, fewer restrictions in operation, full personnel protection and mechanised switching. In the future, there is the prospect of remote control and alternatives to fuse protection.

Introduction

Fuseboards, and their outdoor equivalent, feeder pillars, are the basis of low voltage distribution in most public networks. The function of the fuseboard is to take in a supply of electrical energy from a transformer and distribute it, via fuseways, to a number of outgoing circuits, providing each with a means of protection and control. In effect they are a very basic form of low-voltage (LV) switchboard.

Prior to the mid 1980's, designs for feeder pillars had not changed significantly for 40 years. This paper sets out to identify recent pressures for change, the resulting and anticipated improvement to designs.

Today there are two major 'pressures' for change in LV electricity distribution; safety and, the desire to minimise or eliminate interruptions in supply. These 'needs' are not unique to one particular electricity utility, increasingly they are demanded by all electricity suppliers.

As fuseboards are central to LV electricity distribution, the features and facilities they provide must accord with their changing environment, in addition, they must be cost effective for their application.

All utilities are cost conscious and those that are privatised, as is the trend, have a need to be profitable. It is highly desirable that any evolution is economically advantageous, but analysis should not be restricted to considering initial cost of individual pieces of equipment. 'Life time ownership costs' of the whole network taking full account of operational costs and likely future requirements is a more appropriate measure.

Traditional Designs

Figure 1 shows a typical, traditional design of indoor fuseboard. Essentially it is a frame supporting: open busbars; a means of connecting the incoming supply to the busbars, either directly, or, by means of a simple disconnector (isolator); and outgoing fuseways.

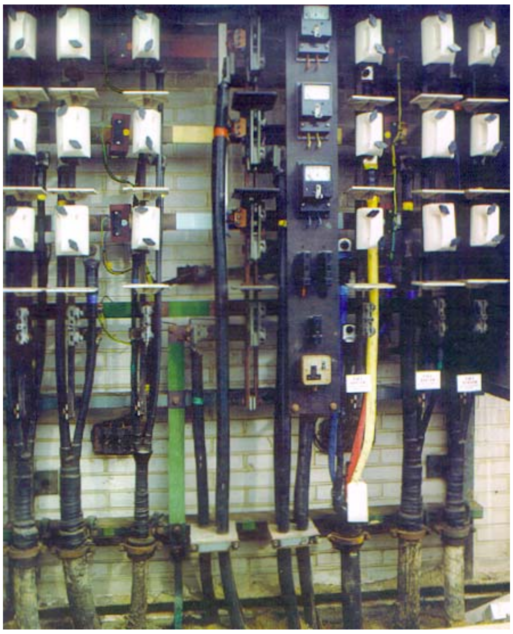

Fig.1 Typical traditional indoor fuseboard.

The fuselinks used in the unit shown in figure 1 are in accordance with BS 88 Part 5[1]. (These fuse links were very recently designated type gU with wedge tightening contacts in accordance with IEC 60269-2-1 Section VI[2].) Contemporary designs based around the use of fuselinks to DIN Standards (now known as fuse links with blade contacts in accordance with IEC 60269-2-1 Section I) were similarly constructed.

Feeder pillars are essentially a fuseboard installed in a ground mounted weatherproof enclosure. They are suitable for installation outdoors without further protection. (Throughout this article the term 'fuseboard' will be used to include fuseboards and feeder pillars, unless otherwise indicated).

Limitations

Traditional designs have their limitations:

(i) Personnel protection is not intentionally included; to IEC 60529[3] they are categorised as IP00- "no protection"! Accidental contact with large areas of live and exposed conductors is only avoided by the care and diligence of the operator and, indeed, anyone else who happens to be in the vicinity of the fuseboard or feeder pillar with its doors open.

(ii) Switching of circuits is carried out by the manual insertion and removal of the fuselinks. This potentially hazardous operation, relies on the skill and firmness of the operator to minimise arcing and ensure safe operation. When carrying out this operation, it is recommended that operators wear gloves and a visor to protect their hands and faces from burns, should arcing occur.

(iii) Cabling of one circuit with those adjacent live and in service is extremely difficult with any degree of safety, due to the proximity of terminals to adjacent and unscreened conductors.

(iv) Large supplies can only be accommodated by either, connecting two or three fuseways in parallel or, in some cases, taking the supply from the busbars via a disconnector (isolator). With the latter arrangement the LV circuit relies on the MV switchgear on the primary side of the transformer for its protection, a significant limitation when earth faults across a delta star transformer are being considered.

Pressures for Change

Traditional designs of fuseboards have a good record and have served their application well. Bearing in mind their obvious limitations, they have proved reliable in service and, due entirely to the skill and care with which they have been operated, safe in operation. However, times change, requirements, expectations and standards progress. Our two major pressures for change bring their often-conflicting requirements to bear in different ways.

1. Safety

Today's society demands ever-greater inherent safety in all aspects of life and, the safety requirements for electrical switchgear are no exception. Improvements are frequently encouraged or obliged by law.

Example these are:

The foreword of EN 50274[4] summarises the pertinent requirements of applicable European Directives as follows:

> ***'The Framework Directive (89/391/EEC) on Health and Safety sets out in article 6 - General Obligations on Employers:***
>
> ***(a) Remove the danger***
>
> ***Or if this is not possible***
>
> ***(b) Separate the person from the danger by means of screens, barriers or obstacles.***
>
> ***Or if this is not possible***
>
> ***(c) Provide personal protective equipment to ensure the health and safety of the person'***

The statement 'Or if it is not possible' linking the options does not allow a great deal of flexibility for new installations when, the technology and reasonable options are readily available to remove the danger.

The UK's Electricity at Work Regulations[5] place similar obligations on employers and individuals. Specifically in respect of live conductors, Regulation 14 stipulates:

> ***'No person shall be engaged in any work activity on or so near any live conductor (other than one suitably covered with***

insulating material so as to prevent danger) that danger may arise unless –

- ***(a)** it is unreasonable in all the circumstances for it to be dead; and*
- ***(b)** it is reasonable in all the circumstances for him to be at work on or near it while it is live; and*
- ***(c)** suitable precautions (including where necessary the provision of suitable protective equipment) are taken to prevent injury.'*

As with the European Directives the exposing of personnel to live conductors under any circumstances is effectively precluded within new installations.

The Republic of South Africa (RSA) also has stringent safety legislation and close links to UK requirements[10]. Work related obligations are set out in the RSA's Occupational Health and Safety Act (OHSACT) I993[6]. This imposes a wide range of duties on the employer. Those particularly pertinent to electrical applications and specifically fuseboards include:

'8. General Duties on employers and their employee

1. Every employer shall provide and maintain, as far as is reasonably practical, a working environment that is safe and without risk to the health of his employees.

2. Without derogating from the generality of an employer's duties under subsection (1), the matters to which those duties refer include in particular –

- ***a. the provision and maintenance of systems of work, plant and machinery that, as far as reasonably practicable, are safe and without risk to health;***
- ***b. taking such steps as may be reasonably practicable to eliminate or mitigate any hazard or potential hazard to the safety or health of employees, before resorting to personal protective equipment.'***

'10. General duties of manufacturers and others regarding articles an substances for use at work

1. Any person who designs, manufactures, imports, sells or supplies any article for use at work shall ensure, as far as is reasonably practicable, that the article is safe and without risks to health when properly used and that it complies with all the prescribed requirements'

'Electrical Machinery Regulations, 1988
5. Switch and transformer premises

1. The user shall cause enclosed premises housing switchgear and transformers –

- ***g. to be of such a construction that persons cannot reach in and touch bare conductors or exposed live parts of electrical machinery.***

2. No person other than a person authorised thereto by the user shall enter, or be required or permitted by the user to enter, premises housing switchgear or transformers unless live conductors as insulated against inadvertent contact or are screened off: Provided that the person so authorised may be accompanied by any person acting under his control.'

'Electrical Machinery Regulations, 1988
6. Electrical control gear

3. The user shall, whenever reasonably practicable, provide switchgear with an interlocking device so arranged that the door or cover of a switch cannot be opened unless the switch is in the 'off' position and cannot be switched on unless the door or cover is locked.'

'Electrical Machinery Regulations, 1998
7. Switchboards

The user shall provide an unobstructed space for operating and maintenance staff at the back and front of all switchboards, and the space at the back shall be kept locked except for the purpose of inspection, alteration or repair: Provided that the requirements of this regulation with respect to the unobstructed space at the back of the switchboard shall not apply in the case of –

a) switchboards which have no uninsulated conductors accessible from the back;

b) switchboards, the switchgear of which is a totally enclosed construction;

c) switchboards, the back of which are only accessible through an opening in the wall or partition against which they are placed, such openings being kept closed and locked; and

d) switchboards which can be safely and effectively maintained from the front and which have all parts accessible from the front.'

Again we see the exposing of personnel to live conductors is restricted and that the use of Personal Protective Equipment (PPE) must be a last resort.

This form of legislation leaves little room for manoeuvre. Strong requirements such as; 'Remove the danger, or if this is not possible', or, 'it is unreasonable in all the circumstances for it to be dead', or, 'taking such steps as are practicable to eliminate hazards before resorting to protective equipment', make it 'illegal' to install fuseboards that expose personnel in their vacinity to live conductors.

LV assemblies, including fuseboards, that avoid exposing personnel to live conductors are readily available.

2. Secure supply

Increasingly, consumers are more demanding and less tolerant of interruptions in supply. Most are now computer dependent; to these a secure electricity supply is their 'life blood': dips and interruptions cause mayhem.

In order to play its part in ensuring a secure supply the substation LV fuseboard must, as far as practical:

a) Be capable of being; where necessary, maintained, repaired, or extended without the need for isolation of the assembly.

b) Facilitate reconfiguration of the network with the maximum amount of the system live and in service.

c) Offer alternative ratings of outgoing circuit up to and including the full capacity of the transformer.

d) Provide suitable overload and short circuit protection for each outgoing circuit, and, discrimination with up and down stream protection.

e) Enable LV supplies to continue to be provided when the normal supply from the associated distribution transformer is not available.

f) Minimise the number customers isolated when a fault occurs and when supplies are being restored. (Due to safety constraints some network operators isolate the MV supply in order to replace a single LV fuse link.)

g) Minimise the skill, supervision and procedures necessary for safe operation. Enable the operation of fuseboards by personnel with widely differing skills and limited experience in fuseboard operation.

The Improvements

Generally, change is an evolutionary process and fusegear improvements are no exception.

a) Shielded Fusegear

The first significant change has been the screening of all live conductors under normal service conditions (in the case of a feeder pillar with doors open). Whilst the approach may differ, depending upon the type of fuselink incorporated, the protection afforded is generally to the recognised level of IPXXB with all the fuselinks in place. This level of protection prevents accidental contact with live conductors. Anyone entering a substation to clean it or decorate it, or opening the doors of the feeder pillar to read the maximum demand indicators (MDIs), is safe from accidental contact with live parts. Figure 2 shows a typical shielded fuseboard.

Switching of circuits with shielded fusegear is rarely proven by type test. It is, however, carried out in exactly the same manner as with the traditional design of equipment. As fuselinks have to be inserted and withdrawn manually, an

Fig. 2 Shielded fuseboard

operator requires the same level of skill, diligence and protection as previously. During this operation he may be exposed to live conductors and arcing associated with switching a load currents as with the earlier designs.

b) Manually dependent switching

Some designs of shielded fusegear based on the use of blade type fuse links now incorporate outgoing fuseways with a manually dependent switching capability. These arrangements offer some comfort but switching performance is still very dependent on the speed and firmness of the operator. The switching action of most designs incorporating fuse links with blade contacts is based on the fuse link being mounted inside a hinged cover that is pivoted at the bottom, a feature results in breaking at the top contact, essentially in the open and, in close proximity to the operators hand.

c) Switched and Insulated Fusegear

The logical progression from shielded fusegear is an arrangement whereby, the fuselinks are inserted and withdrawn in a manually independent manner. Figure 3 shows such an arrangement, switched and insulated fusegear (SAIF)[7]. This offers the same level of protection against accidental contact with live parts as the shielded equipment, but the IPXXB protection is extended to the switching operation and the changing of fuselinks.

In order to provide an assured switching capability, the fuseways within SAIF equipment include a switching capability independent of the skill and speed of the operator, effectively as for a conventional fuse switch with an independent manual mechanism. Technically it is feasible to provide single phase or 3 phase fuse switches for the application, but the costs are prohibitive. SAIF overcomes this difficulty by utilising a detachable, independent single phase spring mechanism.

This novel approach, enables the essential features of the fuse switch to be preserved, but at costs closer to those of the traditional fuseway. With SAIF, fuselinks are mounted in carriers and the carriers transferred between definite ‘ON’ and ‘OFF’ positions and vice versa with the detachable mechanism. The energy stored within the independent manual spring mechanism, is sufficient to insert the fuse safely onto a prospective fault of at least 50KA, or break load currents in accordance with category AC22B of IEC 60947-3[8]. As the operation is single phase, it has the advantage of fewer customers being disturbed in the event of a fuse link failure.

SAIF is more suited to type ‘gU’ fuse links with wedge tightening contacts, however, an equivalent design for fuse links with blade contacts, as shown in figure 4, is now available.

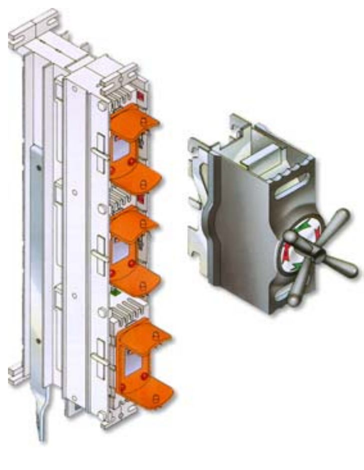

Fig. 3 Switched and insulated fuseway

d) Safety Interlocks

Hitherto, fusegear relied solely on the skill and the diligence of the operators to ensure that it was operated correctly. There were no prompts or inherent safety features to ensure disconnectors were either fully open or fully closed; similarly, fuselinks could be partially inserted or, in the case of those with wedge tightening contacts, not fully tightened. With the SAIF type equipment, interlocks are provided to ensure that, disconnectors are either, closed and full contact pressure applied or, fully open, and locked open. Fuseways are operated with a detachable mechanism, which cannot be removed unless the fuse carrier is fully closed or, alternatively, it is in the definite ‘off’ position.

e) Direct Connection

The close coupling of fuseboards and their associated transformers via a flange or similar, is tending to replace the traditional means of open overhead busbars, with it safety concerns, or cables. This can result in considerable cost savings, a reduction in the size of substation and shorter installation times. As the complete coupling system is provided by the transformer or fuseboard manufacturer, he is responsible for it, and the need for provision of cables or busbars on site is eliminated.

Fig. 4 Manually independent fuse switch-disconnector, blade type fuse links

f) Monitoring

Conventionally, fuseboards have been provided with maximum demand indicators on the incoming transformer circuit. This crude means of monitoring gives an indication of the maximum transformer overload, following the last reset of the maximum demand indicators. It does not give any indication as to when the overload occurred, if it is repetitive, or which outgoing circuits are involved. This information is insufficient when looking at system utilisation and the need for reinforcement.

Fig. 5 Substation monitoring

In order to improve management information substation monitoring systems capable of storing details of transformer loads and transmitting data via to GSM links, etc. to a host computer are now available. See figure 5. In the more dynamic cities and in particular financial capitals, some utilities see benefit in remotely monitoring all feeder circuits continuously and transmitting the loading details back to a central computer, which raises an alarm when a circuit passes into overload.

Accurate on line loading data enables future problems to be predicted and solved in a controlled manner, and without the need for unplanned interruptions in supply.

g) Incoming Circuit Breakers

MV protection, generally in the form of fuses, has provided short circuit protection for the distribution transformer, the fuseboard incoming circuit and busbars. Usually, effective LV and transformer overload protection, has not been included. Transformers have been sized on the basis of assumed loads plus a margin. In some instances load changes have led to unidentified overloads and premature ageing of the transformers. Due to the number and rating of outgoing circuits, these situations can occur without a single outgoing circuit being overloaded.

To overcome this, some utilities are using a circuit breaker in place of the incoming disconnector to the fuseboard. In addition to providing the isolating facilities required, this affords effective overload protection for the transformer and, if so required, can provide back up earth fault protection and enable the full load of the transformer to be switched in a single operation.

If a circuit breaker is employed on the incoming circuit to a fuseboard, care is required to ensure that it can discriminate with the largest outgoing fuse. If there must be a compromise, this should take preference over discrimination between the ACB and the HV protection on the primary side of the transformer.

Where network loads frequently change, or, there is a history of overloading of transformers that has resulted in premature ageing and failure of transformers, or, where overload protection may provide the confidence to permit installation of a smaller transformer, incorporation of an incoming circuit breaker can be economically attractive.

h) Standby Generators

Electricity Supply Utilities are seeking to improve and give a better service, usually measured in terms of the number of minutes lost and the number of customer interruptions. In order to keep customers on supply, many are using standby generators during the maintenance of HV switchgear or other equipment.

The usual point of connection for a standby generator is the LV fuseboard. Initially, connections were bolted or clamped to the exposed LV busbars but, as fuseboards are now frequently fully shielded, this, apart from not being a very safe practice, is not an option. Fuseboards now often include a means of connecting the generator to the busbars, while they remain live from the normal supply but without exposure of the operator to live conductors.

The standby generator can then be synchronised to the normal supply, prior to its isolation and completion of the 'no break' changeover. Reversing the procedure enables the normal supply to be restored and the generator disconnected, again without an interruption in supplies to customers.

For the majority of installations, disconnecting and re-connecting the normal supply requires the opening and closing of an incoming disconnector on the fuseboard. This device, as defined in IEC 60947-3, has no load making or breaking capability, but these limitations can be overcome.

Modern generator control systems are sufficiently sensitive and responsive so as to enable transfer of load to and from the standby generator while it is synchronised to the normal supply. This facilitates the isolation and re-connection of the normal supply, via the incoming disconnector on a fuseboard, without exceeding the defined capability of the disconnector. However, in addition to accurate speed and voltage control of the generator, care, skill and adherence to a strict procedure are required in order to ensure negligible current is interrupted and that minimal volts occur across the open contacts when the disconnector is opened.

Fig. 6 Manually dependent load break switch

Where preferred, the total reliance on care, skill and procedure can be reduced by replacing the incoming disconnector with a switch disconnector, as illustrated in figure 6. Switch disconnectors of the type illustrated have a certified manually dependent switching capability and their costs are not significantly higher than those of the disconnector generally incorporated as the incoming circuit to a fuseboard.

i) Large Supplies

Where an LV supply with a capability in excess of 600A is required from a fuseboard, practices are changing. Increasingly, moulded case circuit breakers (MCCBs) are being used for protection of these circuits in preference to reliance on MV switchgear, or LV fuses in parallel. Loads of this size are predominantly for 3 phase installations, reducing or even eliminating any advantage to be gained from single phase switching.

MCCBs, and in particular those with a more sophisticated micro-processor based protection system, have advantage over the historical approach in this application. They provide:

(i) Effective overload and short circuit protection, and a proven means of isolation for the LV cables.

(ii) The opportunity for earth fault protection with a setting to operate at much less than full load. This can permit the use of longer LV connections to the consumer, giving additional flexibility in system layout and the possibility of reduced cable and earth conductor sizes.

(iii) Facilities for remote emergency tripping or tripping from the customers' installation.

Note of Caution

Many fuseboards presently in service are more than 50 years old. This long life has been achieved as a result of the fuseboards being; of an open and spacious design, based on generous section of conductor, and, the incorporation of the minimum amount of insulation to support the conductors.

As requirements progress, the combined pressures for operational flexibility, increased safety and economy have led to more compact assemblies, use of minimal section conductors, much wider use of insulating materials and an increased utilisation factor. Collectively these changes lead to a significant increase in operating temperatures, which, without adequate consideration at the design stage, leads to a high probability of premature ageing and early failure.

LV assemblies are thermally complex and their ageing mechanisms are not well understood. Plastics, and in particular thermo-plastics as now widely used, age rapidly with increased temperatures. Copper element fuse links, again as widely used for economic reasons, are much more prone to ageing and unexpected rupture at modest temperature than their predecessors with silver elements.

Such problems can be overcome with a good understanding of the application, careful selection of components and insulating materials and a limit on the temperature of fuse link elements under normal load conditions.

Standards

The particular requirements for fuseboards for public networks have never been well-addressed in International or National Standards. In most instances they have been covered by utility specifications. Frequently these are of very prescriptive, of limited scope, and, very different for seemingly identical applications in other utilities.

This has at last been recognised by the International Electromechanical (IEC). Work has commenced within IEC SC17D/MT11 to broaden the scope of IEC 60439-5[9], to include fuseboards. In accordance with IEC requirements the standards should be performance based and an opportunity to detail and share 'best practise'.

Choosing the most suitable option

Figure 7 shows the typical modern fuseboard. This particular fuseboard provides personnel protection in accordance with IPXXB during all normal operations including changing fuselinks. Fuseways are switched and the loading of all fuseways is continuously monitored in a central control room via CTs, transducers and a remote terminal unit. The fuseboard is close coupled to the transformer and transformer loading is continuously monitored by summating the fuseway loads in the central control room. Fuseways plug onto the busbars in order that additional units can be added with minimal disturbance, assuming busbar space is available.

Fig. 7 Modern indoor fuseboard

Perhaps not all of the features of the fuseboard shown figure 7 will appeal to every utility. Each utility must evaluate and establish their own requirements considering the options outlined above and, their own particular obligations, needs, operational practises, future expectations and preferences. Economics will play a major part in the analysis, but, if the most viable solution is to be implemented it is vital this is not limited to the initial capital cost of the fuseboard. Analysis of the life-time ownership costs for the network is now a more usual approach, with areas considered including:

a) **Financial benefits of keeping customer on supply.** Revenue lost due to supply interruptions often cannot be recovered. In a regulated network punitive penalties may be applied. Responding to dissatisfied customers consumes resources. More supply interruptions than expected leads to a damaged reputation.

b) **Current and likely future statutory safety obligations.** The inconvenience and costs, should legal obligations be breached, may be significant.

c) **The benefits of equipment that is inherently 'safe' and simple to operate.** When a fuseboard is suitable for operation by 'anyone' working on network, fewer people need to visit the substation. The costs associated with specialists skills, time waiting for the specialist, training, management and, operation of management safety systems may be reduced.

d) **The ability to re-configure the network without a substation outage.** Being able to add future circuits and/or connect circuits with the remainder of the fuseboard live and in service can have considerable financial benefits in a dynamic or developing network.

e) **Opportunities for increased operational flexibility and efficiency.** The benefits of single phase switching in minimising the number of consumers involved in an interruption in supply are clear when considering a single-phase residential distribution systems. Being able to re-close a circuit in which the fuse link has previously operated, safely, and without the need to first connect a proving device can save time and cost. The ability to restore a faulted circuit without the need to interrupt other healthy supplies adds to the advantage.

f) **Reducing the need for PPE.** In addition to its often being legally a last option; obtaining, regularly testing or replacing, maintaining and managing PPE incurs considerable cost. In addition, its use usually increases the time needed to carry out a task. Therefore, a small premium on the cost of a fuseboard for safety measures may be readily offset by reduced costs associated with PPE over the life of the fuseboard.

g) **Attendance at substations.** The number and level of skill of personnel who visit a substation, for example to clean the substation or read the maximum demand indicators, may be reduced.

h) **The benefits of being able to connect reserve power.** The ability to connect and disconnect a standby generator (or an interconnector to an adjacent substation) without interrupting supplies to customers can have significant benefits, particularly where customers are demanding a secure supply, or, in a regulated network.

i) **Alternative of an incoming circuit breaker.** Providing effective overload protection for the transformer and fuseboard busbars has attraction when it prevents premature ageing of transformers, or, it enables smaller plant with a higher utilisation factor to be used with confidence.

j) **MCCBs for large outgoing circuits.** Compared with fuses in parallel, MCCBs provide more sensitive protection for circuits and enable longer LV cables to be adequately protected, particularly in respect of earth faults. In addition, their single action to isolate a circuit is less prone to operator error than the alternative of removing six or nine fuse links.

k) **Substation configuration.** Use of close coupled fuseboards and transformers (and ring main units) can reduce the overall size of a substation and eliminate the cable or busbar interconnections. This reduces civil and interconnection costs.

l) **Network utilisation.** Remote monitoring of the incoming and/or outgoing circuits may be beneficial in assisting with asset management through, increased network utilisation, use of smaller plant, lower transformer losses and, prompt identification of a need to reinforce the network.

m) **Frequency and extent of maintenance.** Maintenance is a disruptive and labour intensive process. With a suitable design, appropriate choice of materials and lubricants, use of 'non-deteriorating' contacts, etc. the amount of maintenance can be reduced and the interval between maintenance's extended. Subject to local legislation, suitable remote monitoring can further reduce the frequency of maintenance and attendance at substations.

n) **Reliability.** The unexpected operation of an aged fuse link or the overheating of a connection results in considerable cost. Adding a little margin to the design, for example limiting temperatures, can considerably improve reliability.

o) **Life expectancy.** For LV assemblies the most significant factor determining ageing is temperature. As a ‘rule of thumb’, the mechanical life of insulating materials is halved for every 10°C increase in working temperature. Hence, a small premium for the inclusion of conductors of sufficient section to ensure modest operating temperature and the selection of insulating materials with higher operating temperature capabilities may in the longer term be economic.

What Next?

The modern fuseboards is now “safe” and easy to operate with few concerns. In some cases they are intensely monitored, but this alone will not be sufficient to meet the ever-increasing demands for a guaranteed supply. A glance over the transformer may provide clues to the future. On the MV side the pressures are the same for a secure supply but, as the number of customers on each feeder is much greater, it is here that the initial effort has been concentrated.

On the MV side, the trend is towards automation and, in some instances, closed rings, in order to provide “ no break supplies”. The technology is available to automate the low voltage network. Remotely operated circuit breakers can be used to control and protect LV supplies. When the balance of economics is such that this is attractive, the LV system will be automated.

Conclusion

The requirements for feeder pillars have advanced considerably in the last 10 years, and will continue to do so. The need for much improved operator safety, fewer restrictions in operation and more flexibility in use has had, and continues to have, a considerable influence on fuseboard designs.

The economy of the network as whole has and, will increasingly have in the future, a significant influence on fuseboard designs. With the trend towards privatisation of public utilities, there is a need to deliver electricity profitably.

This does not mean installing the cheapest equipment available, on the contrary it may mean the more expensive. The more enlightened supply operators are now making decisions on the basis of lifetime ownership costs. This takes into account, initial capital cost, cost of installation, anticipated life, maintenance costs, operating costs, lost revenue due to interruptions in supply, either planned or emergency, penalties if any for interruptions in supply, and so forth

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