THE INEQUALITY OF CIRCUIT BREAKER STANDARDS

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ABSTRACT

The proliferation of National and International product specifications that cover low voltage circuit breakers has led to confusion regarding the intended application of these protection devices. This paper analyses and draws comparisons between the technical requirements and test parameters of several major specifications that address various types of Low Voltage circuit breakers and identifies the application limitations of devices covered by these standards and specifications. Misinterpretations which have led to incorrect and possibly hazardous application of LV circuit breakers are highlighted, with recommendations being made both in regard to the correct application of these devices, as well as to possible improvements in specifications.

INTRODUCTION

The subject of Standardization is complex and often controversial in consideration of the opposing requirements of free trade and the creation and maintenance of fledgling manufacturing industries in developing economies. This complexity is aggravated in the field of Low Voltage electrical protection, with particular reference to circuit breakers, where available products may be manufactured in accordance with one or more of a variety of National and International product standards.

IEC and CENELEC Standards

A comment often made in circles closely associated with the International Electrotechnical Commission (IEC), is that it is unfortunate that in certain countries and regions of the world, local standards are at variance with, or even contradict, international standards. It is true, that under ideal circumstances, full application of international standards would eliminate trade barriers and could result in increased consumer choice and possibly lower prices. Unfortunately, circumstances are not always ideal. Inevitably, a world standard is, to a degree, a compromise between the various interests and highly diverse requirements of the approximately 50 countries represented at the IEC. Even in Europe, which is the seat of, and driving force behind the IEC, IEC standards are not automatically adopted. Adoption of IEC standards by any country in the world, whether it is a member of the IEC or not, is entirely voluntary. Within Europe, members of the EU or EFTA countries are required through EC Directives, to comply with CENELEC standards which cover most electrical products and techniques. CENELEC, which is an acronym for "European Committee for Electrotechnical Standardization", originated in the early 1960's, and is the European counterpart of the IEC. As voluntary associations of the IEC, CENELEC members are encouraged, wherever possible, to aim towards harmonizing their standards with those of the IEC. The very fact however, that CENELEC standards, and not IEC standards, are adopted in Europe, is some indication of the lack of total commitment to the adoption of all IEC standards without compromise. Even in those cases where CENELEC standards can be shown to be identical with their IEC counterparts, there is no guarantee that compliance with IEC standards would guarantee acceptance in any particular European country. In addition to compliance with CENELEC standards, compliance with the Wiring Rules of any particular country are an inarguable requirement which must be satisfied.

As a general rule, IEC standards, and possibly to a lesser degree, CENELEC standards, aim to be non-restrictive, and allow for various types and classifications of product to be designed and manufactured. However, it is through their National wiring rules and by-laws that individual countries in Europe (as is the case in most parts of the world), can and often do restrict the use of electrical products and techniques. These restrictions usually vary according to particular national requirements, which may be related to safety or to the special needs of the various electricity distribution networks used.

South African Standards

By signing the GATT agreement, South Africa has agreed to minimize technical trade barriers, with technical regulations not being more restrictive than necessary to fulfil identified legitimate objectives. Such legitimate objectives embrace both safety and application requirements peculiar to the South African environment, which may not always be the same as those in Europe, upon which IEC standards are largely based. South Africa, through the South African Bureau of Standards (SABS) is at present actively engaged in following a program of adoption of IEC standards as reference documents. Using these reference documents, existing SABS standards are being reviewed, and where appropriate, the standards are being revised, based on the reference IEC documents.

Deviations from the IEC reference documents are in all cases required to be justified and transparent.

CIRCUIT BREAKER STANDARDS

It is not surprising that specifiers, users, manufacturers and test laboratories are often confused by the myriad of both National and International standards all claiming to be applicable to low voltage circuit breakers. This confusion is exacerbated in free market economies by the uncontrolled importation of product that may be used in applications possibly not envisaged by the original manufacturer.

At the root of this confusion, is usually a lack of appreciation as to the intended scope of application of devices covered by any particular product standard.

As an example, the scope of circuit breaker standards may have restrictions according to :

- *Type of construction*
- *Voltage ratings*
- *Ampere ratings*
- *Application environment*

It is only the "Voltage Rating" category of restriction that is fully justified by the fundamental definition of "Low Voltage", which in turn is defined as being up to and including 1000V a.c. or 1500V d.c. Some countries have realised that both due to the commonality of application requirements as well as for reasons of economies of scale, it may be more appropriate to have a single standard covering the requirements for all low voltage circuit breakers that are connected to the fixed installation.

Circuit Breakers for Equipment (CBE)

Very specialised application requirements such as circuit breakers for equipment protection can justify a separate product standard, provided that through physical differences in their size and mounting arrangements, it is highly unlikely that such devices could inadvertently be used for protection of the fixed installation. In the United States, these devices are not even referred to as "circuit breakers", but are called "Supplementary Protectors". The ANSI / UL standard UL 1077 is titled "Supplementary Protectors for use in Electrical Equipment", and in it's scope, UL 1077 limits the application of these devices to protection within an appliance or other electrical equipment, where branch circuit protection is already provided, or is not required.

Circuit Breaker Standards in the USA

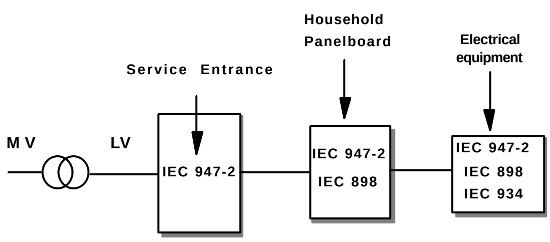
Mainly for historical reasons created through divisions in areas of responsibility, in the USA, separate standards exist for Moulded Case Circuit Breakers and for Low Voltage Power Circuit Breakers. The responsibility for standards covering Moulded Case Circuit Breakers rests with the National Electrical Manufacturer's Association (NEMA) and the Underwriter's Laboratories (UL), whilst standards covering Low Voltage a.c. and d.c. Power Circuit Breakers have traditionally been the responsibility of the Institute of Electrical and Electronic Engineers (IEEE) and the American National Standards Institute (ANSI). There is little risk of confusion between Moulded Case Circuit Breakers and Power Circuit Breakers and their application, due to unmistakable differences in appearance, size, construction and cost. Low Voltage Power Circuit Breakers are covered by the C37 series of ANSI / IEEE standards. Whilst Moulded Case Circuit Breakers are covered by two separate documents viz. UL 489 and NEMA AB-1, these documents are complementary and without contradiction.

UL 489 is the only document that is used for certification purposes for circuit breakers for fixed wiring protection. Additional documents do of course cover specific application devices such as Motor Circuit Protectors.

IEC Circuit Breaker Standards

The general manufacture and usage of circuit breakers as opposed to fuses is a far more recent innovation in Europe, as opposed to that in the USA, with IEC standards covering low voltage circuit breakers first making their appearance in the 1960's. Within the umbrella of the IEC series of product standards, there are three separate documents, all covering Low Voltage circuit breakers. These include :

- *IEC 934 - Circuit Breakers for Equipment (CBE)*
- *IEC 898 - Circuit Breakers for overcurrent protection for household and similar use*
- *IEC 947-2 - Low voltage switchgear and controlgear - Part 2 - Circuit Breakers*



IEC CIRCUIT BREAKER STANDARDS

Limits of Installation applicability

Both IEC 934 and IEC 898 include restrictions as to the SCOPE of their intended application. The scope of IEC 934 provides for protection to circuits WITHIN electrical equipment. IEC 898, in it's scope and title provides for protection of wiring installations for Household and similar use by unskilled persons. Except for the limits on voltage, the scope of IEC 947-2 contains no restrictions on design, rating, or construction, other than to mention that additional requirements may be necessary for specific applications.

Other Countries

Circuit Breaker standards in countries other than Europe and the USA have tended to align their requirements with either European or USA norms, mainly dependent on economic associations and influence. Countries with longer histories of either usage or manufacture of low voltage circuit breakers, such as Japan, Canada and South Africa, have recognised the practicality of single circuit breaker standards and as a result, have adopted single standards documents for all circuit breakers that are used for fixed installation wiring protection. Both the UK and Australia, who historically have had very specialised local requirements for MCB's, through their close connection with each other and Europe have not really had much choice other than to adopt IEC standards. Developing countries and especially those not having either an indigenous circuit breaker manufacturing industry or published standards covering those products, obviously find it easy to follow IEC standards, since they are dealing mainly with imported European product, and often have strong economic ties with that region.

Circuit Breaker standards in South Africa

South Africa is in the unique position of being one of the oldest users of Miniature and Moulded Case circuit breakers, having had an indigenous manufacturing base already in place in the early 1950's, based on North American standards. As far back as 1951, two South African standards covering Miniature Circuit Breakers (MCB), had been published. These included :

- *SABS 155 which covered MCB's for Lighting, Heating and Domestic Installations*
- *SABS 156 which covered MCB's for the protection of Electric Motors*

A decade of manufacturing and application experience, together with the introduction of Moulded Case Circuit Breakers (MCCB) for industrial and mining applications prompted the introduction of a new standard to cover all devices, since it was soon realised that the control of usage of particular MCB's or MCCB's according to their application was very difficult, expensive, and in some cases, impossible.

SABS 156-1963 titled "Standard specification for Moulded-Case Circuit-Breakers" replaced both SABS 155-1951 and SABS 156-1951, and extended the scope of these devices from 100 amperes to 1000 amperes. Like it's predecessors, SABS 156-1963 was based on input from publications of the British Standards Institution (BSI), as well as from NEMA and UL.

SABS 156-1963 was subsequently revised as SABS 156-1977 and then amended in 1987. In compliance with South Africa's commitment to adopt IEC standards, and in recognition of some of the positive aspects of IEC 947-2, SABS 156 is currently being reviewed, using IEC 947-2 as a basis and as a reference document. Some of the identified, mainly safety requirements of SABS 156 that have been proven in over four decades of experience involving all types of applications and environments, obviously need to be retained.

The difficulties in the control of usage of MCB's and MCCB's according to their application, that had already been identified in the 1950's, have in fact increased enormously as a result of the wide acceptance and usage of these devices in South Africa. Neither the Code of Practice for the Wiring of Premises (SABS 0142) nor the Electricity Installation Regulations, makes provision for the identification or control of low voltage protection devices according to their field of application. In the absence of any such identification, control is obviously impossible. Furthermore, the economic justification of separate standards for circuit breakers depending only on their application, has still to be demonstrated.

Circuit Breaker standards are not born equal *!*

IEC standards covering circuit breakers are not "born equal" for several reasons including :

- *Type of application*
- *Installation limitations*
- *Environmental suitability*
- *Voltage rating*
- *Maximum Current rating*
- *Short Circuit interrupting capability*
- *Overload performance criteria*
- *Cable protection capabilities*
- *Operational capability*
- *Dielectric withstand*
- *d.c. performance*
- *Isolation capabilities*

The above list is not intended to be complete nor exhaustive. The criteria listed have been chosen in the main to compare those requirements that have a more significant impact on not only the performance of circuit breakers meeting the requirements of the various standards, but of their suitability for installation and application as circuit protection devices. The listed criteria will be examined in more detail in the following paragraphs.

Type of Application

Circuit Breaker standards are required to define either areas of application or limitations of application in the scope of these documents. e.g.

- *IEC 934 - Overcurrent protection WITHIN electrical equipment*
- *IEC 898 - Overcurrent protection for RESIDENTIAL and similar applications*
- *IEC 947-2 - Overcurrent protection for ALL applications*
- *SABS 156 - All applications, but with limits on maximum current ratings*

Installation Limitations

- *IEC 934 - Installed within EQUIPMENT with back-up by protection on the fixed installation*
- *IEC 898 - Not suitable for installation at the Service entrance. Distribution circuits only.*
- *IEC 947-2 - No installation restrictions*
- *SABS 156 - Limited by ratings only*

In addition, circuit breaker standards now list Overvoltage Category Ratings for equipment energised directly from the low-voltage mains.

IEC 664-1 titled "Insulation co-ordination for equipment within low voltage systems" lists and describes these Overvoltage Categories as follows

Overvoltage category IV - *Equipment for use at the ORIGIN of the installation*

Overvoltage category III - *Equipment in fixed installations and for cases where the reliability and availability of the equipment is subject to special requirements.*

Overvoltage category II - *Energy consuming equipment supplied from fixed installations*

Overvoltage category I - *Equipment for connection into circuits in which measures are taken to limit transient overvoltages to an appropriately low level.*

Circuit Breaker standards list the following Overvoltage category requirements :

IEC 934 Overvoltage category II

IEC 898 Overvoltage category III

IEC 947-2 Not specified, but Overvoltage category IV specified for application at Service Entrance (origin of the installation)

SABS 156 Not specified

Environmental suitability

IEC 664-1 describes pollution in the micro-environment for the purposes of evaluating creepage and clearance distances.

Circuit breaker standards list the following :

- *IEC 934 Pollution degree 2*
- *IEC 898 Pollution degree 2*
- *IEC 947-2 Pollution degree 3*
- *SABS 156 "Normal" ambient conditions*

Pollution degree 1 - *No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.*

Pollution degree 2 - *Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.*

Pollution degree 3 - *Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.*

Pollution degree 4 - *The pollution generates persistent conductivity caused by conductive dust or by rain or snow.*

Maximum Voltage Ratings

Standard	a.c.	d.c.
IEC 934	440 V	250 V
IEC 898	440 V	N/A
IEC 947-2	1000 V	1500 V
SABS 156 (as amended)	1000 V	500 V

It is also important to note that the South African standard mining voltage of 525 volts a.c. is not covered in either IEC or Japanese standards. The preferred and test voltages used in these documents is 500 volts a.c. This difference may not appear to be large, but when considered together with limiting tolerances, can result in a dramatic reduction in circuit breaker interrupting capabilities for both general operational performance and on short circuit. This loss of performance at higher voltages is more evident with "current-limiting" type circuit breakers than is the case for zero-point extinguishing type devices.

Recovery Voltage

All circuit breaker test specifications and standards lay down required minimum values for the power frequency recovery voltage for all breaking capacity and short circuit interrupting tests. The values specified are deemed to cover the effects of the variations of the system voltage under normal service conditions. In South Africa, whilst the Electricity Act at present specifies the tolerance on standard voltage to be + 6% - 10%, this is in the process of being amended to +/- 10%. The recovery voltages specified in circuit breaker standards are as follows:

Standard	Minimum	Nominal	Maximum
IEC 934	100%	105%	110%
IEC 898	100%	105%	110%
IEC 947-2	100%	105%	110%
SABS 156	105%	110%	115%

This is one example of the need to retain some of the tried and tested parameter requirements of SABS 156 in the revised document which is to be based on IEC 947-2.

Maximum Current rating

The maximum circuit breaker ratings covered by the scope of circuit breaker standards are :
IEC 934 - 125 A : **IEC 898** - 125 A
IEC 947-2 - No limit; **SABS 156**-1000 A

Short Circuit Interrupting capability

The ability to successfully and safely interrupt short circuit currents is the major parameter that distinguishes circuit breakers from other switching devices. The short circuit breaking capacity of a circuit breaker is determined by not only the design of the circuit breaker itself, and it's speed of operation, but is influenced by a number of circuit parameters, some of which are listed below :

- *Prospective short circuit current*
- *Short circuit power factor*
- *System voltage*
- *Recovery voltage*
- *System frequency*
- *Point on wave at which the short circuit occurs*

In a dynamic situation such as the interruption of an electric arc, to a greater or lesser degree, each and every circuit parameter will ultimately determine the survival or failure of the circuit breaker to achieve it's intended function. With other factors being equal, there is however one parameter that has been identified as having a major influence on the amplitude of the short circuit current which can be successfully interrupted by a given circuit breaker. That parameter is the short circuit power factor which is determined by the circuit X/R ratio.

Power Factor

It cannot be argued that for circuit breakers which having, by definition, a restricted and limited installation environment and position in the network, the likelihood of "low" power factors or high X/R ratios, is rare. Furthermore, this is also particularly true for conditions in which the prospective short circuit current is limited to relatively low values by high circuit resistances introduced by long lengths of small cross section conductors. On the other hand for circuit breakers that are suitable for installation at ANY point in the supply or distribution network, "high" power factors, i.e. those approaching unity, can not always be guaranteed. This is particularly true for conditions where the energy supply is derived from relatively small distribution transformers up to about 315kVA.
It can easily be shown that for the range of cables that could be connected to these transformers, at positions in the network where cable lengths of less than several metres of smaller cables up to several hundred metres of larger cables are used, short circuit power factors of less than 0,5 are a reality and will be addressed in the revision of SABS 156. For prospective short circuit currents up to 10kA, the nominal power factor associated with short circuit currents specified in the standards are :

Test current	IEC 934	IEC 898	IEC 947-2	SABS 156
	Nominal Power Factor			
<= 1500 A	,93/,98	,93/,98	0,90	
>1500 <=3000A	,85/,90	,85/,90	0,90	,45/,50
>3000 <=4500A		,75/,80	0,80	,45/,50
>4500 <=6000A		,65/,70	0,70	,45/,50
>6000 <=10000A		,45/,50	0,50	,45/,50

Short Circuit test sequences

The short circuit test sequences usually comprise a number of operating cycles whereby the circuit breaker is :

i) Reqd. to OPEN when a short circuit is created "O" operation
ii) Left dormant for a predetermined period "t"
iii) CLOSED onto an existing short circuit fault "CO" operation

There are usually two main categories of tests that are considered. These are :

Icu *or "Ultimate" short circuit breaking capacity*
Ics *or "Service" short circuit breaking capacity*

"Icu" indicates the absolute maximum interrupting capability of the circuit breaker, after which test sequence the circuit breaker will still be operational, but may not be capable of carrying 100% of it's rated current continuously.
"Ics" indicates the short circuit interrupting capability of the circuit breaker after which test sequence, it is still capable of carrying it's rated current continuously. In addition, IEC 898 requires a low level test at 1500A. When

applicable, IEC 934 also includes this as an OPTIONAL test.

The number of operations and test sequences of the considered standards are listed below :

	1500 A	Ics	Icu	Pt. / wave	Remark
IEC 934	**9 x O + 3x CO**		**O-t-CO-tCO**	**Varied**	**Option**
IEC 898	**9 x O + 3x CO**	**O-t-O -t-CO**	**O-t-CO**	**Varied**	
IEC 947-2		**O-t-CO-t-CO**	**O-t-CO**	**Not Specified**	
SABS 156			**O-t-CO**	**Maximum Ipeak**	

Overload Performance

Decades of experience with the installation and application of moulded case circuit breakers has clearly demonstrated that one of the most probing tests in determining the ability of these devices to perform under varying and extreme operating conditions is the "Overload Test". The "Overload" test requirements for the circuit breaker standards being considered are:

	Amps	Ops	ON	OFF	P.F.	Seq.
IEC 934	6 In	40	1 sec	60-80 secs.	0,55/ 0,65	After Trip test
IEC 898	500 A or 10In	9		180 secs.	0,93/ 0,96	After Endurance
IEC 947-2	6 In	12	2 secs	30-60 secs.	0,50	After Endurance
SABS 156	6 In	50	2 secs	10-30 secs.	0,45/ 0,50	Befor Endurance

Given that the overload test has proven to be such a reliable indicator of circuit breaker quality and performance, as well as the fact that even IEC 934 includes more stringent overload test requirements than IEC 947-2, there appears to be a strong case for maintaining the existing overload test requirements of SABS 156, with some possibility of relaxation for higher ampere rated devices.

CABLE PROTECTION

The prime function of the circuit breaker is to provide overcurrent protection to the cable to which it is connected. Overcurrent protection is divided into two discrete zones viz.

- *Overload Protection*
- *Short Circuit protection*

Overload Protection

An obvious requirement of a circuit breaker is that it should be capable of holding 100% of its rated current continuously. For test purposes it is generally assumed that the circuit breaker will not trip once it has held the test current for a period of one to two hours. The degree to which the cable would be protected by the circuit breaker can be determined by the minimum level of current that is required to trip the circuit breaker, taking into account the highest pick-up trip current level permitted by the standard. The conventional tripping currents and times permitted by the standards are as follows :

	Hold current	Trip current	Triptime minutes	Ref. Temp C
IEC 934	**1,0 In**	**ANY**	**60**	**23 +/-2**
IEC 898	**1,13 In**	**1,45 In**	**60-120**	**30+5-0**
IEC 947-2	**1,05 In**	**1,30 In**	**60-120**	**30+/-2**
SABS 156	**1,0 In**	**1,35 In**	**50-100**	**25+/-5**

The worst case pick-up trip currents for IEC 947-2 and SABS 156 are approximately the same, (with IEC 947-2 requiring a closer tolerance) when consideration is given to the difference in reference temperature This would be true for circuit breakers whose tripping point is dependent on ambient temperature, assuming 1% current change per degree Celsius of temperature. The implication is however, that cables protected by IEC 898 circuit breakers, could reach temperatures which are higher than those protected by IEC 947-2 circuit breakers before tripping occurs.

The multiplier on the maximum cable temperature would be equal to the SQUARE of (1.45/1.30), which represents a 124% INCREASE in cable temperature.

Short Circuit Protection

As a general rule, the instantaneous pick-up current of most MCB's and MCCB's lies within the range of 5 times the breaker ampere rating and not more than about 15 times the ampere rating, even for special motor protection MCCB's. Based on instantaneous tripping times even as high as 0,1 seconds, this allows generous safety margins that ensure cable protection under short circuit conditions for all cable sizes using zero-point type circuit breakers. With smaller cables however, for short cable lengths, cable damage is possible. This is true for both zero-point extinguishing breakers and for current limiting type breakers. Depending on the size of the transformer, (for cable cross sections up to about 6 sq. mm.) the minimum length of cable in circuit that is required to ensure that no damage to the cable will result is approximately :

-6 to 12 meters with zero-point extinguishing breakers

-3 to 6 metres with current limiting breakers, and possibly less, depending on the degree of current limiting.

Opening under short circuit conditions

The following table lists the standards requirements for instantaneous tripping elements of circuit breakers opening under short circuit conditions :

	Trip Curve	**Multiple of In**	**Maximum trip time**
IEC 934		Not specified	0.1 sec
IEC 898	B C D	3 to 5 5 to 10 10 to 20	0,1 sec 0,1 sec 0,1 sec
IEC 947-2		Not specified	0,2 sec
SABS 156		Not specified	Not specified

Current Limiting

Current Limiting is a feature of design of circuit breakers and is not generally a requirement of circuit breaker standards. Some European countries do however have limited requirements. Current and energy limiting by circuit breakers do have advantages in respect of the protection of small cross section cables. Current limiting circuit breakers are necessary as back-up protection devices where circuit breakers are installed at points in the network where the prospective short circuit current exceeds the short circuit breaking capacity of the downstream breaker. Whilst current limiting breakers are used as downstream devices in such applications, improved safety factors are obtained by using zero-point extinguishing circuit breakers in the downstream location. The following table lists the standards requirements in regard to the provision of information related to energy limiting and peak let through current.

	Isq t & Ipeak measurement	**Isq t & Ipeak limits**	**Remarks**
IEC 934	Backup coordination	Manuf. spec.	Optional
IEC 898	Required	Manuf. spec.	
IEC 947-2	Backup coordination	Manuf. spec.	
SABS 156	Not specified		

Endurance Tests

The following endurance or operational performance test requirements are specified, with SABS 156 showing the most stringent test requirements.

	Ops. Noload	Ops. LOAD	Total Ops.	P.F.	Amp Rating
IEC 934	Manufacturers specification			0,9/,95	ALL
IEC 898	0	4000	4000	0,85/,9	ALL
IEC947-2	8500	1500	10000	0,8	100A
	7000	1000	8000	0,8	315A
	4000	1000	5000	0,8	630A
	2500	500	3000	0,8	2500 A
	1500	500	2000	0,8	>2500
SABS156	6000	4000	10000	0,75	100A
	4000	4000	8000	to	224A
	1000	4000	5000	0,80	630A
	500	3000	3500		1000 A

Dielectric Tests

Two series of dielectric tests are generally performed on circuit breakers. These include :

- *Dielectric tests on new circuit breakers*
- *Verification tests after performance or short circuit tests*

	Dielectric test 50Hz	Verification tests 50Hz	Impuls tests	Rating
IEC 934	500 1000 1500 2000	375 750 1125 1500	under consid.	50 V 125 V 250 V 440 V
IEC 898	2000	1500 900afterIcn		
IEC947-2	2500	2Ue(min 1000V)		
SABS156		2000 2200		Ue500v Ue660v

Circuit Breakers in d.c. circuits

The maximum d.c. voltages at which circuit breakers complying with IEC 934, IEC 947-2 and

SABS 156 should be applied is specified in those documents and noted in this paper.
*It is important to note that IEC 898 breakers are **NOT SUITABLE** for use on d.c.*

Switch Disconnectors and Isolation

Modern MCB's and MCCB's are often applied as Isolators or Switch-Disconnectors in addition to their overcurrent protection functions.
The degree to which circuit breaker standards cover the Isolation function and its implied safety requirements are shown below :

	Suitability for Isolation	Test Requirement
IEC 934	None	None
IEC 898	Assumed	None
IEC 947-2	Classified and Marked	Impulse Voltage Leakage current
SABS 156	If tested to SABS 152	Increased dielectric test Volts

Circuit breakers conforming to IEC 898 have always been assumed to be suitable for isolation, with only a note indicating that special installation precautions may be necessary e.g. the inclusion of "adequate" lightning arresters. No tests to prove the isolation function are specified.
This shortcoming of IEC 898 has been recognized and proposals have been made to introduce suitable test requirements to justify this assumption.

IEC 898 and DIN mounting

Circuit breaker standards generally have no specification requirements for the dimensions, outline, or form and fit of the MCB's covered by the standard. This is also true for IEC 898.
However, arising out of the European origins of both the IEC 898 standard and the MCB's conforming to that standard, there is a perception that IEC 898 MCB's must be suitable for mounting on the 37mm DIN mounting rail.
THIS IS NOT TRUE !
In fact circuit breakers of ANY form and fit can be built to, tested to, and gain approvals to IEC 898, (or any other standard) provided the requirements of that standard are satisfied.
The mounting systems that are in use in the various regions of the world are mainly a function of usage and market penetration by particular manufacturers or groups of manufacturers.
The stability and commitment of manufacturers in a given territory usually determines the de facto mounting standards in that territory.
Any change away from those de facto standards is generally not economically justified.

CONCLUSIONS

Having examined both similarities and differences between the three IEC standards covering circuit breakers and the current edition of SABS 156, several interesting conclusions and observations can be made.

IEC 934 which covers Circuit Breakers for Equipment, like it's USA counterpart UL 1077 is solely intended for installation WITHIN electrical equipment. Circuit Breakers that comply with IEC 934 are not intended to be used for fixed installation protection. IEC 934 circuit breakers are required to be backed up by other circuit breakers in the fixed installation.

IEC 898 by definition, is intended to apply ONLY to miniature circuit breakers for household and similar use. Circuit breakers that comply with IEC 898 are not suitable, nor are they rated for installation at the origin of a circuit or at the service entrance.
IEC 898 circuit breakers are not suitable for operation in d.c. circuits.
Unless correctly applied, the safety of IEC898 devices could be compromised from both points of view of the successful interruption of short circuit currents, as well as possible damage by uncontrolled surge voltages when compared to IEC 947-2 approved circuit breakers.
Under low overload conditions, cables protected by IEC 898 devices could reach temperatures of almost 25% higher than those protected by IEC 947-2 circuit breakers before automatic tripping occurs.
In the absence of rigid controls covering both product identification and installation, installers need to be particularly aware of the potential hazards of indiscriminate use of these devices.

IEC 947-2 when used in conjunction with it's parent general rules document IEC 947-1 is a good standard for general use, but needs to be addressed in several of it's requirements, before it can safely be applied to the diverse and sometimes onerous application conditions found in South Africa.

SABS 156 has reached a stage of maturity where a revision is required urgently. This revision is presently in progress using IEC 947-2 as a basis and reference document. The benefits of more than four decades of manufacturing and application experience with circuit breakers built to SABS 156 must not be lost. With safety being a prime consideration in the protection products covered by this standard, these proven safety levels need to be maintained in the revised document through enhancement of IEC 947-2 utilising the extensive SABS 156 experience.

REFERENCES

i) SABS 156-1977 Moulded case circuit breakers

ii) IEC 947-1 - 1988 Low-voltage switchgear and controlgear - General rules

iii) IEC 947-2 - 1989 Circuit Breakers

iv) IEC 898 - 1995 Circuit breakers for overcurrent protection for household and similar use

v) IEC 934 - 1993 Circuit breakers for equipment

vi) UL 1077 Supplementary protectors for use in electrical equipment

vii) UL 489 - Moulded case circuit breakers and enclosures

viii) Mounting systems for miniature circuit breakers V Cohen - published in "Vector" September 1994

ix) Circuit breaker standards - a holistic approach V Cohen - published in "Vector" August 1992

x) Moulded case breakers - Specification and testing V Cohen - published in "Vector" December 1985