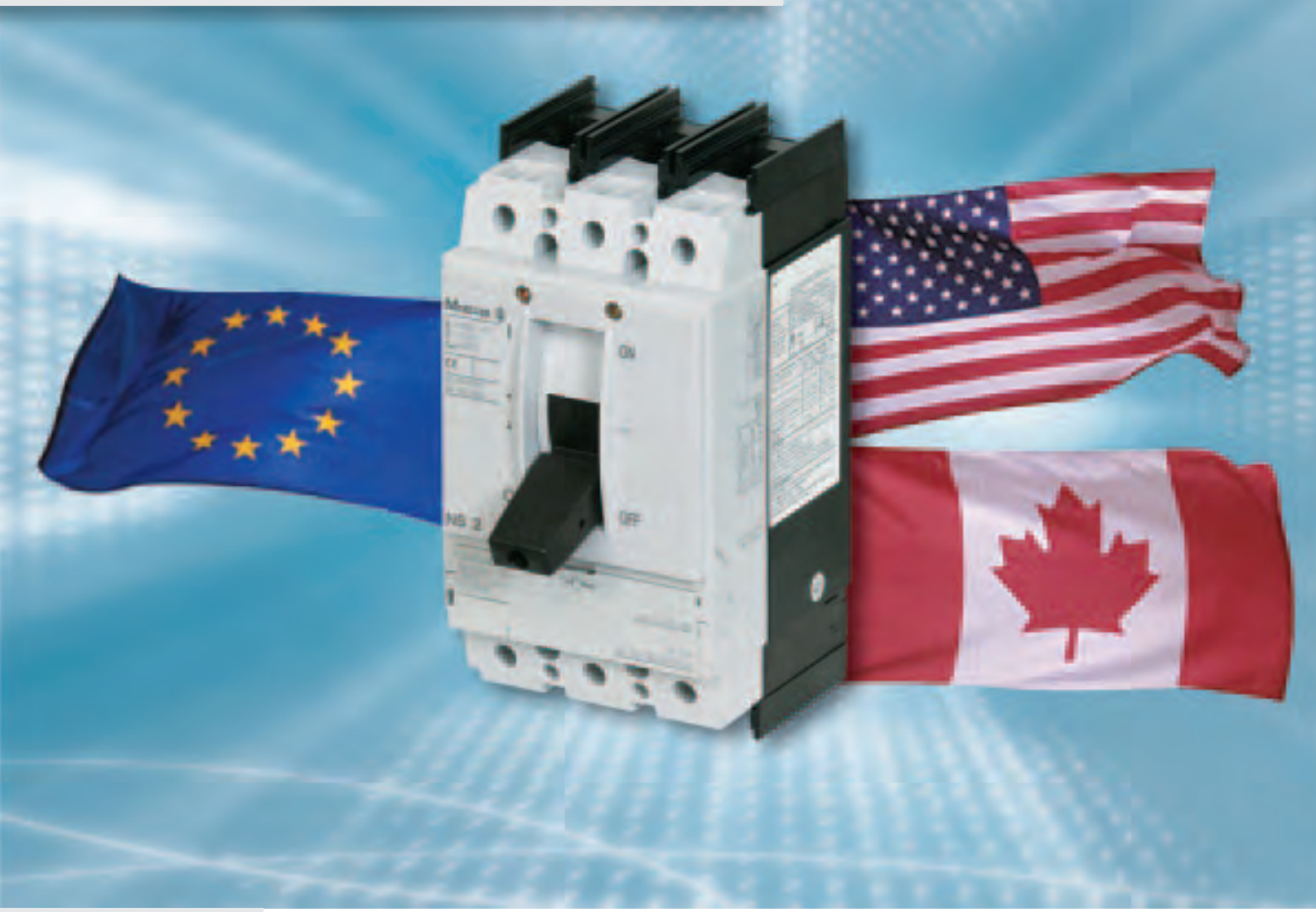
Safe Isolation of Main Circuits with Switch-Disconnectors *N* or with Molded Case Switches *NS*



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Circuit-breaker NZM

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Technical Paper

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- Achieving world market rated switches in spite of differing demands placed on switches in the IEC world and in North America. -

Standards and market conventions associated with low-voltage switchgear and controlgear are often quite different in the IEC world, versus those in which US and Canadian standards are prevalent. Whenever possible, Moeller bridges the varying demands with so-called "devices for world markets". These components are then able to conform to all standards in just a single version, with rating data appropriate to each market, and bearing the necessary approval marks for use world-wide at all pertinent voltage and frequency levels.

This is a very economic solution, not to mention that it's often the best way to meet the demands of exporting customers, who prefer to use globally common switchgear solutions whenever possible. Devices rated for world markets simplify the logistics, the engineering and the entire order handling procedure. Many manufacturers of mass-produced machinery are often unaware of a particular machine's final destination upon delivery. Manufacturers, therefore, are keen on using electrical control equipment, which is simultaneously suitable for the American market as well as globally. (There are, of course, additional factors to be considered when selecting equipment for applications in North America).

This article will point out that IEC switch-disconnectors do not always match up identically with the typical American disconnector, the molded case switch. A significant and distinctive feature of molded case switches in America consists of the integrated instantaneous-trip release, which is generally unknown within the IEC / EN-switch-disconnector standard.

Thus, in order for the IEC world to enjoy the same benefits as North Americans from devices with integrated instantaneous releases, the molded case switch *NS..-..-NA* was developed and classified – per the newly updated IEC / EN 60 947-2, *Annex L* – to be a *circuit-breaker without overload release CBI-X*, rather than a switch-disconnector per IEC / EN 60 947-3. Devices incorporating short-circuit releases continue to belong exclusively to the domain reserved for *circuit-breakers* in most of the world.

Switch-disconnectors supplying power to a machine or installation.

Switch-disconnectors in their open position fulfil all of the functional demands of an isolator. They are primarily used for the electrical isolation of electrical systems from all sources of power and are often called Main Disconnect switches, or rather, referred to synonymously as Supply Power Disconnecting Means, a term that has become the norm in the meantime. Under certain circumstances and with the appropriate identification and markings, these switches can also adopt the function of a main supply Emergency-Stop switch as defined under IEC / EN 60 204-1 [1]. Undervoltage releases for remote tripping, mentioned later in the article, are often combined with the Emergency-Stop function in this scenario. A further application, typical of switch-disconnectors, involves their use as maintenance and repair switches installed locally to the load, and as a means by maintenance personnel to isolate the electrical supply from the machine and thus protect personnel during potentially hazardous work (**Figure 1**).

Figure 1: Enclosed switch-disconnectors for individual operation, for use in the vicinity of a machine as a repair and/or maintenance switch, with Emergency-Stop function. The molded case switch NS is geometrically identical.

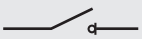
An incoming supply circuit disconnect is always fed with power from a switchboard located upstream. The supply conductors are protected against overloads and short-circuits by the feeder protective devices located in the switchboard for this purpose, which are normally either circuit breakers or fuses. Testing of switch-disconnectors for use in North America usually involves the use of specialized fuses. These are so-called "Umbrella Fuses", and feature a let-through characteristic positioned at the upper end of the permissible tolerance range for fuses. These fuses are only available for a limited range of rated currents and feature a significantly higher let-through energy than conventional fuses. These tests often make the North American approval process rather difficult for typical IEC design switch-disconnectors. The need to assign and verify adequately high short circuit ratings for the American market was the impetus to successfully consider a more favourable solution for these switches. The solution is the molded case switch, which generally features an integrated instantaneous release as a means to provide the device with a higher short circuit withstand capability. The need to procure special fuses to verify ratings no longer becomes an issue with the use of this feature.

The European and international switch-disconnector

Switch-disconnectors for the markets mentioned have for many years been designed, built and tested to the IEC / EN 60 947 part 3 [2] standard. According to this standard, *IEC switch-disconnectors cannot incorporate any current dependent tripping feature*. In addition to IEC / EN 60 947-3, there are also the requirements spelled out in the General Rules standard IEC / EN 60 947 part 1 [3] to be considered.

The IEC switch-disconnectors described here do not feature their own short-circuit **breaking** capacity. Therefore, they must always be protected against destruction due to short-circuit currents by the same type of protective devices mentioned in the previous paragraph. A typical value of an assigned short-time withstand current I_{cw} is at least 12 x I_u for 1 second. *Switch-disconnectors* differentiate from simpler *disconnectors* in that they feature a defined rated making and breaking capacity, which enables them, depending on the utilization category, to safely switch individual motors on and off up to their stated switching capacity. A stated rated **making** capacity I_{cm} further verifies their capability of being switched onto an existing short-circuit fault current of that magnitude. The main operational loading of the switch-disconnector usually consists of conducting continuous current up to the level of its rated uninterrupted current I_u.

Table 1: Relevant tests in accordance with IEC / EN 60 947-2 for circuit-breakers and IEC / EN 60 947-3 for switch-disconnectors, from which the presence of current dependent trip releases and especially short-circuit trip releases in devices can be determined. Moeller circuit-breakers NZM always ensure the capability of providing the isolating function.

Properties	Switches to IEC / EN standards			
	60 947-3			60 947-2
	Load break switch	Disconnector	**Switch disconnector**	**Circuit-breaker**
Symbol				
Heating	■	■	■	■
Dielectric properties	■	■	■	■
Leakage current	–	■	■	○
Rated making and breaking capacity (overload)	■	–	■	–
Overload response	–	–	–	○
Operating characteristics	■	■	■	■
Rated short-time withstand current	■	■	■	○
Rated conditional short-circuit current	■	■	■	–
Rated short-circuit making capacity	■	–	■	■
Rated short-circuit breaking capacity	–	–	–	■
Verification of the overload release	–	–	–	○
Tripping characteristic values and characteristic features	–	–	–	■
Endurance of the actuator	–	■	■	○

■ = test
○ = if appropriate
– = test not required

As mentioned, the IEC / EN 60 947-3 standard does not make any stipulations regarding trip releases, which are current dependent and activated due to the presence of overload or short-circuit currents. The standard, however, explicitly permits the use of voltage-dependent releases, such as the frequently encountered undervoltage and shunt trip releases, as accessory equipment.

Test specifications for current-dependent trip releases relating to the behaviour of switches under "abnormal operating states" (i.e. overload and short-circuit currents) corresponding with **Table 1**, are only referenced in the IEC / EN 60 947 part 2 standard [4] for higher performance circuit-breakers.
As components, circuit-breakers do offer more comprehensive value in this respect and usually feature adjustable settings for the protection against overload and / or short-circuit currents.

Annex L of the IEC / EN 60 947-2 makes it possible to derive a special circuit-breaker (CBI, type X), which features non-adjustable, instantaneous short-circuit protection trip releases for self-protection of the switch, but at the exclusion of an overload release. Annex L thus enables for the first time, the realisation of IEC based molded case switches, which are described in greater detail in the ensuing text. The annex designates the short-circuit release within this CBI device as an overcurrent release, as opposed to an overload release more closely associated with conventional circuit-breakers. This "hybrid" switch is more closely affiliated to the circuit-breaker group as indicated in **Table 2**, and does not formally carry the designation of a switch-disconnector.

Note: A similar design consists of the *Instantaneous Circuit Breaker*, which is frequently used in America and also does not feature an overload release, but rather an *adjustable, non-delayed* short-circuit current release.
The *Instantaneous Circuit Breaker* (circuit-breaker) is **always** combined with overload relays and contactors to form motor starters.

Switch-disconnectors in accordance with IEC / EN 60 947-3, with product reference numbers *N* and *PN* from Moeller, feature only IEC rating and performance data on their rating labels. They do not bear any North American approval marks and are thus not intended for use in North America.
The switch-disconnectors are mainly manually actuated, but may be equipped with an optional motor driven operator for remote control operation. They can be equipped with nearly all the same accessories as the NZM circuit-breaker line. The switches are rated for operational currents up to 1600 A and some models are available for rated operational voltages up to 1000 V.
The switch-disconnector *IN* is available for higher rated currents than covered by the *N* and *PN* series.

The North American version of the switch-disconnector

The application sphere of American molded case switches, listed and certified to UL 489 and CSA-C22.2 No. 5-02 [5] respectively, correspond with the IEC switch-disconnector already described. The main difference between these switch types results from the non-adjustable magnetic or electronic short-circuit release integrated into the American type, which is intended to provide self-protection for the switch up to its stated maximum short-circuit current. A particularly beneficial aspect of that approach is that it makes the selection of protective devices in the upstream panelboard or switchboard fully insignificant up to the marked short-circuit current of the molded case switch. Any type of fuses or circuit-breaker makes can thus be used in the feeder circuit to protect the switch in accordance with its markings.

Table 2: **Summary of possible switch features to IEC in the Moeller product range.**

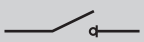
Features	Switches to IEC / EN standards			
	60 947-3 **Switch-disconnector**		60 947-2 **Circuit-breakers**	
	Tripping capable	Non-tripping capable	Standard	Special variation CBI version X
Symbol				
Moeller Type references	***N***	***PN***	***NZM***	***NS* new !**
Current dependent tripping				
Overload release	no	no	yes	no
Short-circuit release	no	no	yes	yes, fixed
Voltage dependent trips				
shunt release	optional	no	optional	optional
undervoltage release	optional	no	optional	optional
Tripped position on the actuator	yes	no	yes	yes

Table 3: Molded case switches NS listed to UL 489 are intended for use on the North American market. At the same time they conform to IEC / EN 60 947-2, Annex L as circuit-breaker variation type CBI-X. As a result they are devices for world markets. They are self-protective up to their marked short-circuit current ratings by the use of non-adjustable, integrated, non-delayed short-circuit releases. They do not feature a short-circuit breaking capacity, nor do they provide any other equipment protective function.

Type	Rated continuous current	Self-protection up to max. short-circuit current [kA]			Very high response range of the fixed short-circuit current release
	$I_n = I_u$ [A]	at 240 V	at 480 V	at 600 V	[A]
NS1-63-NA	63	85	35	-	1250
NS1-100-NA	100	85	35	-	1250
NS1-125-NA	125	85	35	-	1250
NS2-160-NA	160	150	100	50	2500
NS2-200-NA	200	150	100	50	2500
NS2-250-NA	250	150	100	50	2500
NS3-400-NA	400	150	100	50	6600
NS3-600-NA	600	150	100	50	6600
NS4-800-NA	800	85	65	42	25000
NS4-1000-NA	1000	85	65	42	25000
NS4-1200-NA	1200	85	65	42	25000

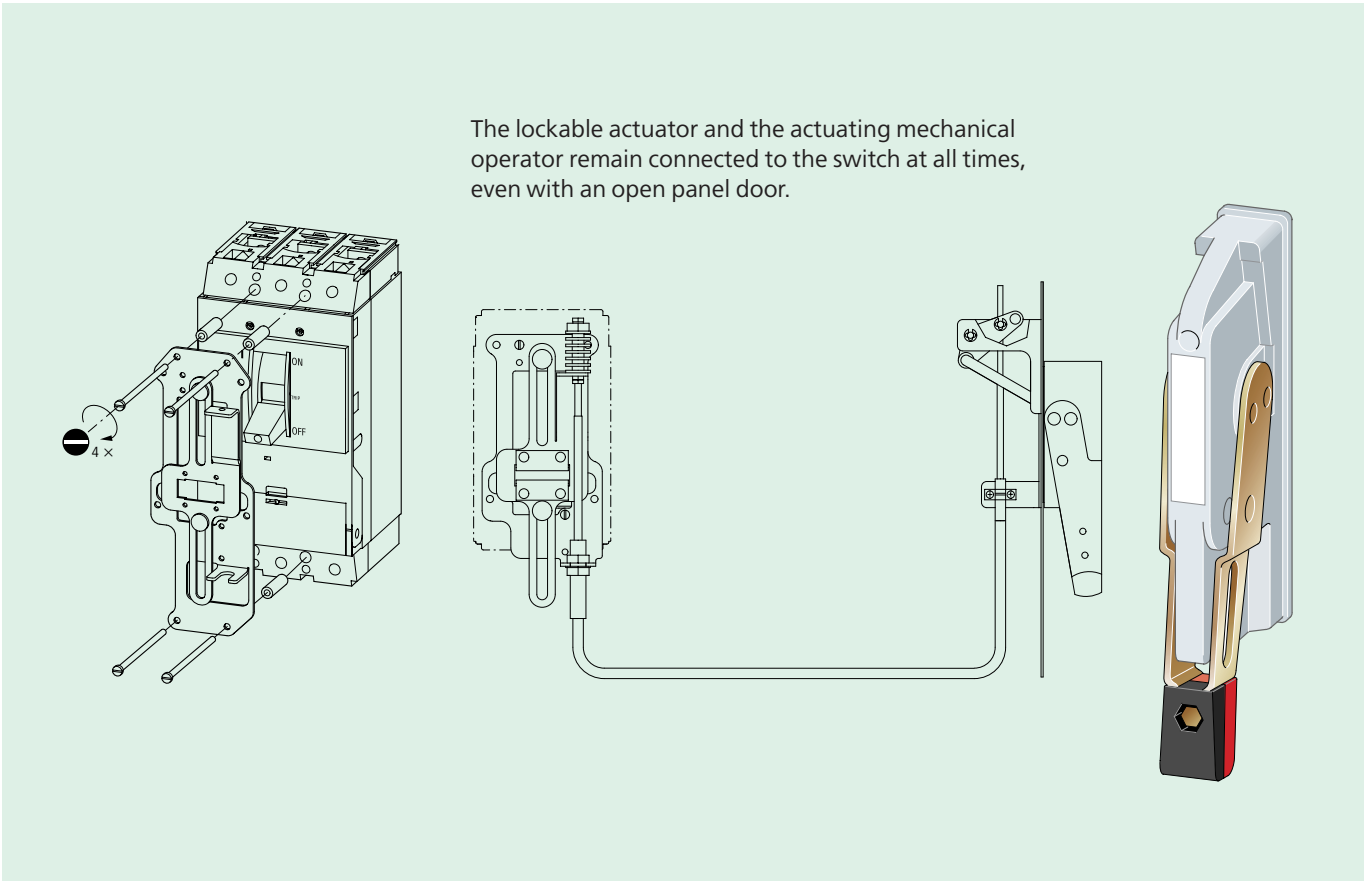


Figure 2: This is the "typical American" solution: the safety handle of choice for main disconnect switches preferred by a great majority of users in North America. This type of switch actuation is commonly encountered expected on machine controls built in accordance with NFPA 79. A vertical movement operator (pictured on the left side of the figure) is fitted to the circuit-breaker. The handle (right) mounts on the control panel enclosure flange located on the exterior of panel. In the example shown above, the lockable handle is connected to the mechanism via a flexible Bowden cable and remains in contact with the switch at all times, whether the panel door is open or closed.

This independence from the type of upstream protective device is particularly useful if the switch is used as a main supply disconnect for a machine.
A common problem with exports to the North American market results from the lack of certainty as to what type of fuse or circuit breaker will be located in the feeder circuit at the end-user's installation site. In the case of fuses, there are also many regional preferences and varied characteristics available, some of which may not be compatible with switch markings and could lead to potential acceptability issues. It is frequently impossible for the exporter to deal with these problems locally. The use of molded case switches greatly alleviates this type of selection anxiety on the part of the exporter. The exporter simply states the maximum permissible short-circuit current for the switch and the end-user determines its suitability with respect to local conditions and available fault levels.

The use of Molded Case Switches with high short circuit ratings, which Moeller introduced as shown in **Table 3**, provides systems designers much greater freedom in the selection of equipment, since no additional consideration of the upstream feeder circuit is necessary up to those ratings. The supply circuit, in practice, will always feature an upstream overcurrent protective device, because the feeder requires overload and short circuit protection, but the type of protective device need not be a concern for the exporter. It can be selected locally in accordance with applicable electrical Codes.

The exporter has several options available with respect to sizing the switch:

- If the machine end-user is able to provide reliable data on available fault levels at the installation site, the exporter can simply select a suitably rated switch per the information in **Table 3**.
- If the exporter is unable to reliably determine available fault levels at the installation site, or if the machine end-user location is not known in advance, or if the exporter simply wants to insure sufficient reserves to guard against a worst case scenario, the solution would be to select a higher rated switch right from the start. For example, instead of an *NS1* rated 35kA / 480VAC in this case, the better choice would be an *NS2* rated up to 100kA / 480VAC to cover all possible eventualities.

The local installer in America, who is connecting power to the machine, will insure that the nominal current rating of the upstream feeder overcurrent protective device, be it a fuse or a molded case circuit breaker, is selected in accordance with the feeder ampacity and molded case switch continuous current ratings. Additionally, feeder overcurrent protective circuit breakers or fuses are selected and sized locally to meet or exceed the available fault levels, for example 50kA / 480VAC.

Similar to the IEC switch-disconnectors, the molded case switches do not feature a short-circuit breaking capacity. They simply serve to safely isolate a circuit from its source of supply without providing any protective function. The switches have been UL listed and CSA certified. The electrical data on their nameplates reflect both North American and IEC rating values. The switches are world-market devices and suitable for use in both North American and IEC markets. They incorporate a TRIPPED position in addition to their ON and OFF positions. They can be additionally equipped with undervoltage and shunt trip releases, remote control drives, and trip-indicating bell alarm auxiliary contacts. They also feature main disconnect switch characteristics per IEC / EN 60 204-1. The switches also bear the CCC mark and are approved for use in China.

Summary:

The new type of *circuit-breaker CBI-X, without overload release* (IEC term), protect themselves against the destructive effects of short-circuits. They now also provide machine and electrical system designers in the IEC world with greater independence with respect to short-circuit ratings and co-ordination levels. Moeller was able to quickly offer devices suitable for world markets with its new range of *NS* circuit-breakers and/or molded case switches (**Table 3**). Exporting machine and electrical system designers are now able to fully utilize the particular advantages of molded case switches and at the same time cut down on their inventory by relying on a lesser number of switch variations.
In cases where the molded case switch is used as a main disconnect switch for electrical machines and installations compliant to NFPA 79 [6], the method to actuate it should preferably consist of the side handle typically used in North America (**Figure 2**). The side handle will be available from Moeller soon for switch frame sizes 2 and 3. Many enclosure manufacturers offer control panel enclosures which readily accommodate mounting of a side handle and which allow a means to mechanically interlock the handle to the door or cover, or even multiple doors extending across several control panel units. The use of components which are widely seen and accepted on the American market is particularly crucial in insuring successful export activities to America. It is important to note that the side handles are not devices for world markets as they are not in compliance with some of the more stringent demands placed on handles of main disconnect switches by IEC and EN standards.

Current Status of standards and development:

December 2005

Literature:

[1] *IEC / EN 60 204-1, DIN VDE 0113 Part 1* "Electrical equipment of machines, Part 1: General requirements" (IEC 204-1: 1997 + Corrigendum 1998, Draft 2002-09)

[2] *IEC / EN 60 947-3, DIN VDE 0660 Part 107* "Low-voltage switchgear and controlgear, Part 3: Switch-disconnectors, disconnectors, switch-disconnector and switch-fuse units" (2001-12)

[3] *IEC / EN 60 947-1, DIN VDE 0660 Part 100* "Low-voltage switchgear and controlgear, Part 1: General rules" (IEC 60947-1:2004; German edition EN 60947-1:2005-06)

[4] *IEC / EN 60 947-2, VDE 0660 Part 101* "Low-voltage switchgear and controlgear, Part 2: Circuit-breakers" (2001-11)

[5] *UL 489*, "Molded Case Circuit Breakers, Molded Case Switches and Circuit Breaker Enclosures"

[6] *NFPA 79*, Electrical Standard for Industrial Machinery, 2002 Edition

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