Product selection for North American exports made easy

Technical Paper
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Powering Business Worldwide

Content

Why are the issues related to the key export markets "USA and Canada" so strongly emphasized in a German industrial switchgear main catalog?

Extensive discussions with industrial machinery manufacturers and builders of engineered assemblies and control panels, of varying sizes and representing a broad range of technologies, have revealed that, without exception, this customer base expects the highest level of support and assistance from their supplier partners in export related matters. Why?

Support of export business activities to North America in this respect is crucial and successful, because:

- The components necessary to support machine manufacturers and panel builders in these activities contribute to significant volumes of indirect export business, which more than justifies an especially qualified presentation of the material.
- A deeper understanding of North American Codes and Standards is required, and these standards are much lesser known and markedly different than IEC/EN norms.
- The use of properly certified equipment is an absolute must for export projects.
- Certified equipment is often rated and combined differently than what is typically the norm per IEC and EN standards.
- Little known North American market and application conventions, not always spelled out in books, must nevertheless be taken into account for successful project design engineering.
- These customers want to build machines that enjoy universal acceptance, possess a highly qualified in-house staff to design them, and don't necessarily want to share specialized machinery Know-How with anyone on the outside.
- Panel building firms are not looking to purchase electrical equipment from a supplier who may also be a competitor in the panel building business.
- Qualified panel building firms want to expand their business and expertise in this challenging field.

Customers with confidence in their ability to tackle this market segment will come to the pleasant realization that most products found in the Eaton catalog are suitable for all major global markets. They will also discover a host of new and interesting offerings to further complement their activities in this area. But the catalog alone will not be the sole medium for customer contacts going forward. Catalogs will never totally replace the rapport which is established through personal contact and personal consultations with Eaton Electric personnel: Two important aspects which have always been a trademark of the Company.

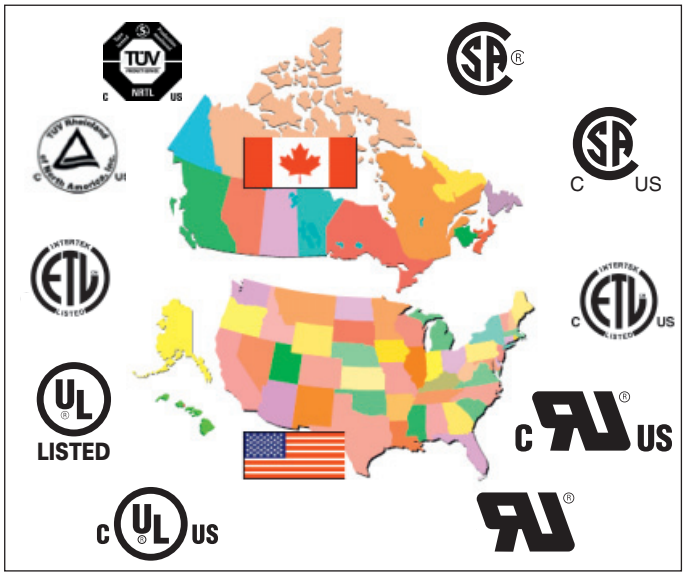


Figure 1: Target markets for exporters of machinery and electrical equipment for which the IEC and EN standards do not apply. Examples of certification marks used by various "Nationally Recognized Testing Laboratories" (NRTL).

The comprehensive changes undertaken in the new catalog are a direct result of extensive discussions with our exporting customers. Eaton made a point of seeking out feedback on requirements and wishes from those very sources who actively work with the product and generate the many inquiries we receive; from the engineering desk as well as the production facilities. Real people talking to real people. The expertise available in product support, combined with the input received through many training seminars specifically dealing with the export market, also weighed in heavily in our planning. The improvements in the catalog are a clear signal that Eaton was committed to making equipment selection matters as simple and straight-forward as possible for our customers. The catalog features Eaton products exclusively. In some cases, e.g. circuit breakers in higher frame sizes beyond Eaton's current range, international offices can rely on access to additional components from Eaton Corporation's vast offering of certified products.

This paper attempts to briefly expand upon the key features of components that are especially relevant for the export market[1]. A number of technical papers[2] [1] from Eaton dealing more comprehensively with major topics directly related to North American exports, as well as a dedicated chapter in the official Wiring Manual, are available free of charge. A glossary in the catalog now provides additional explanations on specialized terms and definitions that are commonly encountered in North American Codes and Standards publications. The term "North America" or the abbreviation "NA", referenced throughout the paper, addresses both the US and Canada.

Basis for product certifications and their legal implications

In the US, OSHA[3], an arm of the federal government, and the NEC/NFPA 70[4], require the approval of electrical equipment and assemblies. Tests and certifications to that end are carried out by "Nationally Recognized Testing Laboratories" (NRTLs). Amongst NRTLs, Underwriter's Laboratories (UL)[5] enjoys by far the greatest recognition and highest level of acceptance on the part of local authorities. As alternatives, product certifications conducted by recognized US subsidiaries of international laboratories such as the German (TUV)[6], as well as ETL-Intertek[7], could also be considered (Figure 1). Local approvals conducted solely on the basis of manufacturer supplied information are usually unsuccessful. The use of "Third Party Certification" is considered a necessity, and forms the basis of the North American safety system for electrical equipment and assemblies.

1 Validity date of referenced codes and standards as well as product related design and certification information: January 2010
2 Refer to: http://www.eaton.eu/DE/Europe/OurCompany/News/Publications/index.htm. The publications are available in both German and English languages, and can be downloaded free of charge.
3 Occupational Safety and Health Administration, http://www.osha.gov
4 National Electrical Code [3]
5 UL, http://www.ul.com
6 e. g. TUV Rheinland of North America, Inc., http://www.tuv.com/us, TUEV SUED America http://www.tuev-sued.de
7 http://www.intertek.com, http://www.intertek.de

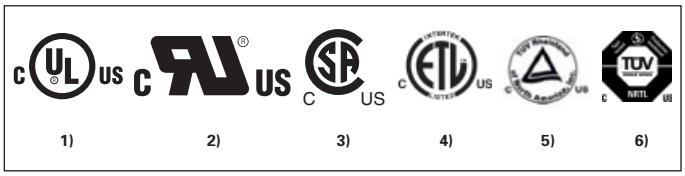


Figure 2: Certification marks of various NRTLs, which are applicable in both the US and Canada.
1) UL Listed, 2) UL Recognized, 3) CSA certified, 4) ETL Intertek certified, 5) TUV Rheinland of North America, certified, 6) TUEV SUED, USA.

Canada has its own set of electrical standards and a stipulation that all equipment conform to CEC/CSA-C22.1-09[8], which requires that components and assemblies be certified by CSA[9], or alternatively, by agencies that have been legitimately recognized for such purposes by Canadian governmental authorities.

Some years ago, as a consequence of the NAFTA agreement[10], a memorandum of understanding was issued between UL and CSA which facilitated a process by which clients could obtain product certifications from each respective agency that would have legitimacy in both countries. The equipment would then bear a certification label with appropriately distinctive markings (Figure 2). Eaton has, up to this point, made relatively little use of this dual marking option, simply because many local inspectors and end-users appear reluctant to accept them. The trend towards acceptance of this dual country mark may even be dwindling in the opinions of many machinery manufacturers, based on their recent experience. Eaton thus makes it a priority to eliminate for their customers any concerns related to product certifications and for this reason works directly with both agencies in each respective country. Eaton Corporation is also well represented at all levels of the standards making process in North America.

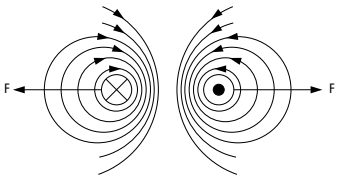
The electrical inspector at the installation site

A distinctive feature of the North American market is that all types of electrical installations, be it residential, commercial or industrial, with very few exceptions, are legally subject to approvals by local electrical inspectors (Authorities Having Jurisdiction- AHJ) before power is allowed to flow on the premises and at the time of commissioning. Electrical inspectors[11], also known as Approval Agency Representatives, or "Code Enforcement Officers", have legal empowerment to keep power off or shut down machines and/or assemblies which are deemed to be non-compliant with locally enforced regulations. In those cases, power can be restored only when improvements are made to satisfy the needs of the inspection authorities. It's also worth noting that corrections made locally aren't always possible without the intervention of hired contractor assistance i.e. personnel from outside the affected party or manufacturer.

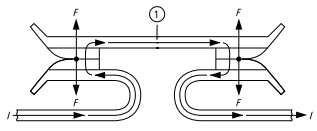
There are various ways in which the services of the electrical inspector are initiated. These come as a result of permits, local utility involvement, private insurance companies etc. The end-user can also require an inspection as a matter of routine whenever a need arises through changes, or arrival of major new electrical equipment. In North America, the local owner is responsible for safeguarding all aspects of the employee workplace, and to that end, the involvement of an electrical inspector forms a necessary and integral part of the process. The owner shows due diligence in this respect to the workforce by working closely with local inspection authorities to insure that the integrity of electrical assemblies throughout the plant, from which dangerous hazards can occur, has been suitably verified to meet acceptable safety standards and requirements. It's also advisable, in the case of large or complex projects, to touch base with the local inspection authorities ahead of time and during the initial design phases, in order to clarify any aspects or requirements that may not be so evident in the written text of local codes and standards. That way, a correct interpretation of local regulatory requirements can be made and provide the basis for successful commissioning at a later date. In certain cases, the local inspector may need to engage the consult or services of an NRTL to determine an outcome or reach a decision.

Inspectors are likely to verify, as a first step, that components used in the assemblies are in conformity with local codes and standards. However, component certification alone is not necessarily sufficient in this regard. Component certifications must be the correct ones for the application (type of assembly, type of load etc…), and the certified equipment must meet the requirements of the electrical codes (NEC and CEC) when it comes to sizing and the manner in which various components are combined together and applied in the final end product. Listed assemblies such as combination motor controllers usually offer better overall ratings as a certified unit than the individual component themselves. That's because their physical interaction, from a technical point of view, is better co-coordinated. Short-circuit currents are more easily dampened in component combinations because of the presence of additional power contacts in series. Each contact set only has to deal with a portion of the arc voltage generated during fault clearing. Eaton mostly incorporates very quick, current limiting type contacts in its components to optimize this process (Figure 3). In the case of modern circuit breakers these would consist of dynamic rotational contacts. A good portion of the line is additionally certified as "current-limiting"[12], which is an additional selection criteria highlighted in the main catalog. Achieving the best possible performance from individual components in this respect is ultimately

Circuit breakers with current limiting properties. How is current limitation achieved?



Current flow in adjacent opposing conductors will generate magnetic fields around each conductor that will repel each other. This dynamic and physical repulsion effect forms the basic of the circuit breaker's current limiting design.



The principle behind a current limiting contact system. The magnitude of the repulsive force can be approximated by the formula $F \sim I^2$.
① = Movable contact

Figure 3: Current flow in adjacent opposing conductors will generate magnetic fields which repel each other. At high fault current levels the associated force leads to a dynamic lift-off of the contact surface. (Direct opening of contacts without the assistance of a trip mechanism).

8 Canadian Electrical Code [4]
9 Canadian Standards Association, http://www.csa.ca
10 North American Free Trade Agreement
11 The paper often makes references to inspectors. The inspectors that are associated to the certification agencies such as UL are called "Certification Agency Representatives".
12 The current limitation effect reduces a short circuit current's available let-through current and energy values down to a fraction.

Figure 4: Example of a listed "Enclosed Industrial Control Panel" label.

key in being able to secure an optimal "Short Circuit Current Rating[13]" for the overall engineered assembly.

Many machine manufacturers and panel builders prefer to submit their products (i.e. machinery assemblies[14]) for certification in the country of origin, e.g. European countries, or even own production facilities which are certified manufacturing locations, and thus have the capability of labeling their own control panels and assemblies. A panel or assembly label issued through a recognized certification agency is extremely useful in securing an approval from AHJs or local approval authorities. A certification label (Figure 4) greatly alleviates the burden an AHJ has to bear in the approval process, but is not always a guarantee of acceptance locally. A further advantage to undergoing the certification process in the country of origin, as opposed to much later and farther away at the end-user's site, is that the need for any improvements or correctional remedies can generally be performed much more quickly and economically by the manufacturer locally.

Component certification approach at Eaton

US and Canadian Codes & Standards are in some ways markedly different from the IEC/EN norms[15] that govern most of the industrialized world beyond North American borders. Allowable temperature rises on components tend to be less, which generally can lead to lower rated currents overall. These differences can influence the way a manufacturer goes about the certification process from a global perspective. Eaton generally breaks down certification of its electrical equipment in two distinct groupings:

1) Ideally and predominantly, components will be identified as **"World Market"** devices, meaning that they share the following characteristics:

- World Market devices are in conformity[16] with all the relevant global product norms and standards, including those in North America.
- World Market devices can be applied universally, albeit under potentially different technical ratings.
- World Market devices have rating nameplates, which feature all the ratings required for worldwide installation, including those necessary for applications in North America.
- World Market devices also carry the CE mark to provide unimpeded access to all markets across the European Union.

Examples of World Market devices from Eaton include:

Signaling and Control devices, rotary cam switches, limit switches, industrial control relays and contactors, manual motor protectors, overload relays, measurement and protective relays, programmable controllers, electronic controllers and systems. The majority of these components are certified in North America under the Industrial Control standards UL 508 and CSA C22.2 No. 14-05 [5].

2) Component variants for North America, or for the rest of the world

These components were derived from IEC/EN equipment and, in order to meet North American product standard requirements, were subject to design modifications which are significant enough, both technically and economically, to set them apart from global product lines. Additional certification costs tied to production volumes also play a role, and these are ideally applied solely to products that are exported exclusively to North America.

Eaton identifies this equipment as "NA devices" (for "Listed Components")[17] or "CNA- devices" (for "Recognized Components")[18]. Both groupings feature the following distinctive characteristics:

- They are certified to UL and CSA standards and are thus suitable for installation within North America, as well as anywhere else in the world where customers or end-users have specified compliance with North American standards as criteria for product acceptance[19].
- North American variations have nameplates which include all relevant technical ratings for applications in the US and Canada. They nearly always include international IEC/EN rating data as well since they are also subject for export outside North America. North American variants, which are also marked with IEC/EN ratings, additionally bear a CE mark, as well as a CCC mark for markets in China[20].
- In many respects, they are identical to IEC/EN equipment from the same product groupings. They differ in certain constructional aspects and occasionally have lesser ratings, which are a direct result of the certification process to North American product standards. They can also be considered and applied as World Market devices throughout the world as long as the ensuing reduction in ratings does not present a conflict with respect to end-user requirements outside of North America. Indeed, many notable Eaton Electric customers have opted to standardize on North American versions for their usage world-wide, as a way to keep the need for varying products down to a minimum and thus better manage their own product inventories.

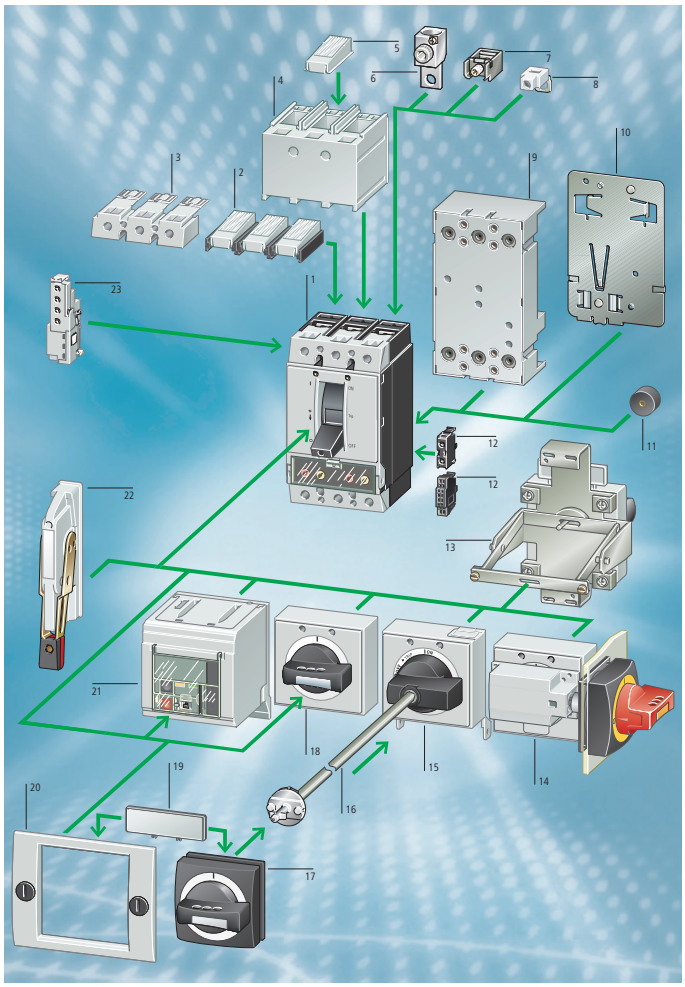
IEC/EN and NA variants have, with very few exceptions, identical dimensions and, wherever applicable, share the same product accessories such as auxiliary contacts, voltage trips and remote control drives. In North America, equipment related accessories are also subject to individual certification under the product standards. Accessories for Eaton equipment are, of course, fully certified. There are, in addition, accessories that have been specially developed to fulfill particular North American requirements and market conventions. Those would include many of the operating handles found on main disconnect switches in power circuits, and especially those which are

13 SCCR, short circuit current rating of an industrial control panel, per Supplement SB of UL 508A.
14 Machinery assemblies refers to a group of machines which have a functional interdependence.
15 International Electrotechnical Commission, http://www.iec.ch, EN = European Norms
16 Refer to the certification overview section of the main catalog.
17 Full certification. The designation "RT" for FAZ…-RT is an exception, and has the same significance as "NA".
18 Conditional certification.
19 e.g. in off shore applications, or when there is a need to have uniformly designed panels and assemblies globally acceptable.
20 For additional certification and classification information, refer to the certification overview section in the main catalog.

intended to be part of the supply circuit disconnecting means used for industrial machinery control applications[21]. (**Figure 5**).

The type of certification that applies to these North American variants is clearly indicated by the part number assigned to the component in question. **Table 1** shows the part number suffixes used by Eaton to identify product certification, and the type of certification marks that would correspondingly appear on the component's rating plate.

21 Supply Circuit Disconnecting Means (Isolating).



1 Circuit Breaker or Molded Case Switch
2 IP2X Finger protection
3 Terminal cover, with knock-out segments
4 Cover
5 IP2X Finger protection for cover
6 Barrel type termination lugs
7 Box type termination lugs
8 Control circuit terminations
9 Component busbar adapters
10 Clip plate
11 Spacer
12 Single or double auxiliary contacts
13 Rear operation mechanism
14 Sidewall drive mechanism
15 Supplementary handle for NA
16 Extension shaft with door handle coupler
17 Door mounted rotary handle
18 Switch mounted rotary handle
19 Identification label
20 Cutout frame
21 Remote control drive
22 Vertical motion handle for NA
23 Undervoltage and shunt trips

Figure 5: Representative overview of the *NZM1* through *NZM4* family of molded case circuit breakers. The series also includes a line of *NS1* through *NS4* molded case switches derived from each respective circuit breaker frame size. The graphic highlights key components of the modular design, which help make it especially compatible with all major global markets. The North American version is adapted to meet the specialized requirements and conventions typical of that market. All product accessories pictured are also fully certified per North American standards.

Type suffix	Type of certification	Certification marks
-NA	The device is UL listed and CSA certified	
-CNA	The device is component recognized by UL and its proper application is subject to additional Conditions of Acceptability. (COAs). The device is CSA certified **and its proper application may also be subject to similar constraints from Canadian based Codes and Standards.**	

Table 1: Certification marks associated to North American ….*-NA* and ….*-CNA* part number suffixes.

Listed Devices	***Recognized Component Devices***
Listed components have no restrictions when properly applied per their certification	Recognized components may be incomplete in contruction or restricted in performance capabilities. Their proper application is subject to additional conditions of acceptability.
• Equipment is suitable for ***„Field Wiring"*** • Suitability for *„Field Wiring" also covers „Factory Wiring"*	• Components are suitable for ***„Factory Wiring"*** only • Recognized equipment in some cases needs to be combined with additional components in order to complete an end product or a listed assembly. • Recognized equipment is subject to *„Conditions of Acceptability (CoA)"* for proper application in the field. The manufacturer should be consulted in all cases. Additional information can be obtained through UL's *„Category Control Numbers"* and in Supplement SA of UL 508A.
Suitable for field wiring in factory plants and for installation in industrial control panels by panel shops.	Component installation is performed in appropriate factories and panel shops and subject to design, wiring and testing by qualified and technically trained personnel.
Certification Marks:	Certification Marks:

Table 2: Notable differences between „Listed Equipment" and „Recognized Components" in Industrial Control Equipment e.g. per UL 508 and UL 1077.

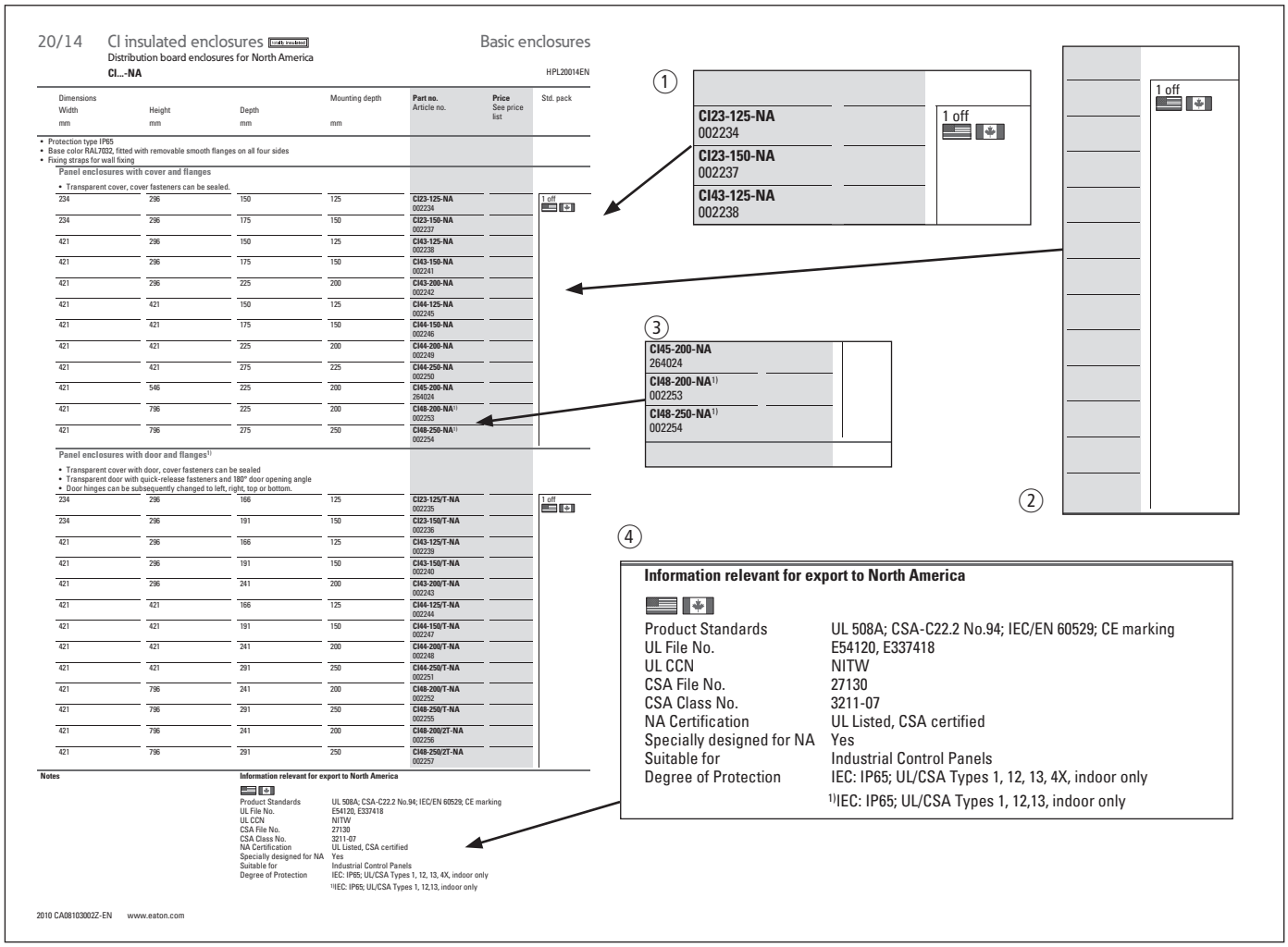


Figure 6: Example of how certified equipment for the North American market is presented in the new main catalog 2010 (currently in the German language edition only).

Examples of Eaton products of the Moeller® series for which special North American versions were created include:

NZM Molded case circuit breakers, *NS-…-NA* molded case switches and variations of the *FAZ* miniature circuit breaker line (refer to additional information on *FAZ, FAZ-NA and FAZ-RT*).

Table 1 differentiates between "Listed Equipment" and "Recognized Equipment" for products that are certified per US standards. The product standards will often dictate how product certification will be determined. **Table 2** shows the differences between both types of certification with respect to product design and application. Recognized components are often subject to miss-application on the part of users because of failure to take into account all of the Conditions of Acceptability (CoA[22]) that are assigned to a component as a result of the certification process. Local inspectors are aware of this situation, and are thus more likely to pay closer attention to the manner in which recognized components in an assembly have been applied. Miss-application of equipment will often lead to delays in start-up or commissioning, as it invariably involves some form of corrective action to take place before the equipment is deemed to be in compliance. Diligent preparation, especially during the project's initial design phase, is always good practice. Significant complications can occur locally, particularly if available panel space is not sufficiently large to accommodate required upgrades[23]. In Canada, a differentiation similar to UL's component listing and recognition is not part of the certification approach but in certain cases, particularly for critical components that are often miss-applied, and which are recognized only per UL standards, CSA has begun to implement a component acceptance service denoted by the appearance of a small, solidly filled triangle indicator next to the CSA monogram as a way to better draw the attention of local inspection authorities during the approval process to the component's special recognition under CSA standards.

Technical Data and certification status for North America

The Main Catalog contains complete technical data and electrical ratings for certified equipment, and serves as a useful resource in the design of engineered products for the North American market, such as control panels and assemblies for industrial machinery[24].
Panelboards and switchboards used primarily for energy distribution are seldom exported, and would require additional certification[25] to be deemed in compliance with North American electrical codes. Workshops that are certified to build industrial control panels would also require additional certification in order to build and label energy distribution equipment suitable

22 CoA = Conditions of Acceptability.

23 e.g. Installation of missing protective devices, replacement of supplementary protectors with circuit breakers, need to separate certain circuits etc…

24 e.g. Industrial control panels for industrial machinery per UL 508A and NFPA 79.

25 e.g. Testing in specifically designed housings for those applications.

Category Control Numbers (CCN) from UL and UL file numbers of important Eaton products (not a complete list) **AHJs search information on product certification preferably through UL based information such as CCNs and UL file numbers**									
Device Type	**Part Reference Number**	**Product Certification Standard**	**Classification**	**Paragraph Reference, Table SA1.1 UL508A**	***Category Control Numbers (CCN) UL*** **Listed**	**Recognized**	**Refer to reports for additional details** (CCNs applicable to UL only) **USA: *UL-Report E-File No.***	**Canada: *CSA Master Contract 165628* *Certificate No.***	***Class No.***
Bus Bars	***SASY 60i***	UL508	*Recognized Bus Bars*	29.2.2	-	**NMTR2**	E307559, E300273		2362 17, 2321 40
Flexible Bus Bars							E248096		
Inverse Time Circuit Breaker	***NZM..-..-NA***	UL489	*Listed Molded Case Circuit Breaker*	30.1.1 31.1.1	**DIVQ**	-	E31593	1467684, 1501796, 1524747, 1535062,	1432 01
	FAZ..-NA						E235139		2044 53
	FAZ-NA-DC	UL489A	*Only use in Communications Equipment*	-	**DITT**	-	E316023		- No comparable standard
Instantaneous-Trip Circuit Breaker	***NZM..-S..-CNA***	UL489	*Recognized Instantaneous-Trip Circuit Breaker*	30.1.1 31.1.1	-	**DKPU2**	E31593	1467684, 1535074, 1706746,	1432 01
Molded Case Switch	***NS..-NA***	UL489	*Listed Molded Case Switch*	30.1.2	**WJAZ**	-	E148671	1342868,1586570, 1639426,1639431, 1709587	4652 06 / 6452 06
	P3-…MCS							12528-110	1342868
Auxiliary contacts for circuit breakers and molded case switches from the RMQ line of control circuit devices	***M22-K10(01) NZM-XHI..L***	UL508	*Listed Auxiliary Devices*		**NKCR**	-	E29184	1279974,	3211 03
Manual Motor Controller	***P1, P3**) T0, T3, T5**)***	UL508	*Listed Manual Motor Controller* **) P / T switches additionally evaluated as Motor Disconnects* ***) suitable for Group Installation*	30.1.5 31.4.1© 31.4.3 33.1.1 34.1.1	**NLRV**	-	E36332	1034563, 1183233, 1183565, 1183568, 1279969	3211 05 / 3211 06 / 3211 08
	PKZM0 PKZM4**)							1017572, 1017555, 1161578, 1183570, 1183573, 1187878, 1338165, 1727267, 1759086	
UL 508 Type E Manual Self-Protected Combination Motor Controller	***PKZM0+BK PKZM4+BK BK25, BK50***	UL508	*Listed Self-Protected Combination Motor Controller*	30.1.6 31.1.4 33.1.1 34.1.1	**NKJH**	-	E123500	1183570	
UL 508 Type E Self-Protected Combination Motor Controller	***MSC-DE-...M...-SP***							2508766	3211 08
UL 508 Type F Self-Protected Combination Motor Controller	***PKZM.. +BK.. +DILM MSC***	UL508	*Listed Self-Protected Combination Motor Controller*	30.1.6 31.1.4 33.1.1 34.1.1	**NKJH**	-	E123500		3211 04 / 3211 06 / 3211 08
NZM Handles, Accessories	***NZM..-X…***	UL489	*Listed Circuit Breaker Accessories, Disconnect Handles*	30.1.7	**DIHS**	-	E140305	1467680, 1501807	1437 01
Contactors	***DILEM DIL..M DILM… DILMC… DILMF… DILK RA-MO***	UL508	*Listed Magnetic Motor Controller*	33.1.1 33.1.3 45.1.1(a)	**NLDX**	-	E29096	1017504, 1017510, 1017580, 1088090, 1115237, 1562824, 1563064, 1585868, 1607103, 1624966, 1639421, 1740217, 1759091, 1806980, 1832670	3211 04
Soft Start Devices	***DM4***	UL508	*Listed Solid-state Motor Controller*	33.1.1 42.3.1 90.4.2	**NMFT**	-	E208760		cUL, same UL-File
	DS7						E251034		cUL, same UL-File
Adjustable speed drives Vector Frequency Inverters	***DA1/DC1***	UL508C	*Listed Power Conversation Equipment*	33.1.2 90.4.2	**NMMS**	-	E172143		cUL, same UL-File
Supplementary Protectors	***FAZ FAZ-T***	UL1077	*Recognized Supplementary Protector*	40.1.3	-	**QVNU2**	E177451		204453 (not FAZ-T)
Overload Relays	***ZB.., Z5, ZEV, ZE***	UL508	*Listed Overload Relay*	26.2.4(c) 34.1.1 45.1.1(a) 46.1.1(a)	**NKCR**	-	E29184	1064969,1234992, 1234992,1328702, 1389320,1389324, 1402710,	3211 03
Thermistor machine Protection Relays	***EMT6***	UL508	*Motor Protection Tripping Units*					LR 12528-361	
Control Circuit Devices Light Towers	***RMQ-Titan Q16, Q18 FAK LS, SL***	UL508	*Listed Auxiliary Devices*					1013342, 1098159, 1098164, 1121561, 1128392, 1279979, 1446446, 1770948, 1789786, 1894943,	
Control Relays	***DILA DILER …DIL(M) … DILE(M)***	UL508						1088090, 1279974, 1576618, 1618537, 1792497	
Electronic Timers	***ETR4 DIL ET***	UL508						1882986, LR12528-407	
Programmable Relays	***Easy, Smart-Wire***	UL508	*Programmable Controller*	42.3.1 45.1.1(a)	**NRAQ**		E135462	1017514, 1389312, 1576604, 1827346, 1832948	2252 01
HMI Multi-function display	***MFD***							1504203	2258 02

Table 3: The availability of „Category Control Numbers" (UL) und „Classes" (CSA)" simplify component searches in certification data banks. Certification agency charts exist which provide cross-referencing information between both classifications. (Lists showing product types and their corresponding Category Control Number and Class designations.)

Category Control Number differentiation	
CCN without suffix number	UL-Listed
CCN with suffix number 2	UL-Recognized
CCN with suffix number 7	cUL-Listed, certification is valid in Canada
CCN with suffix number 8	cUL-Recognized, certification is valid in Canada

Table 4: „Category Control Numbers" help determine at first glance if components are Listed or Recognized and where the certification is applicable regionally.

for the North American market. Anyone involved in designing, building and testing electrical assemblies for the North American market must have, at the very least, a complete set of all relevant North American product standards associated to the equipment.

As a first, the 2010 edition of the German Main Catalog will supplement each equipment selection page with small US and Canadian flag markers to more clearly highlight the components that have been certified to North American standards. A single flag, positioned on the upper portion of the page, will appear as a marker in cases where a page or double sided page only features certified equipment (**Figure 6**). Should the page or double page also include non-certified products, the certified components will be grouped together or per clear type designation, and be appropriately identified with a small flag under the column marked "Packaging unit or VPE". This particular column was selected because it provides a clear delineation per each type designation and avoids the need for an extra column. Up to 13 product certification characteristics were used to identify each type designation and the results were compiled in a product data base. The data is also available in on-line catalogs and data sheets, which can be individually stored and printed out by customers in .pdf format.

Unfortunately, an elaborate identification process such as this one, featuring country flags in catalogs and certification marks on the product themselves, is not always sufficient to fully satisfy an inspector's wish for regulatory compliance information on equipment. Doubts can remain as to the suitability of the equipment for the application in question. In such cases, access to UL/CSA product file numbers, or even the certification records themselves, can prove vital. In order to satisfy this need, an additional column was added in the catalog which includes all applicable UL and CSA file numbers for products shown. The column is appropriately entitled "Information relevant for export to North America" and is located either at the right side or bottom of each catalog page in which certified equipment appears. The column also includes product "Category Control Numbers (UL)[26] and Classes (CSA)[27] (**Tables 3 and 4**) to further enhance the information given.

Customers can access information found in certification reports for the majority of our products directly from the certification data link at the Eaton web site[28], for example by entering part number designations such as "*DILM…*" as well as the certification agency in question. Unfortunately, the information from certification reports is not always presented clearly and can sometimes be difficult to interpret. The accuracy of product type designations appearing in the reports is not always uniformly maintained. However, inspectors from certification agencies have the ability to access complete reports through their own agency data bases for clarification purposes.

We urge you to contact your local Eaton Electric representative in case of problems or queries, some of which are often rooted in simple misunderstandings. Questions will remain that are best addressed directly with the equipment manufacturer in spite of the additional codes and standards information provided in our catalog and the generally much clearer presentation of the equipment in this regard. We are constantly working at improving and enhancing certification matters related to our products. The certification status of our equipment is also bound to change throughout the validity date of this particular catalog. Changes and updates will be provided on a timely basis both at our website and in our on-line catalogs[29]. The certification agencies themselves are also routinely updating their own data base of information. The on-line catalog can thus be a useful resource to access current certification status on products, and the information can easily be stored and printed out as data sheets in .pdf format.

Additional access to information in product certification reports can be accessed directly through the certification agency's internet site:

- UL's on-line product certification database can be accessed through the following internet address: http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/index.html
- For CSA, the address is: http://directories.csa-international.org/

Please note that the CSA certification report numbers available at the CSA site don't always match the actual report numbers issued to Eaton by CSA. It's advisable, therefore, when using the CSA site, to just enter the appropriate product Class number (available in our catalog info). The actual CSA file number can also be used to provide access. Generally speaking, the information available at a certification agency site will only confirm that a product associated to a particular part number designation by a manufacturer has been certified, and does not provide any additional data, such as electrical ratings.

North American related technical data for world market rated devices will also be included at the end of each catalog section, where the IEC/EN technical data is also located. Even though contactors and motor starters are also considered world market devices from a certification standpoint, a number of additional data pages for these products are provided in order to facilitate selection per North American data, such as HP ratings and typical North American voltage levels. Motors rated solely in kW often end up as part of exported equipment. In these cases, local inspectors are likely to convert kW motor data into HP ratings[30] using appropriate formulas, and then assign current ratings based on the next larger size HP rated motors per the code tables. This can often lead to the need for larger conductor cross-sections at the installation site. Project designers should, therefore, take this likelihood into consideration at the design stages whenever incorporating kW only rated motors into their equipment. In addition, correction factors related to sizing of conductors and

26 UL Classification system used in the US, referenced in the UL White Book and UL 508A.
27 CSA Classification system used in Canada.
28 https://wss.Moeller.net/approbationen.
29 de.ecat.Moeller.net
30 HP = Horsepower

equipment, which are normally not known in the IEC world, could also apply and be enforced locally per North American electrical code requirements.

Comprehensive selection information applicable to North American versions of *NZM* molded case circuit breakers and *NS…-NA* molded case switches has also been included in the new catalog under the heading "Circuit breakers per UL/CSA, IEC". The section features inverse time circuit breakers with fixed overload response trips *(NZM…-AF…-NA)* which are often combined with contactors and separately mounted overload relays in North America for the control of relatively large motors (3 component motor starter combinations). Molded case circuit breakers with fixed overload trips in that size are rarely encountered in IEC/EN countries. Breakers in the size 2 frame *(NZM..2..-NA)* also cover the current ranges of the smaller size 1 frame *(NZM..1..-NA)*, but have higher interrupting ratings, which can be useful if circuit breakers with greater short circuit ratings are required for the lower current ranges. There are more circuit breaker variants, as an overall total, to cover the North American market than comparative IEC/EN versions. The catalog pages for North American models contain all the necessary ratings to facilitate proper selection. Additional data can be found at the end of the section under the heading "Technical Data". The selection process for circuit breakers tends to be generally more complex than for other components. For this reason, additional breaker data was provided under the column entitled "Information relevant for export to North America". Examples of that would include an indication as to whether a particular type of breaker is suitable for installation in both feeder and branch circuits per the electrical codes. Also, information as to whether the circuit breakers have additionally been listed and certified as "current limiting". The content will also provide references to other pages which contain breaker characteristic trip curves as well as let-through values at relevant North American distribution voltage levels. The page may also specify key "Conditions of Acceptability (CoA)" which apply in the case of recognized components, which is denoted by the suffix "-CNA" in their type designation. An Instantaneous-Trip circuit breaker is an example of a recognized only device since it must always be combined with a contactor and overload relay as part of a listed combination motor controller. A short circuit rating (SCCR)[31] in this case applies only to the complete motor starter assembly. The motor starter tabulation pages in the catalog facilitate the selection process for these components.

Voltage and distribution networks in North America

It's important to determine for application purposes whether individual products, such as manual motor controllers, combination motor starters and circuit breakers, carry "full voltage ratings"[32] (e.g. 480 V, 600 V) or may be "slash rated"[33] only (e.g. 480Y/277 V, 600Y/347 V)[34]. Devices with slash ratings are suitable for solidly grounded, wye type power distribution systems only (**Figure 7**). These networks can appear both as grounded (with neutral) or as ungrounded systems in installations, so it's important to make the distinction. A solidly grounded wye power distribution system is not a rarity. It is actually quite common, and one of the most frequently encountered power distribution systems in a majority of European countries. The majority of modern installations in both the US and Canada also feature this kind of power distribution system. The 277 V and 347 V ratings are not typical single phase voltage ratings encountered in residential applications, but are quite often used in commercial and industrial settings to supply lighting loads in plants and buildings. The problem for exporting machine manufacturers is that they are often unaware of local power distribution systems in areas where their equipment will be used and installed. The use of suitable power transformers, as it is often done in Canada and as described later in this paper, can be of assistance in this respect. The alternative is to conservatively plan on the basis of full voltage ratings, in order to cover all possible scenarios. A machinery control design and tender should always clearly specify the type of power distribution network for which the equipment is suitable. That way, another price can be calculated on the basis of additional ratings, which may better address the needs of both manufacturer and end-user.

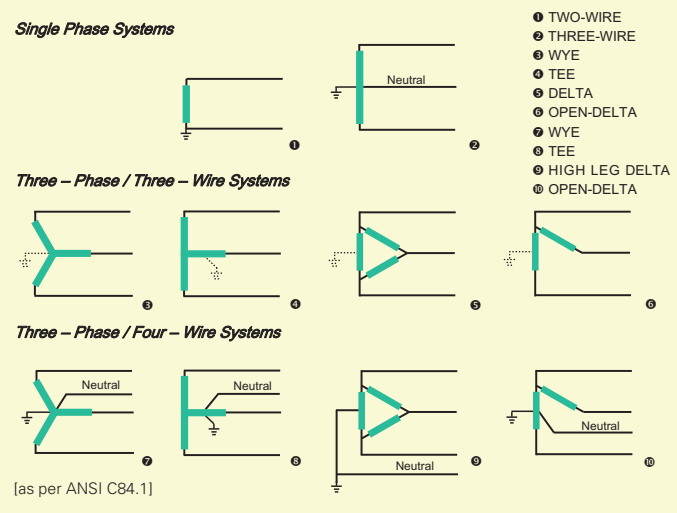


Figure 7: Many modern and smaller IEC/EN protective devices are marked for use in „Slash-Rated" power distribution systems, e.g. 480Y/277VAC. These refer to solidly grounded, 3 phase 4 wire systems as shown in the ANSI diagram.

In North America, predominant load switching requirements in power distribution networks involve 3 poles only. Full voltage rated devices are suitable for all wye and delta type networks, both grounded and ungrounded. Protective devices can also have combined slash and full ratings on their nameplates, such as 480V, and 600Y/347 V. The lower voltage rating in that case is considered the full rating, and the higher one would be the slash rating. The actual voltage rating in the application ultimately determines the type of power distribution network the equipment is suitable for (In the afore-mentioned example, 600 V refers to a solidly grounded 600 V network, i.e. 600Y/347 V). It's important to note that a control panel into which a slash rated protective device is installed must also reflect the same slash voltage rating on its nameplate. (marked as: …Y/… V). All power circuit and protective devices installed in DC circuits must be tested, certified and marked to indicate suitability for DC.

Certain components are unable to meet the full voltage 600 V requirements often encountered in Canadian based applications. That can also be the case even if the equipment is suitable for 690 V networks per IEC/EN standards. The explanation

31 Short Circuit Current Rating (SCCR) = The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria. (NEC, NFPA 70 definition).
32 Phase to phase, or line to line voltage.
33 Phase to neutral voltage. The term "slash rating" comes from the slash used in the voltage representation on nameplate ratings.
34 A 600Y/347 V rating does not cover a full 480 V rating. A full 480 V rating would have to be tested by the manufacturer.

Energy Distribution Equipment Large electrical clearances	used in … Circuits	Suitable as Branch Circuit Protective Device (BCPD)	Suitable as a Supply Circuit Disconnecting Means for Industrial Machinery Controls*
• Circuit Breakers (UL 489, CSA-C22.2 No. 5-09)	Feeder, Branch	x	x
• Molded Case Switches (UL 489, CSA-C22.2 No. 5-09)	Feeder, Branch	-	x
• Disconnect Switches (UL98, CSA-C22.2 No. 4-04)	Feeder, Branch	-	x
• Fuses (UL 248, CSA-C22.2 No.248)	Feeder, Branch	x	
• Fusible Disconnects (UL98, CSA-C22.2 No. 4-04)	Feeder, Branch	x	x
Industrial Control Equipment **Smaller electrical clearances**			
• Contactors, Controllers	Branch	-	-
• Control Relays	Control	-	-
• Manual motor Controllers	Branch	Only as a UL 508 Type E device, or as part of a UL 508 Type F Combination Starter for individual motor branch circuits	-
• Rotary Cam Switches	Branch, Control	-	-
• Signalling and Control Circuit devices	Control	-	-
• Solid State relays	Control	-	-
• Programmable Controllers (per UL 508/UL 60947-4-1 und CSA-C22.2 No.14)	Control	-	

* per UL 508A Part 2, NFPA 79

Table 5: Notable differences between „Distribution Equipment" und „Industrial Control Equipment" in North America. Distribution Equipment construction features larger electrical clearances than Industrial Control Equipment. „UL" and „CSA..." are the predominant product safety standard agencies in the US and Canada respectively. „Distribution Equipment" is subject to the more stringent certification requirements. The concept of Feeder and Branch Circuits will be expanded upon in upcoming sections. Branch Circuit Protective Devices, as will be shown later, denote the line between feeder and branch circuits and provide protection for outgoing circuits connected to loads. These devices also incorporate the larger electrical clearances in their design.

lies in the differing test requirements found in North American product standards. Customers will often bypass the need for fully rated 600 V equipment by installing power distribution transformers rated 600/480 V or 600/400 V as step-down interfaces. The use of power transformers with isolated secondary windings can be useful since it allows the formation of a solidly grounded power circuit on the secondary which can then accommodate the use of slash rated devices in the machinery and electrical portion of the control assembly. But there is a point at which the use of such transformers becomes prohibitive price wise, depending on the size and power requirement of the machinery. For very large and complex machinery, it is recommended to engage the end-user and local utility in discussions that would hopefully lead to a more appropriately suited power distribution network at the installation site.

The majority of product standards in North America are written around a maximum voltage rating of 600 V. However, there has been a recent acknowledgment that this maximum may not be sufficient to accommodate the higher power demands of emerging new technologies such as the photo-voltaic and wind energy industries. New standards, as well as changes to existing product standards, are currently being formulated and considered to address this need, and these will most likely allow for higher rated voltages to become established. Product standards such as UL 489 (molded case circuit breakers and enclosures) are affected by these changes.

Misunderstandings and irritation on the part of exporters occur when they are confronted with seemingly conflicting North American voltage levels in product descriptions and specifications. Examples of those would be 115 V vs. 120 V, 230 V vs. 240 V, 460 V vs. 480 V, 575 V vs. 600 V etc.. . Per local conventions the higher values refer in this case to nominal voltage ratings at the point of service or energy distribution level[35], whereas the lower values, taken at the point of load connection[36] are referenced as utilization voltages[37]. A further distinctive feature in North America: Motors that are rated and marked based on a utilization voltage level of 460 V are connected to a service voltage level rated at 480 V. The situation is analogous at the other standardized voltage levels. Both values appear in the motor starter selection tables provided by Eaton for their Moeller® series products to eliminate confusion even though motors fully rated and marked 480 V are not typical.

Product certification invariably presents end-users and customers alike with a great deal of information and technical data for them to assimilate. The most important information will always appear on component rating labels and be included in main catalogs. Additional information related to certification can also be part of manufacturer supplied documentation such as mounting installation sheets (AWA) and instructional leaflets (IL)[38]. The location of certification information for equipment is normally dictated by the product standards, and is also verified in manufacturer certification reports. Certain circuit breaker parts referenced in manufacturer supplied documentation, such as insulating plates and covers, may be necessary to maintain proper electrical clearances in supply circuits, and would need to remain mounted at all times. It is, therefore, vital for end-users to consider manufacturer supplied documentation as an integral part of the electrical equipment being purchased, and this information should always be readily available at the installation or end-user site for reference purposes.

35 Service Voltage
36 Point of Connection, Point of Common Coupling
37 Utilization Voltage
38 AWA = Installation and mounting instructions; IL = Instructional leaflet

Codes and standards in North America

North American norms differentiate between component based product standards and installation standards, much like the situation in the European and IEC/EN based world. Product standards (e.g. UL 489 [6], UL 508 [7], UL 508C [8], UL 1077 [9]) are geared more towards component manufacturers whereas installation standards (e.g. UL 508A [10], NFPA 79 [11]) address requirements faced by installers, users and builders of electrical assemblies and control equipment. The situation in Canada with respect to installation standards is not as clearly defined. The requirements exist, but they tend to be grouped somewhat ambiguously in both the CEC and the CSA product standards. It is recommended therefore, generally speaking, to rely on US installation standards for North American design and engineering purposes, which are more clearly delineated and outline similar sets of requirements, even though manufacturers and producers would do best by familiarizing themselves more thoroughly with the standards that are applicable to each distinct market. In addition to nationally adopted electrical codes and standards in the US and Canada, there are local ordinances at the state, province, county or city level which producers, builders and users may also need to take into account. The current edition of the NEC in the USA is usually not adopted uniformly by all 50 states. It is recommended, therefore, particularly if the installation location is known ahead of time, to verify which edition of the NEC is enabled locally. It's also good practice, at the time of a bid or tender submittal, to specify the standards with which the equipment is in conformity.

Equipment groupings in North America

In the US and Canada, a marked differentiation exists between components designed for installation in energy distribution circuits and those that are primarily located closer to the load (industrial control equipment) (**Table 5**[39]). This aspect is also referenced in the equipment selection pages of the new catalog:

Energy Distribution Equipment

Typical components in this grouping include:
- Molded case circuit breakers (UL 489, CSA-C22.2 No. 5-09 [12]
- Molded case switches (UL 489, CSA-C22.2 No. 5-09)
- Disconnect switches (UL 98, CSA C22-C22.2 No. 4-04)
- Fuses (UL 248, CSA-C22.2 No. 248)
- Fusible Disconnect switches (UL 98, CSA C22-C22.2 No. 4-04)

These products tend to be more robust in their construction and incorporate larger electrical clearances (for 301-600 V: 1 inch = 25.4 mm through air, and 2 inches = 50.8 mm over surface).

Energy distribution equipment assemblies (Switchgear, switchboards, Panelboards) will typically feature equipment in this device grouping in incoming and outgoing circuits. These components are naturally also suitable for industrial control applications and will often be used as main disconnect switches and/or as protective devices in motor and non-motor load branch circuits.

The requirements outlined in these product standards are dutifully enforced through periodic and regular follow-up testing. Factory production is also closely monitored by inspectors or representatives from each certification agency. UL/CSA molded case circuit breaker testing standards are amongst the most stringent in the industry world-wide. NA type circuit breakers from Eaton successfully meet all of the requirements.

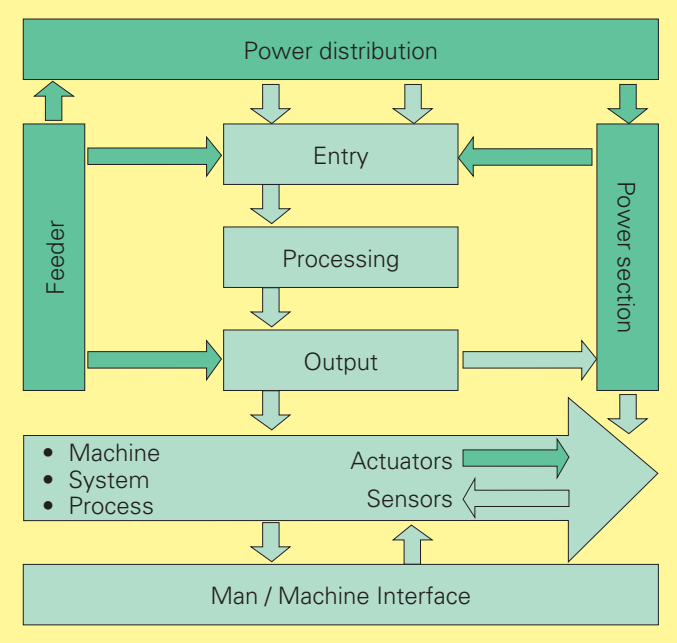


Figure 8: The electrical equipment for industrial machinery is usually grouped as per its function. All components are usually fitted into one enclosure depending on the size and power requirements of the machinery. In larger machines, individual function groups are normally decentralized, e.g. for wiring layout purposes and dedicated circuits. Decentralizing functions can sometimes make safety related measures, e.g. door interlocking, removal of power etc…harder to realize. Both energy distribution and industrial control components are normally found in industrial control panels.

Industrial Control Equipment

Components are typically certified to UL 508 and CSA-C22.2 No. 14-05:
- Contactors
- Industrial control relays
- Overload relays
- Manual motor controllers
- Rotary cam switches
- Control and signaling devices
- Solid state controllers and systems
- Programmable controllers (per CSA-C22.2 No. 142-M1987)[40]

These components tend to be smaller in size and have electrical clearances that are less than energy distribution equipment. Factory production of this equipment is also audited by the certification agencies, but not to the same level of scrutiny and follow-up that apply to protective devices such as circuit breakers.

Industrial control equipment is predominantly installed in control panels, in motor branch and load circuits of various types, in motor control centers and in auxiliary circuits of energy distribution assemblies. They can be directly combined with energy distribution equipment in industrial control panels, e.g. with circuit breakers in a motor branch circuit (**Figure 8**).

Power circuit groupings in North America

A differentiation is made in North America between "Feeder Circuits"[41] and "Branch Circuits"[42] (**Figure 9**). Feeder circuits

39 The table provides preliminary hints on selected topics described later in the paper.

40 As of 2012: CSA-C22.2 No. E61131-2; UL = UL 508 and UL 61131-2.

41 Feeder circuits are considered to be primarily supply circuits.

42 Branch circuits are considered to be load circuits.

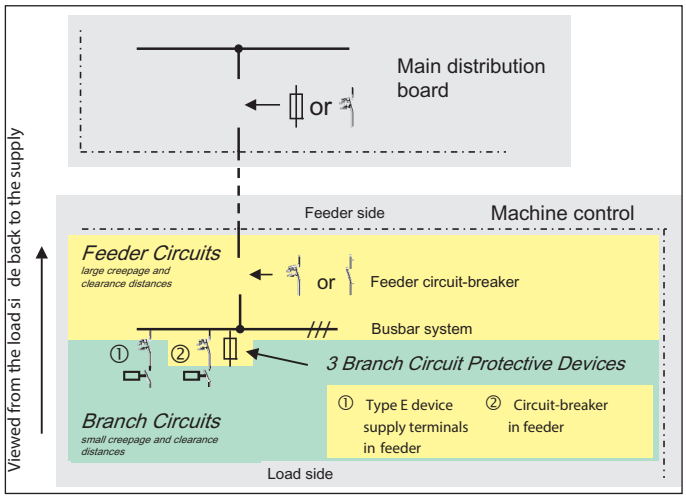


Figure 9: The border between branch and feeder circuits is denoted by the Branch Circuit Protective Device. It's helpful to look at the diagram from the point of view of the load back towards the source of supply. The first protective device encountered which provides protection for the load circuits is the BCPD. The supply circuit terminal of Type E self-protected controllers and Type F controllers lies at the border between feeder and branch circuits and must have large distribution spacings. Protective devices such as circuit breakers and fuses fulfill the requirements for large spacings in their construction.

require the larger electrical clearances (**Figure 10, Table 6**), as is the case with molded case circuit breakers certified per UL 489. The interface between both circuit groupings is the "Branch Circuit Protective Device", BCPD[43]. Branch circuit protective devices must feature, as a minimum, the larger electrical clearances on their incoming supply side. Typical BCPDs consist of circuit breakers, such as *NZM…-NA, PKZM4…-CB, FAZ..-NA, FAZ..-RT* (**Table 7**) from Eaton's range of protective devices, or fuses available in various characteristics and recognized as branch circuit protective devices per the electrical codes. Selecting the right BCPD is often a source of error on the part of export project designers.

43 BCPD = Branch Circuit Protective Device.

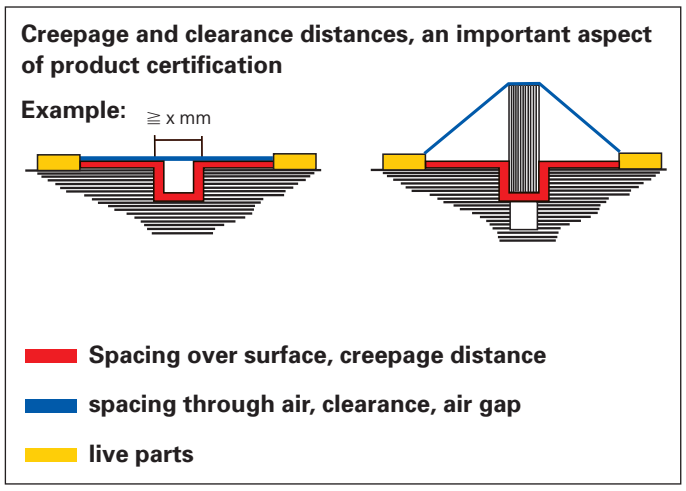


Figure 10: Surfaces of insulating materials can become susceptible to creepage or leakage currents, especially in high humidity and heavily soiled environments. Greater clearances hinder the likelihood of flash-overs between parts of opposite polarity. Creepage clearances per UL 489 for 480V and 600V circuits are nearly 51mm. For example, a 3 phase component of 50 mm width would have to accommodate that spacing up to 3 times within that width. Such a requirement can only be accomplished by incorporating into the design a system of elaborate grooves and ridges along component surfaces.

Minimum required spacings in feeder circuits Source: UL 508A Table 10.2			
	≤ 125 V	126 - 250 V	251 - 600 V
Through Air	12.7 mm	19.1 mm	25.4 mm
Over Surface	19.1 mm	31.8 mm	50.8 mm
Between live parts and grounded metal parts	12.7 mm	12.7 mm	25.4 mm
Minimum required spacings in branch circuits Source: UL 508A Table 10.1			
	51 - 150 V	151 - 300 V	301 - 600 V
Through Air	3.2 mm	6.41 mm	9.5 mm
Over Surface	6.4 mm	9.5 mm	12.7 mm
Between uninsulated live parts and the walls of an enclosure	12.7 mm	12.7 mm	12.7 mm

Table 6: General overview of electrical creepage and clearance distances which apply in North American feeder and branch circuits. The highest voltage rating must be considered for the majority of applications in the US and Canada.

Certified circuit breakers will be marked "LINE" and "LOAD" per UL and CSA standards unless they have been tested and evaluated to verify that they are suitable for reverse connection. Circuit breakers with LINE and LOAD markings would have to be fed through their LINE side only. Circuit breakers from Eaton do not have this restriction. This question comes up quite often even though we have included a note in the technical data section of our catalog specifically stating that the breakers are suitable for reverse connection. Stand-alone UL 508 Type E self-protected motor controllers and manual Type E controllers that are part of Type F combination motor controllers are also suitable as BCPDs, but for individual motor branch circuits only, and not for non-motor loads. Auxiliary circuits are referred to as "Control Circuits". The control circuit voltage source for motor starter units in motor control centers is typically derived from control circuit transformers located in each unit.

Electrical ratings on industrial equipment

A design engineer involved in export projects should best avoid relying on IEC/EN technical data in catalogs as a basis for selecting and sizing equipment for applications in North America. Only UL/CSA certified ratings should be used as guidelines for engineering purposes. Just as IEC and European based norms define various utilization categories as guides for properly selecting electrical equipment, North American standards take a similar approach and assign specific categories or load duty ratings to assist in choosing appropriately rated equipment for the application. Electrical load duty markings on equipment will match the type of load to be switched, and should be followed for equipment selection purposes. **Table 8** provides an overview of typical North American load duty ratings.

DILM Motor contactors and *DIL*…special purpose contactors

Contactors are considered industrial control equipment in North America (Industrial Control Equipment per UL 508 and CSA-C22-2 No. 14-05). North American users either specify motor contactors per traditional "NEMA sizes"[44] or, alternatively, prefer to more closely match motor and contactor HP ratings for selection purposes as is done in the IEC world. NEMA sizing

44 NEMA = National Electrical Manufacturer's Association (USA, http://www.NEMA.org

Suitability of various breaker and switch types to fulfill a range of applications											
Primary application functions						**Additional applications**		**Type**	**Used**		
Over-current protection	Short-circuit and overload protection for										
	Systems	Cables	Generators, Transformers	Selective protection with time delayed short-circuit trips	Motor-protection	Main Disconnect switch	Emergency OFF	All Switches certified per UL 489 and CSA-C22.2 No. 5. as either Circuit Breakers or Molded Case Switches	in Feeder Circuit	in Branch Circuit	as Branch Circuit Protective Device (BCPD)
	x	x			(x)[3]	(x)[6]	(x)[6]	***FAZ...-NA(-RT)***	x	x	x
	x	x			(x)[3]	(x)[6]	(x)[6]	***PKZM4-..-CB***	x	x	x
[1]						x	x	***NS..-..-NA***	x	x	-
x[2]					(x)[3]	(x)[5]	(x)[5]	***NZM..-S..-CNA***	-	x	(x)[5]
x[2]					(x)[3]	(x)[5]	(x)[5]	***NZM..-SE..-CNA***	-	x	(x)[5]
	x	x			(x)[3]	x	x	***NZM..-AF..-NA***	x	x	x
	x	x			(x)[3]	x	x	***NZM..-AEF..-NA***	x	x	x
	x	x	x	x	(x)[3]	x	x	***NZM..-VEF..-NA***	x	x	x
	x	x			(x)[3]	x	x	***NZM..-A..-NA***	x	x	x
	x	x			(x)[3]	x	x	***NZM..-AE..-NA***	x	x	x
	x	x	x	x	(x)[3]	x	x	***NZM..-VE..-NA***	x	x	x
	x	x			x[4]	x	x	***NZM..-ME..-NA***	x	x	x

(x) Conditionally applied
1) Switch is internally self-protected up to its maximum short-circuit current rating.
2) Applied only as part of a listed assembly per North American Codes and Standards *(Listed or Certified Combination Motor Controllers)*
3) Only in combination with suitable contactor and overload relay
4) The circuit breaker will more commonly be combined with a magnetic contactor to form a combination motor controller.
5) Used only as part of a combination motor controller in individual motor branch circuits.
6) Not suitable as a Supply Circuit Disconnecting Means per NFPA79 and UL 508A requirements for Industrial Machinery.

Table 7: The table shows which applications are particularly suited to each device type. Additional power components may be required depending on the assembly and application. Additional economical or technical factors may impact the suitability of a particular type for any given application. The columns on generator, transformer and selectivity protection do not purport to cover all cases. For example, in the case of a selective network, circuit breakers with undelayed short-circuit trips could conceivably be applied close to the load. Miniature type ***FAZ...-NA*** circuit breakers could be used for transformer protection if their 10 or 14kA short circuit rating is determined to be sufficient for the application. In most cases, only circuit breakers or fuses are allowed as protective devices for non-motor loads per North American electrical codes. With the exception of ***NS..-..-NA*** molded case switches, all types shown in the table are circuit breakers, which enjoy broad universal appeal and usage as protective devices in power circuits.

features a set of standardized HP ratings per frame size at common North American utilization voltage levels, as well as a thermal continuous current rating. **Table 9** ("Three phase NEMA contactors") provides an overview of standard HP and continuous current ratings assigned per NEMA standards.

Load Duty Ratings **Rating data on equipment**	
1) **Motors**	Horsepower (HP)
2) **Coils** (Coils in in auxiliary and control circuits)	Coils: Volts, Frequency, Volt-ampere Coil switching Control Circuit Contacts: Standard Pilot Duty or Heavy Pilot Duty.
3) **Resistance (heating)**	Amperes, restistance only
4) **Incandescent lamps**	Amperes or Watts, Tungsten
5) **Ballast** (electric discharge lamps)	Amperes, Ballast
6) **General Use** *	Amperes (A)

* The category „General Use" applies for general usage, and is in accordance the IEC/EN utilization category AC1.

Table 8: Various load type designations common in North American standards

You will find in chapters 5 and 9 of the Main Catalog all the North American certified HP ratings for Eaton contactors and motor starters. As previously mentioned, a conversion to HP ratings will be necessary if using kW only rated motors. Conductor sizing is not based on the current ratings marked on the actual motor nameplates, but on standardized HP rating motor full load current tables from the electrical codes. Conductor sizing is normally based on a factor of 1.25 (125 %) times the motor rated current appearing in the tables. This over-sizing, coupled with the fact that a 460 V rated motor is connected to a 480 V rated supply (a difference of about 4 %) eliminates the need for any additional voltage drop calculations. The need to consider voltage drops may still arise in the case of very long cable lines.

The Main Catalog also provides a selection table for contactors used in non-motor applications (Special Purpose ratings). Contactors for special purpose applications, such as *DILH, DILL, DILK, DILMF*[45] are available[46]. It is worth noting that the electrical codes require the use of either circuit breakers or fuses as protective devices for non-motor load branch circuits. Motor protective switches, including Type E and Type F starters, are acceptable in motor branch circuits exclusively.

45 DILMF...are special contactors designed to meet the requirements of the US semi-conductor industry SEMI F47 standard. http://www.semi.org/eu
46 North American "Special Purpose Contactors" also have particular design characteristics (e.g. single and two pole versions).

NEMA-Sizes for Contactors per the NEMA ICS 2 standard						
3 Phase contactors per NEMA NEMA-Sizes	Rated current	HP-Ratings*				
		1-phase		3-phase		
		115 V 60 Hz	230 V 60 Hz	200 V 60 Hz	230 V 60 Hz	460 V 60 Hz 575 V 60 Hz
	A	HP (PS)	HP (PS)	HP (PS)	HP (PS)	HP (PS)
00	9	1/2	1	1 1/2	1 1/2	2
0	18	1	2	3	3	5
1	27	2	3	7 1/2	7 1/2	10
2	45	3	7 1/2	10	15	25
3	90	7 1/2	15	25	30	50
4	135	-	-	40	50	100
5	270	-	-	75	100	200
6	540	-	-	150	200	400
7	810	-	-	-	300	600
8	1215	-	-	-	450	900
9	2250	-	-	-	800	1600

* HP Ratings for single speed motors, without jogging, reversing and current breaking.

Table 9: North American NEMA-Sizes for contactors. A NEMA-Size has an assigned general purpose current rating along with definite HP values at various motor nominal voltage ratings. All values per each NEMA size must be covered by one device in order for it to be assigned that designation. A standardized arrangement such as this is not always efficient at matching up closely to load requirements.

Contactor and overload relay combinations (Non-Combination starter)

It's important to note that customers in North America refer to the combination of a contactor and an overload relay in motor branch circuits as a "Non-Combination motor starter" (**Figure 11**). Complete "contactor and overload relay" non-combination starter listings from Eaton are tabulated and provided in the catalog. A protective device, either a circuit breaker or fuse, would be required in this case for overcurrent protection of the motor branch circuit. The catalog provides information as to the largest size of protective device permitted for each respective combination. The largest allowable protective device may not be the best choice, however, when it comes to achieving the best possible short circuit rating (SCCR) for the combination. The best results with respect to SCCR are usually attained when the starter combination and protective device are selected to match as closely as possible with respect to their ratings. The majority of export firms prefer fuseless based solutions.

Figure 11: A North American "Non-Combination" motor starter is made up of a contactor and an overload relay.

Eaton has emphasized high fault testing of its combination motor starters ever since the establishment of an overall short circuit rating for industrial control panels became a requirement. In the past, testing was done mostly at 600 V in order to cover all lower voltages, incl. 480 V. The voltage, however, plays a crucial role in the overall determination of a short circuit rating. SCCR testing of combinations at 480 V can yield much better results, and the overall impact of SCCR ratings in the market has increased significantly. By targeting additional testing of our combinations at 480 V levels we are thus able to achieve short circuit ratings better suited to meet the demands encountered in US based industrial applications.

Combination motor starters

The European style motor starter, which integrates the functions of disconnect, short circuit and overload protection and motor switching into one assembly (e.g. circuit breaker, contactor and overload relay) is referred to as a "Combination motor starter" in North America (**Figure 12**). Putting all the neces-

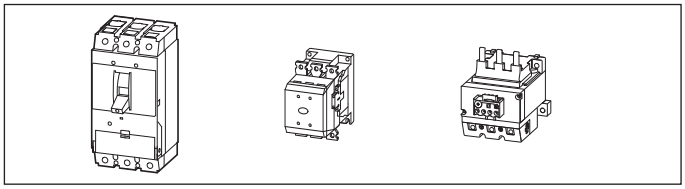


Figure 12: A motor starter, which combines the isolating, short circuit, overload and motor switching functions in a motor branch circuit (e.g. a circuit breaker, contactor and overload relay) is referred to as a "Combination Motor Starter" in North America. Putting all the necessary components together to create such a combination motor starter is not unlike engineering a small industrial control panel.

Figure 13: Efficiently combining motor starter components using plug-in mechanical and electrical connector kits. This type of construction is certified, just like the traditional way of combining components using hard wire. This type of motor starter requires an additional back-up protective switch per North American standards, or it can be applied as a stand alone Type E or F combination controller when equipped with a large spacing BK25/3-PKZ0-E supply terminal. (Refer to Figure 19).

sary components together to create such a combination motor starter is not unlike engineering a small industrial control panel. As previously mentioned, selection of the right combination controller is facilitated with the help of tabulated information available in the catalog.

Eaton offers modern design techniques to combine motor starter components into an assembly. The most efficient of these involves electrical and mechanical plug-in connector sets (**Figure 13**). All variations of starter combinations, whether hardwired or assembled with such connector sets, are fully certified. The same applies for starters mounted on busbar shoes or adapters from our *SASY60i* busbar system.

IEC/EN Motor protective switches

Typical IEC/EN motor protective switches, regardless of manufacturer, are not applied in the same manner in North America as they are per international and European installation standards. These devices, which have proven themselves universally for many generations and are produced monthly in huge numbers, are classified more simply as "Manual Motor Controllers" per North American standards and do not enjoy the same kind of functional versatility as they do in the IEC world. This classification has important ramifications with respect to project design work for North America and will be described in better detail in the forthcoming section.

Manual motor controllers are certified and evaluated per UL 508 and CSA-C22.2 No. 14-05 industrial control product standards. Even though the technology in these controllers has proven itself per IEC and EN standards as able to provide main disconnect and isolating function capabilities in power circuits, and in spite of the fact that devices from Eaton in small current ranges are considered short-circuit proof and self-protecting in the IEC world, the built-in isolating and short circuit protective capabilities of these controllers are not recognized in North America. For this reason, the electrical codes require that both controller and branch circuit be additionally protected by UL/CSA certified circuit breakers or fuses. From an IEC point of view, these restrictions needlessly increase the size and cost of industrial control assemblies. The simple manual motor controller, barring any additional evaluation per the product standards, which will be described more fully later in the section, is not permitted as a Branch Circuit Protective Device (BCPD) for motor branch circuits. Just like any other UL 508 type device, its usage in feeder circuits is even more restricted. Although the controller's internal short circuit trip element is basically ignored in product certification testing it still responds to trip the device during short circuit testing. After clearing the fault the device can still be fully operational and be put back into service. There is also the very likely possibility, due to the device's extremely quick operational speed, that it may in fact clear the fault before the upstream protective device has had any chance to react.

The additional upstream device is used for the protection of individual motor controllers and their branch circuits, but it can also serve as a group protective device for a branch circuit serving multiple motors and controllers under the electrical code rules known as "group installations" (**Figure 14**). Controllers in this case would have to be additionally tested and marked as being suitable for group installations[47]. The manual motor controllers from Eaton fulfill these requirements. Motor controllers type *PKZM0* and *PKZM4* have additionally been evaluated as "Tap Conductor Protectors". The new *PKE* controller is currently under submittal for the same type of certification. The size of the back-up protective device, of each group controller, as well as incoming, tap, and motor circuit conductor cross-sections, are all parameters within a group installation configuration which must be carefully considered during the planning stages. Rules governing component and branch circuit sizing in group installations are outlined in the NEC and CEC. The 1/3 rule involves the ratio of incoming and outgoing conductors to each motor, whereas the 1/10 rule ultimately determines the size of each tap conductor in relation to the ampacity of the upstream branch circuit protective device. Ideally in a group installation, the group back-up device will be sized just

47 The lesser accurate descriptive term "Group Protection" is also used interchangeably, although it refers more to the back-up overcurrent device, which provides protection for the group.

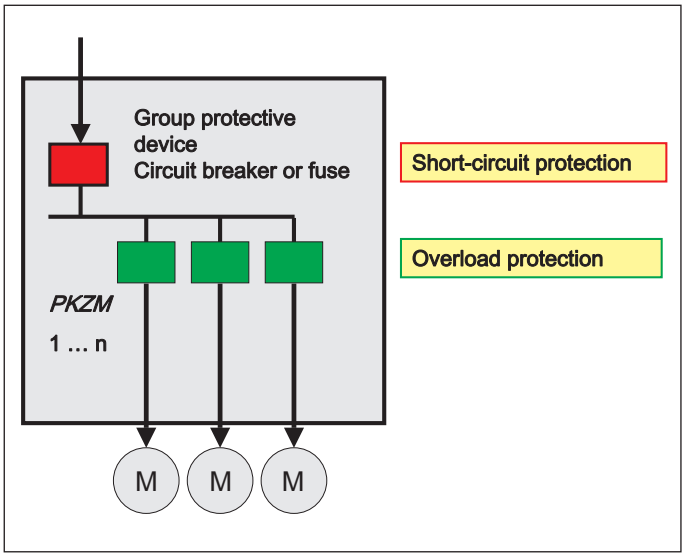


Figure 14: The IEC/EN motor protective switch, also referred to as a "Manual Motor Controller", requires additional back-up overcurrent protection in North America. An additional evaluation of the motor controller for "Group installations" would enable a larger back-up protective device to protect a group of similarly evaluated controllers.

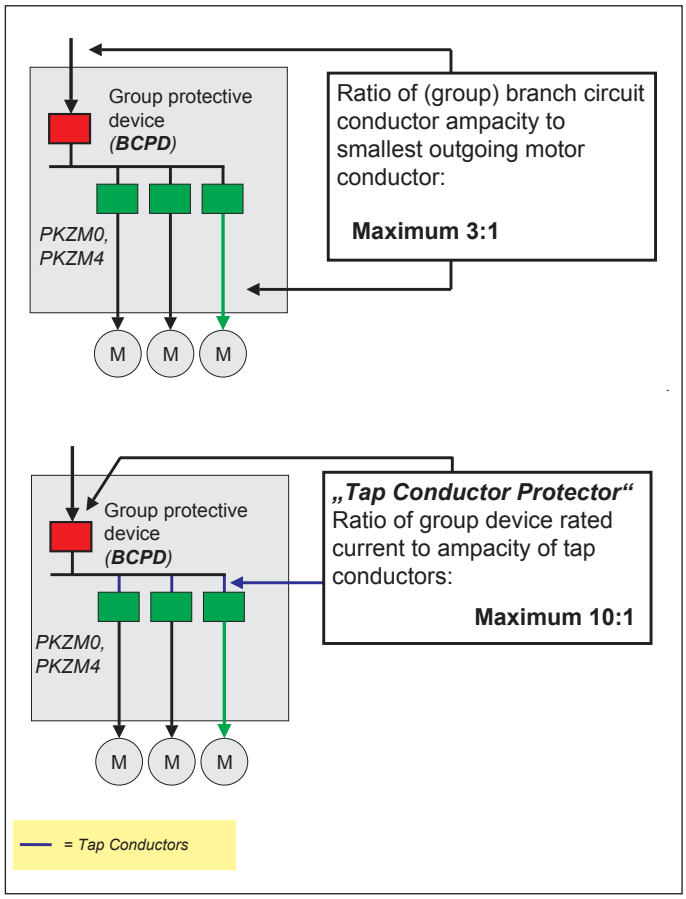


Figure 15: The IEC/EN motor protective switch requires additional back-up protection in the form of circuit breakers or fuses per North American electrical codes *. Individual controllers need to be protected or, if they have been suitably evaluated, can be grouped together under one larger back-up protective switch. The group installation requirements of the electrical codes (1/3 rule, 1/10 rule) must be observed (simplified view). It becomes difficult to efficiently create groupings if motor sizes within a group vary considerably from one another. Tap conductor protectors are normally suitable for installation in solidly grounded distribution networks only (Slash Ratings). This category is not officially recognized in Canada.

* UL 508 Type E and Type F controllers offer a stand-alone alternative for individual motor branch circuits.

large enough to accommodate the total load and allow multiple motor starting currents, but still be able to provide a degree of protection to the smallest conductor in the group.

The use of controllers additionally evaluated as tap conductor protectors can be very advantageous in this case. The 1/10 rule with respect to tap conductor sizing and the rating of the back-up protective device can be applied to create larger groups, and each controller is able to provide closer sizing and better protection to each outgoing motor circuit conductor. Motor controllers used in group installations with a fully rated back-up protective device are also suitable for all power distribution systems, including delta and ungrounded networks. Tap conductor protectors, however, are usually marked with slash ratings and are thus suitable for solidly grounded networks only (**Figure 15**). They are also not yet recognized by Canadian based standards. **Figure 16** provides a comparative overview of these various design concepts, including individual branch circuits and available solutions for group installations, as well as the use of UL 508 Type E and F controllers, which are yet another option that will be described in more detail in an upcoming section. Type E and F controllers usually offer by far the best solution to users with respect to co-ordination planning, materials, space savings, and quicker overall assembly and wiring time. They are, however, usually restricted for installation in solidly grounded networks only.

Manual motor controllers PKZ(M), PKE

These devices are certified as industrial control equipment (UL 508 and CSA-C22.2 No. 14-05) and they are commonly installed as manual motor starters in industrial control panels or individually housed in dedicated enclosures. They are HP rated for direct across-the-line motor switching, and can be fitted with auxiliary contacts that are pilot duty rated for control circuit load switching requirements. They feature either fixed or adjustable instantaneous magnetic, or electronic, trips for short circuit protection[48], and bimetal or electronic trips for motor overload protection. The *PKE* line of controllers features exchangeable, solid state plug-in trip modules which are adjustable and individually rated to cover a wide range of motor full load currents. The System *PKE* controllers can also be interlinked via the certified Darwin Smart Wire connectivity system for full bi-directional communication capabilities. Per North American standards, the *PKZM* and *PKE* line of manual motor controllers are suitable for the protection of motor circuits only, and not for non-motor loads. The controllers can also be equipped with a full line of accessories, including shunt and undervoltage trips (**Figure 17**).

PKZM0 and *PKZM4* motor controllers are certified for use in group installations and have been additionally evaluated as tap conductor protectors. The same type of certification is planned for the *PKE* line and is currently underway. The definition and application of these terms were described in the previous section.

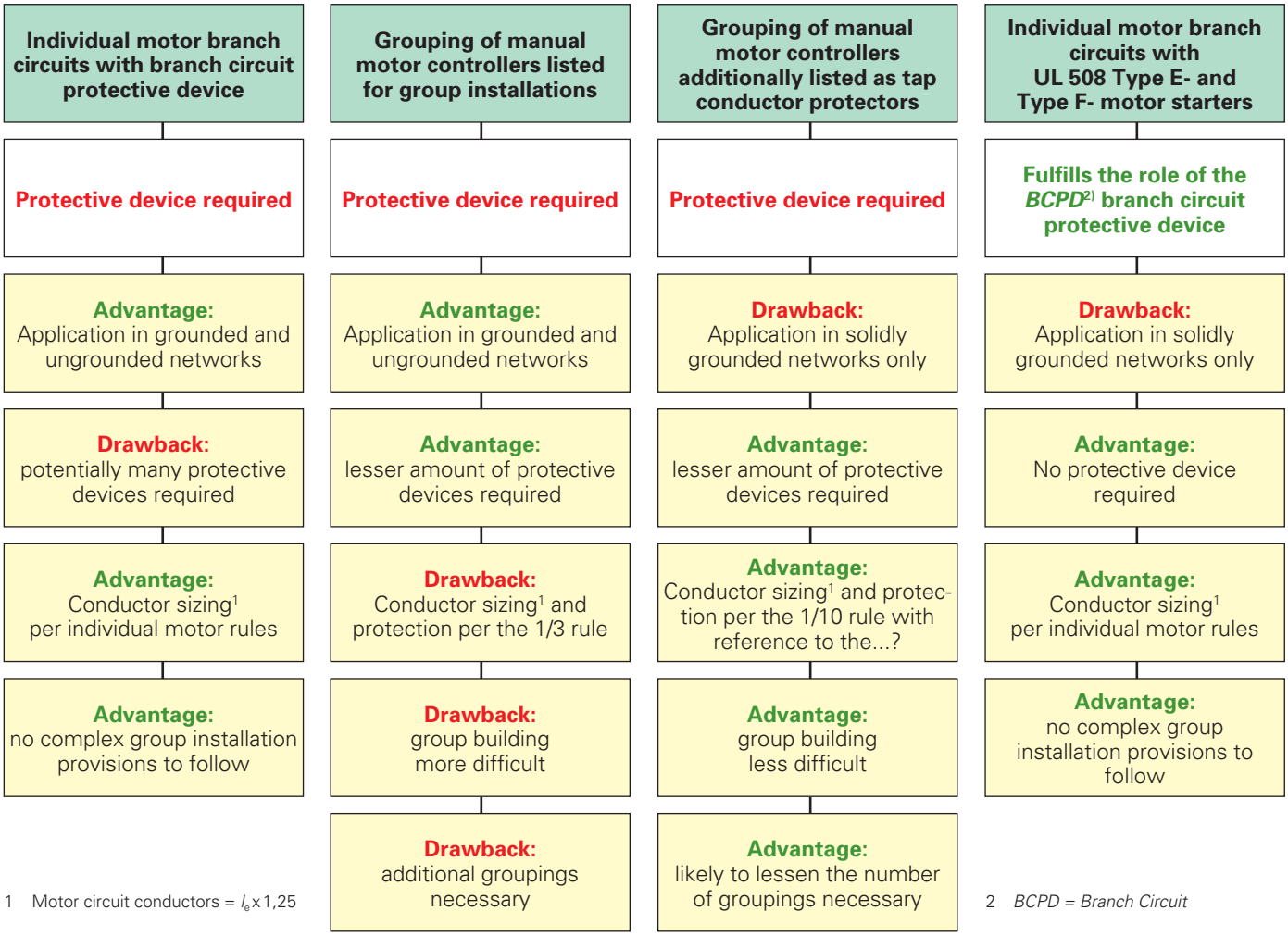
Stand-alone motor controllers without the need for additional back-up protective devices, UL 508 Type E Self-Protected Combination Motor Controllers

In accordance with the test provisions of the UL 508 standard, these motor controllers can also be evaluated as "Type E Combination Motor Controllers"[49], which allows their application as stand-alone devices in motor branch circuits without additional need for a back-up protective device (self-Protected Combination Motor Controller). This type of controller is also recognized by the CSA standards. Type E starters are typically slash rated, meaning that they are suitable for solidly grounded networks in accordance with their voltage rating, e.g. 480Y/277 V. They fulfill the branch circuit protective function for individual motor circuits only, and cannot be used in the same capacity for the protection of non-motor loads. They can be used in combination with adjustable speed drives, but must be specifically evaluated for this purpose.

An individual Type E controller fulfills all the functions of a combination motor controller, including short circuit protection of the motor branch circuit. The solution provides obvious space saving advantages and eliminates the need for any inter-wiring between components. They are suitable for installation in motor control centers (MCCs), in industrial control panels, and as individually enclosed combination motor controllers up to their maximum short circuit rating without the need for additional back-up protection.
In the PKE system, these devices are available with part no. *MSC-DE-...-M...-SP* **(Figure 18)**.

48 Refer to previous sections.
49 Type E starter construction. At this time there are construction types A through F.

Advantages and drawbacks of various motor starter configurations achieved with IEC/EN manual motor controllers, in applications per North American electrical



1 Motor circuit conductors = I_e x 1,25

2 *BCPD = Branch Circuit*

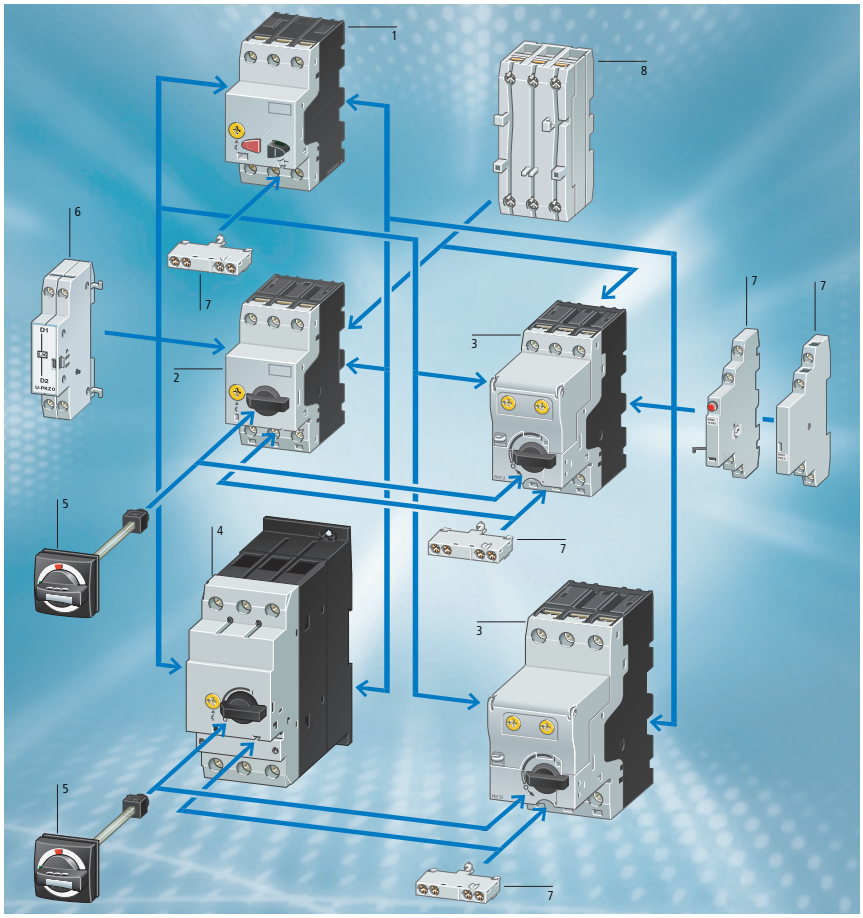
Figure 16: Comparison of various ways to apply typical IEC/EN Manual Motor Controllers in North America. The left side of the table represents manual motor controllers individually protected with branch circuit protective fuses or circuit breakers. The middle two columns apply to controllers that have been additionally certified for use in group installations and are applied under a common "group" branch circuit protective device. The certification as "Tap Conductor Protector" is not yet recognized by the Canadian standards and has validity only in the US at this time. The right side of the table details the greater application possibilites of controllers that meet North American requirements as Type E and F combination motor controllers.

The *MSC-DE-...-M...-SP* comes with an extension terminal designed to increase clearances and creepage distances, as well as with a lockable knob. Both these mechanisms are factory-installed. This motor starter combines both short-circuit protection and overload protection functions, as well as manual switching and automatic remote switching (e.g., from a PLC) functions. In addition, it can function as a BCPD[50] in individual motor feeders, up to its switching capacity, without additional upstream protection devices.

50 feeder circuit-breakers

Type E Combination Motor Controller								
Maximum motor rating Three-phase current				**Setting Ranges overload release**	**Rated short-circuit breaking capacity**			**Combination Motor Starter**
200V HP	230V HP	460V HP	575V HP	A	240V kA	480Y/277V kA	600Y/347V kA	
		1/2	1/2	0,3–1,2	14	14	14	MSC-DE-1,2-M17-SP(...)
3/4	3/4	2	-	1–4	18	18	-	MSC-DE-4-M17-SP(...)
3	3	7 1/2	-	3–12	18	18	-	MSC-DE-12-M17-SP(...)
5	7 1/2	15	-	8–32	18	18	-	MSC-DE-32-M32-SP(...)

Table 10: *MSC-DE-...-M...-SP,* Type E Combination Motor Controller with PKE



1 PKZM01 Motor Protective Switch
2 PKZM0 Motor Protective Switch
3 PKE Solid State Motor Protective Switch
4 PKZM4 Motor Protective Switch
5 Door mounted interlocking handle
6 Shunt and Undervoltage trips
7 Auxiliary contact module, front mounted
8 Trip indicating module
9 Side mounted auxiliary contacts
10 Current limiter module

Figure 17: Per IEC/EN standards the controllers pictured here are complete, stand-alone motor protective switches. Per North American standards they are simply manual motor controllers with an instantaneous trip function, and must rely on an additional back-up protective device to provide motor branch circuit short circuit protection.

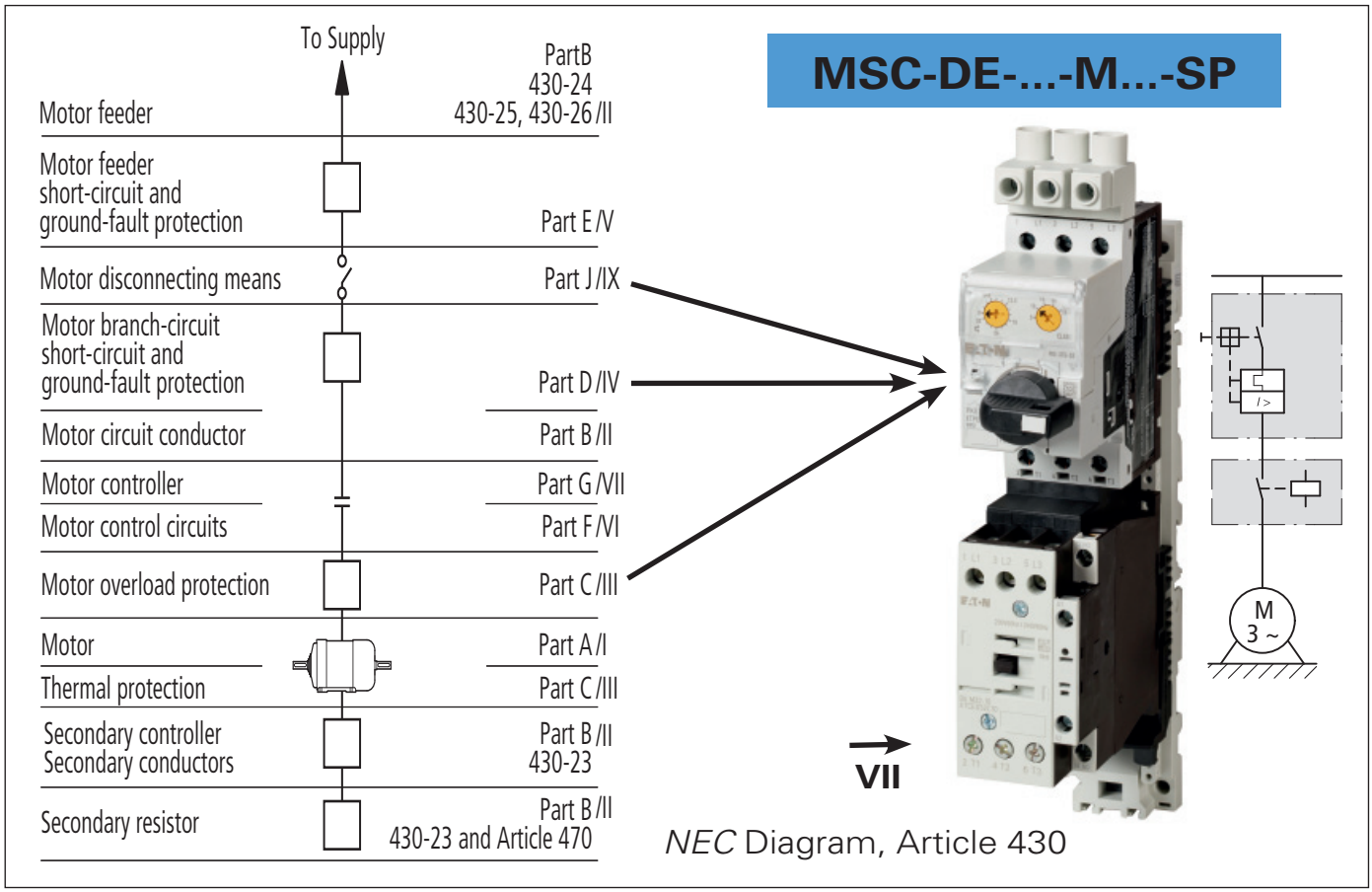


Figure 18: The diagram shows that all of the NEC/CEC requirements for a combination motor starter in a motor branch circuit are fulfilled by the *MSC-DE-...-M...-SP,* a UL listed and CSA certified Type E Self-Protected Combination Motor Controller featuring a compact, unitized construction, and a high fault capacity rating (SCCR) for use in modern industrial control panels and motor control centers.

Figure 19: The manual motor controller on the left, with the incoming terminal block, is fully certified as a "Manual Self-Protected Combination Motor Controller", also commonly referred to as a "UL 508 Type E Starter". This additional terminal block on the incoming supply side of the controller provides the larger electrical clearances required for this application. The single terminal is allowed to feed additional self-protected controllers in this manner, as long as they are inter-connected using busbar accessories specifically listed for this purpose. This particular configuration provides both a useful way of complying with North American requirements and a space saving feature typical of similar designs conforming to IEC/EN standards. This solution is applicable in solidly grounded power distribution networks. Applications in Canada would require each open panel mounted self-protected controller applied in this manner to be equipped with a padlockable knob. These controllers are suitable for installation in motor branch circuits only.

UL 508 Manual Type E Starter

An additional variation of the Self-Protected controller is the "Manual Self-Protected Combination Controller" or, "Manual Type E Starter" for short. From a design standpoint, these devices must also have a large spacing termination capability on their incoming side, in accordance with UL 489 and CSA-C22.2 No. 5-09, in order to provide branch circuit protection without the need for an additional back-up protective device. These devices are used exclusively as manually operated protective switches for individual motor circuits. They are suitable for solidly grounded power distribution networks only when so marked, e.g. for the slash rating 480Y/277 V. They fulfill the role of branch circuit protection for the motor branch circuit up to their maximum short circuit rating without the need for back-up protective devices. They are suitable for motor circuits only and cannot be used as protective devices for other loads.

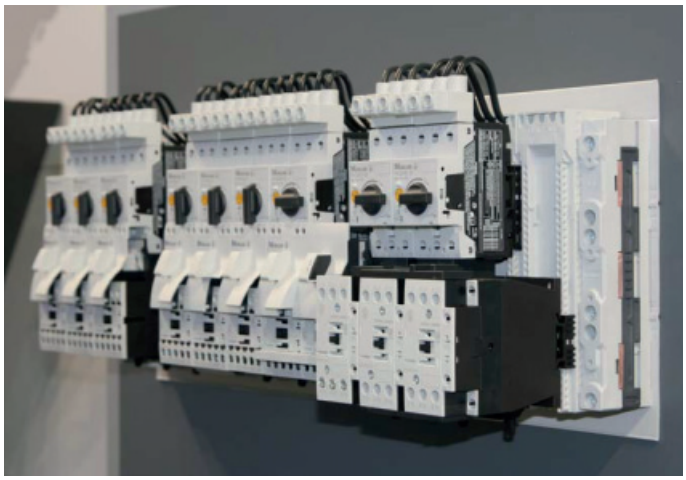


Figure 20: The photo shows an array of combination motor starters directly mounted on *SASY 60i* busbar systems. The busbar system configuration shown is suitable for installation in the feeder portion of the circuit, for which larger electrical clearances are required. Each starter is equipped with the large spacing terminal block *BK25/3-PKZ0-E* on their incoming supply side.

In the *PKZM0* or *PKZM 4* family of controllers, the "Manual Self-Protected Combination Motor Controller" is constructed with the addition of a terminal block, *BK25/3-PKZ0-E* resp. *BK50/3-PKZ4-E*. This terminal block establishes the necessary electrical clearances on their supply side, and facilitates at the same time the termination of larger cross-sections, which can also be useful in group installation arrangements. In Canada, all such controllers must be additionally provided with a padlocking capability. The open style controllers are thus equipped with the padlockable *AK-PKZ0* knob. It is permissible to electrically group a number of controllers with a commoning link specifically certified for the purpose, e.g. *B3…-PKZ0*, as long as the grouping is supplied via the large *BK…* spacing terminal (**Figure 19**). In the case of Manual Type and Type F starters mounted on bus bar adapters that are part of the *SASY 60i* system, each *PKZM* and/or *PKE* controller must be equipped with a large spacing terminal (**Figure 20**).

UL 508 Type F Combination Motor Controller

The combination and certification of a "Manual Type E Starter" with a contactor creates a "Type F Combination Motor Controller" (**Figure 21**). These are also stand-alone assemblies up to their maximum short circuit rating without the need of additional back-up protective devices. Type F starters can be built in accordance with the selection guidelines provided in the catalog. These combinations are also normally rated for installation in solidly grounded power distribution networks, e.g. 480Y/277 V. They are suitable for individual motor branch circuits only, and cannot be used to provide protection for non-motor loads. Type F starters find general acceptance in Canada, even though they are not officially recognized by Canadian based standards. The open style *PKZM* controller has to be equipped with padlockable knobs for use in Canada.

The 3 phase commoning links and the large spacing incoming supply terminal can also be used to electrically group these controllers. An alternative would be to mount them on bus bar adapters that are part of a busbar system, such as

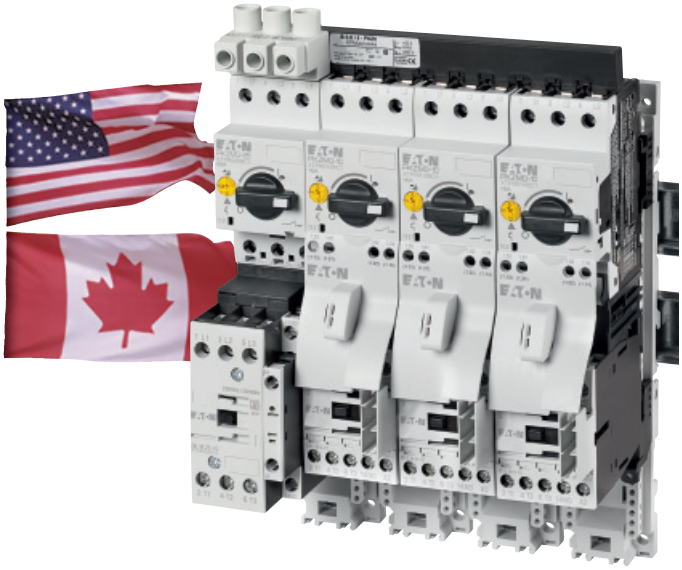


Figure 21: The combination of a „Manual Self-Protected Combination Motor Controller", or "Manual 508 Type E Starter", and a magnetic contactor, forms a Type F Combination Motor Controller, also called "UL508 Type F Starter" for short. The photo shows four such starters, which are also interconnected using busbar links and fed via a single large spacing terminal block. These starters are applied in solidly grounded power distribution networks and are only suitable for motor branch circuits per the North American electrical codes. Each open mounted controller would be equipped with a padlockable knob for applications in Canada.

the *SASY 60i* busbar system certified for use in North America. Eaton offers these Type F "two component" combination motor starter solutions for motor currents up to 52 A. The introduction of Type E and Type F controllers represented a significant step towards minimizing common approval problems which previously occurred in export related installations when, out of ignorance, required back-up protective devices had been inadvertently left out of control panel engineering designs. Invariably, there was little spare room left in the panel to accommodate necessary corrective actions, which usually involved the addition of protective components to satisfy local requirements. Type E and F controllers now enable a more uniform control panel design in this range which is able to meet both IEC/EN and North American standards requirements.

Starter solutions for larger motors

Typical circuit breakers in North America, like their counterparts in the IEC world, are not usually designed and calibrated to provide motor overload protection per the requirements of local electrical codes. A new range of *NZM..-ME…-NA* motor protective circuit breakers will be presented in an upcoming section. These have undergone additional evaluation per the UL 508 standard to verify their ability to fulfill motor overload protective requirements.

Motor starters in the higher ranges (for Eaton > 52 A) are usually made up of at least 3 separate components in North America (**Figure 22**). The usual combinations consist of a molded case breaker, a contactor, and a separately provided motor overload relay. We offer the following conventional circuit breakers for the North American market to meet this demand:

- *NZM…-A(E)F…-NA*, with fixed overload trips
- or *NZM…-A(E)…-NA*, with adjustable overload trips
- or *NZM…-S(E)…-NA*, with instantaneous trips only.

The separately provided motor overload relays feature either thermal bimetal trips, or solid state trip circuitry. The adjustable trip class settings of an electronic type overload relay allow for optimal match-up to motors that have particularly demanding characteristics, e.g. long starting times. The circuit breaker in the starter assumes the role of BCPD for the individual motor branch circuit.

***NZM…-ME…-NA* Motor Protective Circuit Breakers**

These new circuit breaker versions are fully certified as inverse time circuit breakers (Molded Case Circuit Breakers per UL 489 and CSA-C22.2 no, 5-09) but are additionally evaluated to verify a motor overload protective capability per the industrial control standards (UL 508 and CSA C22.2 No. 14). These new "Motor Protective" circuit breakers were not yet officially described in any North American product standard at the time of this writing. This had led to undue delays with respect to their certification. These circuit breakers can be applied just like any other traditional inverse time circuit breaker (**Figure 23**). They are

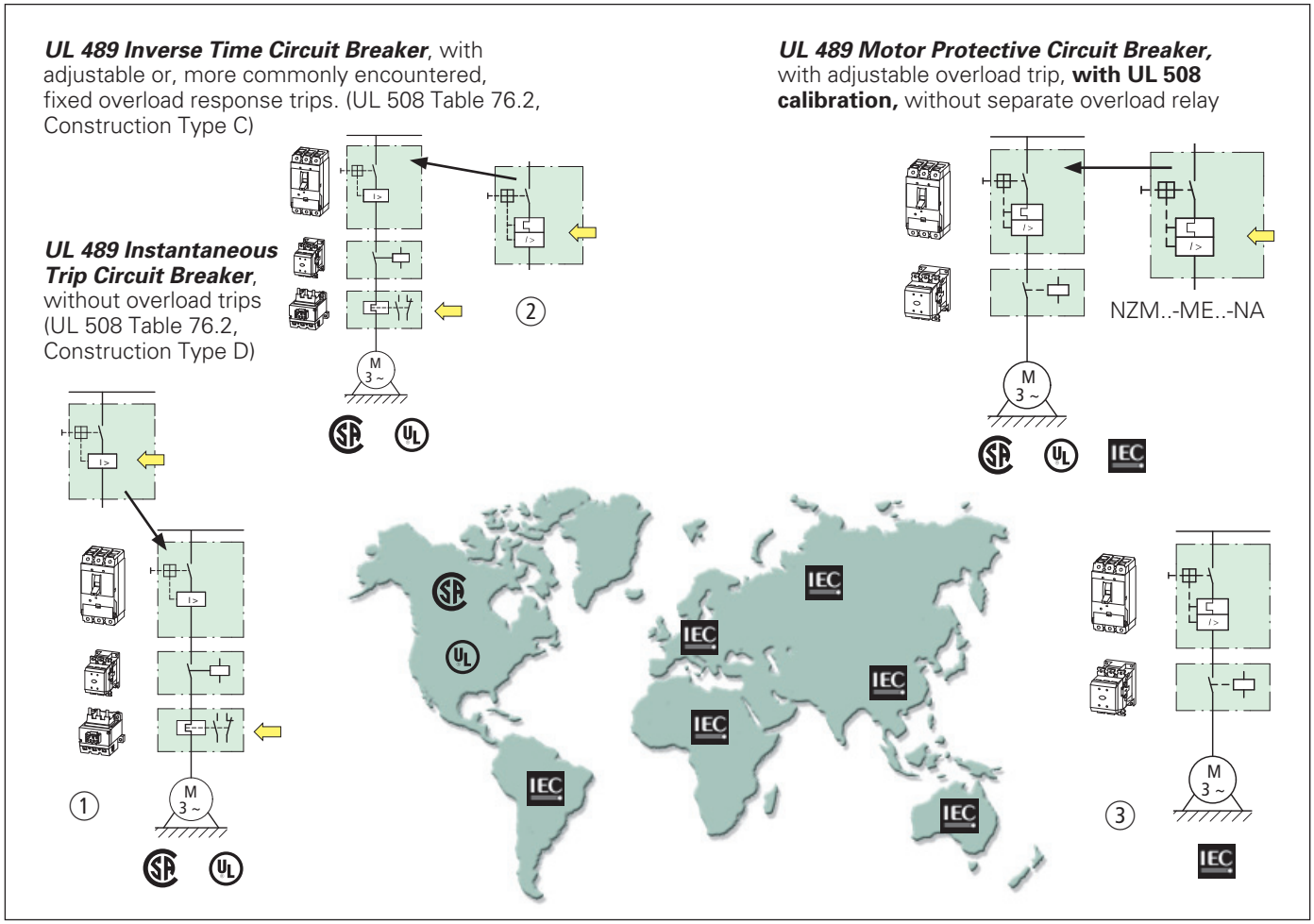


Figure 22: Most combination motor starters in North America are made up of at least three components, e.g. circuit breaker, contactor and motor overload relay, whereas in the IEC world, equivalent starters usually feature only two, a circuit breaker or motor protective switch and a contactor. The two component combination motor starter solution is projected to gain more acceptance in North America with the availability of equipment such as the listed inverse time molded case circuit breaker Type *NZM...2-ME…-NA* which features additional motor overload calibration ratings per North American certification standards.

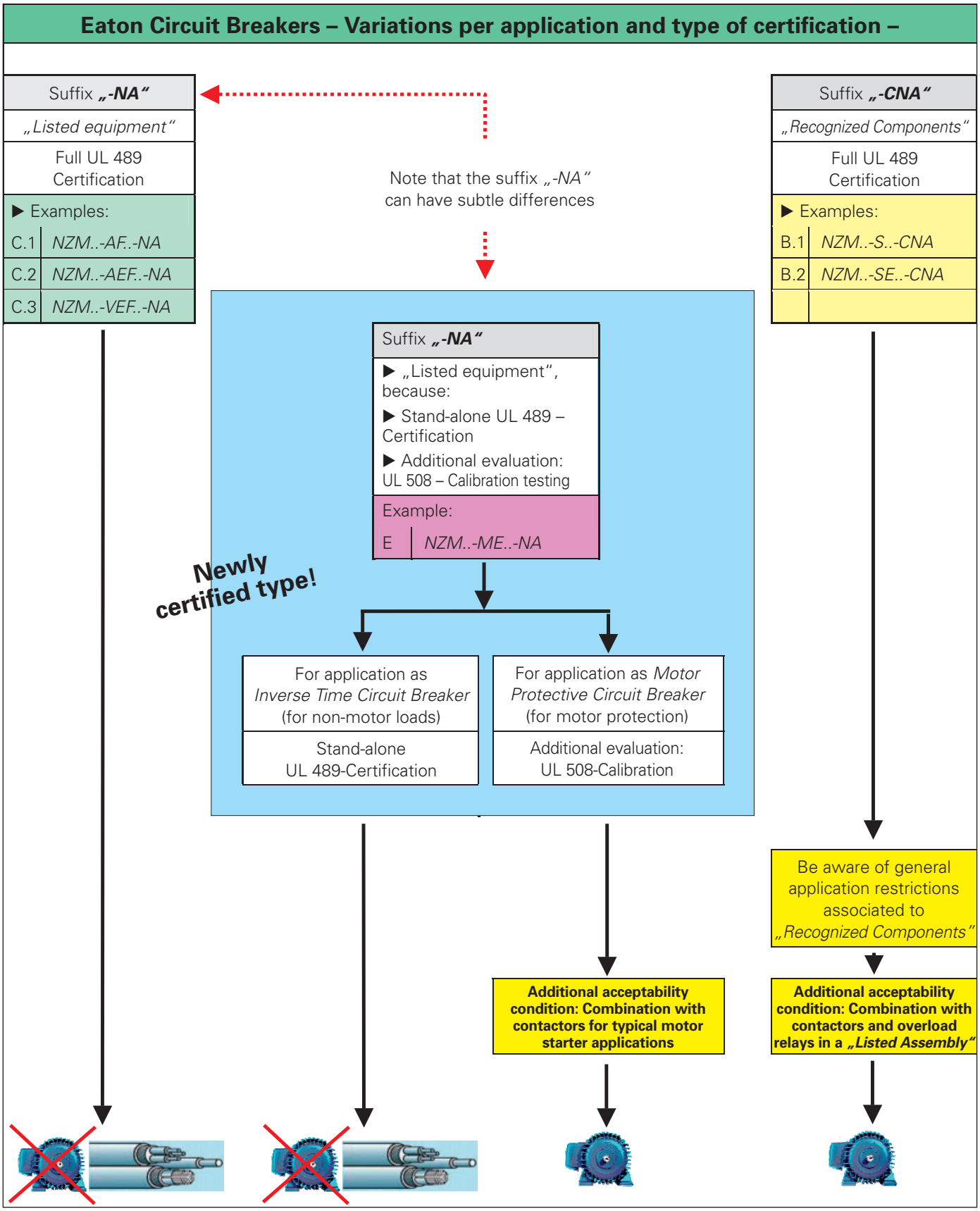


Figure 23: Variations in certification categories and application possibilities. Both certification categories on the left hand side of the table would allow for protection of cables and systems. As described in thie paper, such breakers could also be used for generator protection and be suitable for selectivity functions in energy distribution networks.

suitable as protective devices for feeder and branch circuits, and fulfill the role of branch circuit protective device when part of a combination motor controller (**Table 7**). They are primarily installed in industrial control panels and motor control centers (MCCs). They have kA rms sym. short circuit interrupting ratings as part of their rating labels, and can be equipped with pilot duty rated auxiliary circuit contacts. They can optionally be fitted with voltage trips (either shunt or undervoltage) to trip them open electrically, or combined with motor operators to switch them on and off from a remote location.

Circuit Breakers used for motor overload protection **NEW!**

3-pole · Adjustable electronic overload trip range set to motor rated currents · Time delay setting to adjust for motor inrush current starting conditions · Adjustable, instantaneous short circuit trip · 100 % rated · Screw terminations supplied as standard · Box terminations available as option

	Adjustable ranges			Motor 3 Phase HP rating in combination with magnetic contactor		Suitable magnetic contactor	Circuit breaker with Normal switching capacity Type SCC 85 kA 240 V 35 kA 480 V	Circuit breaker with High switching capacity Type SCC 150 kA 240 V 100 kA 480 V
	Overload trip	Instantaneous short-circuit trip						
$I_n = I_u$ [A]	I_r [A]	I_i [A]	I_i	230 V 240 V HP	460 V 480 V HP			
90	45 - 90	90 - 1260	2…14 x I_n	20 - 25 30	40 50 60	*DILM50* *DILM65* *DILM80* *DILM80*	*NZMN2-ME90-NA*	*NZMH2-ME90-NA*
140	70 - 140	140 - 1960	2…14 x I_n	40 50	75 100	*DILM95* *DILM115*	*NZMN2-ME140-NA*	*NZMH2-ME140-NA*
200	100 - 200	200 - 2800	2…14 x I_n	- 60 75	125 - 150	*DILM150* *DILM185* *DILM225*	*NZMN2-ME200-NA*	*NZMH2-ME200-NA*

Table 11: These new circuit breakers used for motor overload protection are certified per UL489 and CSA-C22.2 No. 5-09, with additional motor overload calibration evaluation per the Industrial Control Standards UL508 and CSA-C22.2. This allows them to be applied with magnetic contactors as combination motor controllers for motor branch circuits without the need for a separately supplied motor overload relay (2 component solution). The breakers have an incremental time delayed trip setting tr to allow for motor inrush current starting conditions, adjustable between 2…20 seconds at 6 x Ir (locked rotor conditions) to match varying motor loading requirements. These circuit breakers are also in full conformity with the IEC circuit breaker standard IEC/EN 60947-2.

These breakers feature adjustable electronic instantaneous trips for short circuit protection, and broad range, adjustable long time response electronic trips for motor overload protection[51]. The overload trip class adjustment allows optimal matchups to varying motor starting characteristics and differing motor start-up times.

In motor branch circuit applications the circuit breaker will normally be combined with a contactor, which yields a variation of a "Type C combination motor controller". The contactor assumes the normal motor switching duties and provides the motor starter assembly with a long electrical life. The circuit breaker fulfills the role of protective device and main disconnect to the motor. The HP ratings of the combination motor starter correspond to the HP ratings marked on the nameplate of the contactor and also appear in the catalog selection page for these controllers. These "2 component" based combination motor controllers, when compared to more conventional 3 component North American motor starter solutions, effectively reduce component and assembly costs, and minimize heat losses in the overall panel or assembly. These reductions are particularly noticeable in tighter space confines, such as those typically found in MCC units. The introduction of 2 component solutions also leads to more uniformity between IEC/EN and NA panel layouts, and contributes an additional step towards meeting the demand of a truly universal industrial control panel design.

NZM…-ME…-NA circuit breakers, together with the associated contactors that form the combination motor starter, can be applied up to their maximum short circuit ratings without additional back-up. The breakers are available in 3 models, each with 2 sets of interrupting ratings in one frame size (**Table 11**) and can accommodate motor full load currents ranging between 45 and 200 A. The breakers are 100 % rated, meaning that, similar to Type E controllers, the entire current setting range can be utilized to match up with motor full load currents. The range intentionally overlaps those of the *PKZM0* and *PKZM4* Type E and Type F controllers, available up to 52 A, to provide a seamless transition between the two versions. It is now possible to offer 2 component style combination motor starters for motors rated up to 200 A and 150 HP @ 480 V, thus providing an efficient and cost effective starter solution for more than 95 % of all motors.

NZM..-S(E)..-CNA, Instantaneous Trip circuit breakers (without overload trips)

These devices are referred to as Instantaneous Trip circuit breakers in North America (certified per UL 489 and CSA-C22.2 No. 5-09), and they are installed as part of combination motor starters in assemblies such as motor control centers (MCCs), industrial control panels and individually enclosed combination motor controllers. They are rated solely in amperes, and can be equipped with pilot duty rated control circuit contact accessories. They do not have individually marked short circuit ratings.

These breakers have adjustable magnetic or electronic instantaneous trips for short circuit protection and no overload tripping elements. They are used as switches in motor starter assemblies and have auxiliary contact accessories for switching of control circuit loads. They are used exclusively as branch circuit protective devices for individual motor branch circuits (**Table 7**). They can optionally be fitted with voltage trips (either shunt or undervoltage) to trip them open electrically, or combined with motor operators to switch them on and off from a remote location.

NZM..-S(E)..-CNA Instantaneous Trip circuit breakers are certified per UL standards solely as Recognized components. They cannot be installed individually as stand-alone protec-

51 The long time response trips of the circuit breaker additionally fulfill the motor overload calibration requirements of UL 508 and CSA-C22.2 No. 14-05.

tive devices but must always be combined with a contactor and a separate overload relay to handle the motor switching duties and motor overload protective function respectively. The breaker provides the short circuit protection for the motor branch circuit. The certified assembly is referred to in North America as a "Type D Combination Motor Controller" per the product standards (**Figure 22**). As an additional benefit, this particular component combination readily allows for a differentiated trip signalization, either overload via the tripped contact of the overload relay, or short-circuit via the breaker's own auxiliary contact circuitry. This particular style of motor starter is commonly encountered in MCCs, in UL 508A/NFPA 79 industrial control panels, or is individually enclosed in its own housing. Separately provided electronic overload relays would enable protection of motors with more demanding starting characteristics. Thus, these particular combinations are also applied throughout the IEC/EN world whenever motors are encountered with difficult or long starting times.

Individual short circuit interrupting ratings are not assigned to instantaneous-trip circuit breakers. The short-circuit rating of the complete combination motor controller applies, and listed assemblies can be installed up to their maximum short circuit rating without any additional back-up protection. A selection table is located in the "Motor Starter" section of the main catalog.

NZM…A(E)…-NA, NZM…A(E)F…-NA, NZM…VE…-NA, NZM…V(E)F…-NA, Molded Case Circuit Breakers

These devices are certified in North America as inverse time molded case circuit breakers (per UL 489 and CSA-C22.2 No. 5-09)[52]. They represent the type of circuit breaker that is commonly found in energy distribution assemblies, and also frequently applied in motor control centers (MCCs) and in industrial control panels (**Table 7**). All models in frame sizes *NZM..1…-NA*, *NZM..2…-NA*[53] and *NZM..3…-NA* are additionally certified as "current limiting" and bear the marking on their nameplate. They are rated at various voltage levels depending on the frame size. Certain models are slash rated and thus suitable only for solidly grounded networks at those marked voltage levels. They are rated in amperes (A), are marked with various levels of short-circuit interrupting ratings, and can be equipped with pilot duty rated control circuit contact accessories.

They are equipped with either magnetic or electronic adjustable instantaneous trips for short circuit protection, and either fixed or adjustable, bimetal or electronic, long time tripping response elements for conductor overload protection. Additional types are available with short-circuit trip elements that have an adjustable short-time delay function. These particular trips introduce an incremental, time delay based tripping capability into the breaker which is useful in establishing selectivity in networks and also helpful in overriding momentary current surges that would otherwise lead to nuisance tripping. Inverse time circuit breakers are also suitable as protective devices in motor branch circuits[54], and can be equipped with pilot duty rated control circuit contact accessories. They can be applied up to their maximum short-circuit interrupting rating. The circuit breakers mentioned in this section can be applied without restriction in both feeder and branch circuits, and as branch circuit protective devices for motor and non-motor loads (**Table 5**). They can also fulfill the role of supply circuit disconnecting means for control panels and assemblies. They need to be combined with additional components[55] to complete individual motor branch circuit requirements. The letter "E" in the Eaton's Moeller® series device part number denotes the models that are equipped with electronic tripping means. The letter "V" denotes electronic trip breakers that have the additional, time-delayed short-circuit trip functionality. They can optionally be fitted with voltage trips (either shunt or undervoltage) to trip them open electrically, or combined with motor operators to switch them on and off from a remote location. Circuit breakers with fixed overload trips are often selected in North America to more closely match conductor ampacities. Consider a circuit with a conductor rated 150 A as an example. If an adjustable circuit breaker with a maximum adjustment rating of 250 A were to be used for the application, North American electrical codes would in most cases require a corresponding increase in size of the conductor to match the breaker maximum adjustable rating, whereas a fixed 150 A breaker would have been allowed as a protective device for the 150 A conductor. The option to fix the overload trip setting for a more closely matched selection can also be of advantageous in the IEC/EN world, particularly in the case of higher rated current loadings and lengthy cable lines.

A comprehensive selection of accessories is available for the entire circuit breaker line. Nearly all of them are certified (please refer to detailed info in the main catalog), and the range includes a number of accessories that have been specially developed to meet North American requirements. These include features that go beyond basic certification requirements and address market specific needs and conventions peculiar to North America. The most significant amongst those with respect to molded case circuit breakers and switches would include the variety of multiple operators available for the line as well as field installable terminations to accommodate a broad range of conductor connection options. A few of the accessories are essential for North American versions since they help maintain proper electrical clearances. The information provided in maintenance and installation instructions (AWA's) supplied with the breakers and switches is to be strictly followed in this regard. Devices up to and including

52 The term "inverse time" is commonly left out of the description. It denotes that the circuit breaker's tripping time is inversely proportional to the magnitude of the current.

53 Except for NZM2-ME…-NA.

54 In association with motor overload relays.

55 Refer to the section on motor starters for larger HP ratings

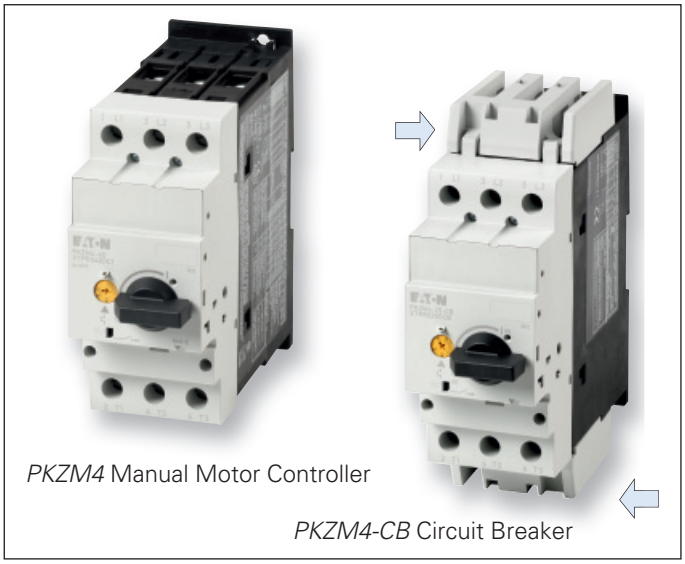


Figure 24: The *PKZM4-…-CB* circuit breaker (right) is a derivative of the *PKZM4* motor controller (left). The arrows indicate the construction changes necessary to provide the circuit breaker with the appropriate clearances in the field termination area of the component.

frame size 3 can be directly mounted on bus adapters that are part of the *SASY60i* busbar system. The high degree of flexibility offered by this most recent line of molded case circuit breakers was at first deemed unconventional for the North American market, and the complexity of the range also made the certification process initially challenging. Aided by the positive influence and proven competency of the Eaton group, exporters and end-users alike have in the meantime come to better understand and appreciate the special North American touches that were incorporated into the line and have proven to be very beneficial to their needs. This process has made it possible for the Eaton brand to achieve much improved recognition in this very important market segment.

PKZM4-…-CB, Molded Case Circuit Breaker

A fully UL 489 certified molded case circuit breaker has been derived from the line of *PKZM4* manual motor controllers. This variant is somewhat bigger lengthwise than the *PKZM4* controllers since it has been modified to incorporate the larger electrical clearances on its line and load sides per the product standard requirements (**Figure 24**). The circuit breaker version of the *PKZM4* is ideally suited as a branch circuit protective device, and can be equipped with the same line of accessories available for the *PKZM4* controllers.
The purpose of the design was threefold: Firstly, to create a device with a current range lower than what is presently available in the *NZM* circuit breaker line. Secondly, to offer it in a smaller footprint, and lastly, to provide a short circuit interrupting capability comparable to, or in some cases greater than, the *NZM* devices. The *PKZM4-..-CB* breaker thus lines up in the market comparatively well with miniature type circuit breakers like the *FAZ…-NA(RT)*, which are also available in lower current ranges, but features a much higher short-circuit interrupting rating, which can be particularly useful in short-circuit rated assemblies like industrial control panels. There is an added necessity for such designs in North America since, unlike the IEC world, local electrical codes stipulate the exclusive use of circuit breakers or fuses for all non-motor load branch circuit protective requirements. These loads often have low current consumption ratings. That can also be the case with adjustable speed drives, although the ultimate load in this instance would be a motor. Exporters thus prefer breaker or fuse based solutions for these applications, as is the recommendation of Eaton. The use of fuses is still relatively high in North American installations, in spite of the very restrictive requirements outlined in the NFPA 70E[56] standard with respect to the safe replacement of blown fuses.

N, PN Switch-Disconnectors

The IEC/EN series of *N, PN* switch-disconnectors derived from the *NZM* line of circuit breakers have successfully been applied in IEC markets globally, but are not ideally suited for applications in North America. This is based mostly on differing market expectations for these products. As a result, a line of *NS…-NA* molded case switches better geared towards North American market conventions was introduced to address the requirement, and is described in the following section.

NS…-NA, Molded Case Switches

The *NS…-NA* line of molded case switches is certified per UL 489 and CSA-C22.2 No. 5-09 and represents the more typical switch-disconnector design encountered in North America. They are mostly used as main disconnect switches in energy distribution circuits, as well as in motor control centers (MCC's) and industrial control panels. They are identical in size and similar in construction to the *NZM* breaker line of products. Both use the same range of accessories. They are rated in amperes (A), are marked with short-circuit ratings, and their auxiliary contacts are pilot duty rated for switching of control circuit loads.

These switches have an internal short-circuit trip pre-set at the factory, and no overload trips. The built-in instantaneous trip is there for the self-protection of the switch only and does not provide the switch with any protective capability for associated conductors and circuit components. The *NS…-NA* molded case switches can be applied up to their maximum short circuit rating and do not require additional back-up protection. Their auxiliary contact accessories are rated for switching of control circuits. They can optionally be fitted with voltage trips (either shunt or undervoltage) to trip them open electrically, or combined with motor operators to switch them on and off from a remote location. Although these products are considered in North America to be main disconnect switches without a protective function, they are classified per the IEC/EN circuit breaker standard as CBI-X[57], a special category of circuit breaker. It is worth noting for troubleshooting purposes that, in the event of a fault, any *NS…-NA* molded case switches installed in the circuit could react to the fault because of their internal trip mechanism. They would thus assume a tripped position, something that a non-automatic IEC style switch-disconnector would not be able to do since it lacks the tripping element. If the molded case switch does trip in the event of a fault, it would be necessary to reset it just like a breaker (switching it first to the OFF position and then back to ON).

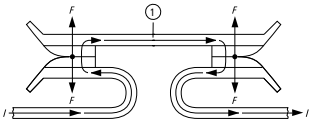
Current Limitation

Current limitation is a design feature of modern circuit breakers that provides them the capability of clearing faults much more quickly than conventional circuit breakers. It is also a feature available in a number of industrial type fuses. In the case of circuit breakers, the contact mechanism of a current limiting device is purposely designed to initiate circuit opening *before*

56 NFPA 70E, "Standard for Electrical Safety in the Workplace".

57 Circuit breakers classified as CBI-X do not have overload trips. Per IEC/EN standards switch-disconnectors are not allowed to be equipped with current actuated trips.

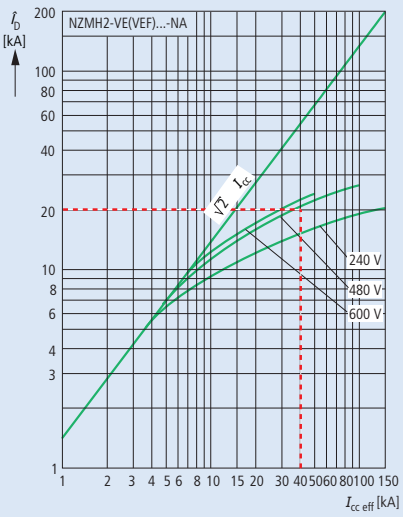
Circuit breakers with current limiting properties. How is current limitation achieved?



Current flow in adjacent opposing conductors will generate magnetic fields around each conductor that will repel each other. This dynamic and physical repulsion effect forms the basic of the circuit breaker's current limiting design. The principle behind a current limiting contact system. The magnitude of the repulsive force can be approximated by the formula $F \sim I^2$.

① = Movable contact

Figure 25: Current flow in adjacent opposing conductors will generate magnetic fields which repel each other. At high fault current levels the associated force leads to a dynamic lift-off of the contact surface. The same principle applies to modern rotational contact designs pictured above.



Characteristic let-through current curves of circuit breaker type *NZM2* with breaking capacity H = High.

The maximum available fault I_{cc} selected for this particular example is 40 kA rms sym.

The associated let-through current in a 480 V distribution network would then be 20 kA, peak value.

Per IEC/EN standards all components located downstream from the current limiting protective device would require a short circuit rating no greater than 20kA. In Control Panels for Industrial Machinery per UL 508A and NFPA 79, this physical effect is used in more restricted fashion.

Figure 26: The characteristic let-through current curve shows the effect of current limitation. In the example shown a peak available I_{cc} fault level of 40kA yields only a maximum $\hat{I}_D$ let-through current of 20kA. Please note: I_{cc} is an effective current (RMS sym) whereas $\hat{I}_D$ is a peak value. The current limiting effect is also voltage dependent.

the built-in trip elements can react. The fault current can thus be cleared well before it can reach its maximum level. The design is sometimes described in more detail as a dynamic lift-off of the power contacts through the use of magnetic fields surrounding the contact circuit paths (**Figure 25**). The key point is that the quick interruption of the short-circuit current leads to drastically reduced levels of let-through current and energy, which greatly minimize the destructive effects of dynamic and thermal forces on the installation downstream of the circuit breaker (**Figure 26**).

Per IEC/EN standards, the short circuit ratings of all components installed downstream of current limiting circuit breakers are selected in accordance with the breaker let-through values. The North American installation standards on the other hand, such as the requirements outlined in NFPA 79 and part 2 of UL 508A for industrial machinery control panel assemblies, only make limited use of this physical effect. Supplement SB of UL 508A, which deals with the determination of a panel's overall short circuit rating (SCCR), acknowledges the special properties of current limitation, but still requires that all branch protective devices (BCPDs[58]) located on the load side of a current limiting device have a short circuit interrupting rating at least equal to that of the feeder protective device. The advantages of the current limitation effect in this regard are practically ignored, which leads to control panel assemblies that are unnecessarily expensive. In reality, the destructive forces unleashed by a short circuit current are always greatly lessened on the load side of a current limiting device. The standard at least recognizes the effect with respect to passive components installed in load side branch circuits[59] by requiring that their respective short circuit rating be determined in accordance with the upstream current limiting protective device's let-through values.

58 Protective switch for individual load or branch circuits.
59 e.g. contactors, drives.

Eaton offers a number of UL/CSA certified current limiting molded case circuit breakers under the brand name Moeller® series, including devices in frame sizes *NZM1…-NA, NZM2…--NA*[60] and *NZM3…-NA*, as well as the miniature style *FAZ..-NA* and *FAZ..-RT* circuit breakers. All of these were designed with current limiting characteristics and they are marked and certified accordingly.

Circuit breakers in the larger *NZM4…-NA* frame size feature a single break contact mechanism, which is better suited for selectivity purposes in energy distribution circuits. The power contacts of circuit breakers in higher current ranges are usually located at the upper end of an energy distribution network and can better operate selectively if they can remain closed for longer periods of time. The one second withstand current performance test per IEC/EN standards is an important criterion in this regard. Ideally, circuit breakers in the upper levels of the energy distribution network remain closed while lower rated downstream breakers located closer to the affected load can react more quickly to clear the faulted circuit (**Figure 27**). That's the general idea behind selectivity, in a nutshell. The selectivity effect is aided in the case of upstream circuit breakers by adding short-time delayed tripping elements into their design. Selectivity in a properly functional circuit thus more or less rules out the use of current limiting devices in the upper current ranges of the energy distribution network.

Series ratings of protective devices, back-up protection

The IEC/EN standards generally permit the use of additional upstream devices with higher short circuit ratings as a solution whenever the short circuit rating of downstream protective devices is determined to be insufficient at handling the available fault for any given application. The serial arrangement of two protective devices in this manner combines to safely interrupt the larger short circuit current. The overall array is referred to as "group protection" when the higher rated protective device is supporting/protecting a group of downstream protective devices with lesser short circuit ratings.

60 Except for NZM..2-ME…-NA.

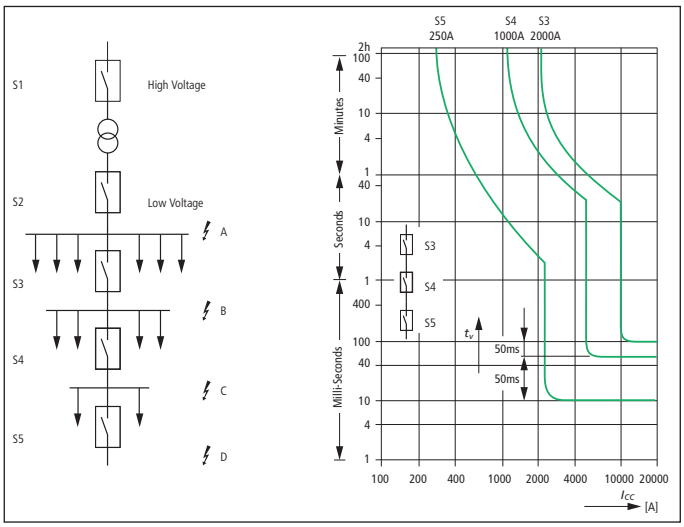


Figure 27: Example of a cascading supply system network. The breaker in each respective sub-division must operate selectively with one another. This can be accomplished using time delay trip settings on circuit breakers for selectivity purposes. The devices at the lowest level and closest to the load (S5 in the example) would be equipped with instantaneous trips. In the levels above, the trip settings of the upstream breakers would be intentionally delayed, in increments of 50 ms, 100 ms, etc...

North American based energy distribution equipment standards also allow groupings of protective devices in similar fashion (series ratings), but this capability does not extend to industrial control panels (ICPs), such as those used for industrial machinery per NFPA 79 and part 2 of UL 508A. For those particular standards, an increase in the overall short circuit rating of the assembly using series rated combinations of protective devices is currently not allowed. Popular protective devices in the IEC/EN world, such as the *FAZ…-NA* and *FAZ…--RT* miniature style circuit breakers, have short circuit interrupting ratings no greater than 10 or 14 kA, depending on their nominal current ratings. These devices are ideally suited for use in industrial control panels. Unfortunately, there is at present no possibility per the North American panel standards to introduce an upstream breaker or fuse as a means of raising the combination's overall short circuit interrupting capability. A protective device that is part of a control panel assembly must always have a rating equal to, or greater than, the panel's overall short circuit rating. The panel's design can certainly call for a series arrangement of protective devices in its feeder and branch circuit layout, but the panel's overall rating is not positively impacted by the fact. The interrupting rating of each protective device in the panel must always be equal to, or greater than, the available fault current at the panel's incoming supply circuit termination point.

Operating handles for molded case circuit breakers and switches

The operating handles of circuit breakers and switches, particularly when the equipment is used as the supply circuit disconnecting means for industrial machinery, are very closely scrutinized by local electrical inspectors. That is especially the case for IEC style door mounted rotary handles that are interlocked with control panel doors. A description of the rather complex requirements pertaining to industrial machinery applications is provided in the next section. There is also a separate technical paper by this author[61] on this very topic.

Part 2 of UL 508A (Industrial Control Panels)[62] and NFPA 79[63] are the major North American standards covering the requirements of electrical equipment for industrial machinery (**Figure 28**). These standards stipulate that the operating handle of a supply circuit disconnecting switch[64] for this equipment must remain in physical contact with the switch at all times, independent of the door position. The operating handle must be padlockable in the OFF position, and, during normal operation, switching the supply circuit disconnect to the ON position should only be possible when all panel doors are closed. Furthermore, all doors need to be interlocked, either electrically or mechanically, or both, in such a way as to prevent their opening when the switch is in the closed or ON position[65]. The use of an overly simple electrical interlock, such as a voltage trip accessory to trip the switch in case a panel door is opened, is best avoided because it could still subject personnel and the equipment to hazardous or dangerous conditions depending on

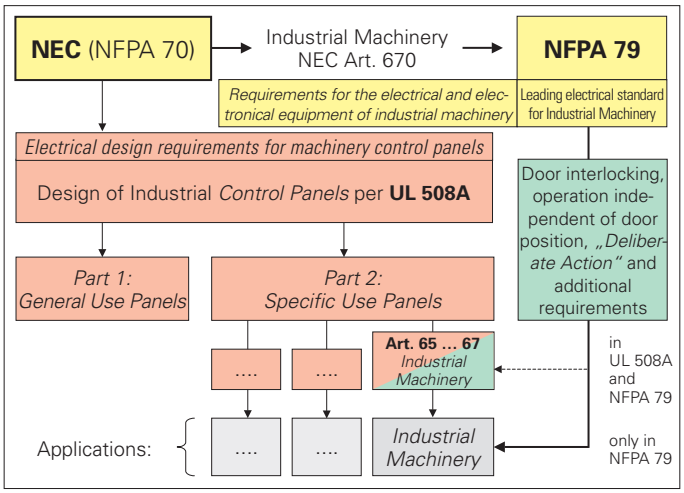


Figure 28: Relationship between the relevant standards NFPA 70 (NEC), NFPA 79 and UL 508A dealing with electrical control panels for industrial machinery. There are many different types of industrial control panels. Control panels for industrial machinery are usually afforded the most stringent requirements, including, for example, specific door interlocking provisions and permissible ways to secure operation of the supply circuit disconnecting means when the control panel door is open.

the circumstances[66]. A suitable defeat mechanism[67] should be in place to allow qualified persons to override the interlocking provision for troubleshooting purposes; however, it's always best and safest to switch off all power in order to conduct any corrective action.

A vertical motion or side flange mounted operator is the most commonly encountered North American operating handle design which establishes a permanent connection with the disconnecting means. These operators usually mount to the side and are linked to the switch either mechanically or via a Bowden style cable for a more flexible connection. The typical enclosure design to house the disconnect switch will feature a flanged side along the length of the enclosure with an opening into which the operating handle is mounted (**Figure 29**). The design ensures that, even with the panel door opened, the operator remains in contact with the switch at all times. The use of enclosures with flanged sides is what led to the term "flange mounted handle" as a way to reference this particular style of operator. The handles are also mechanically

61 VER1230-966 "Supply circuit disconnecting means with rotary handles in compliance with NFPA 79 and UL 508A.
62 UL 508A, UL Safety Standard for Industrial Control Panels.
63 NFPA 79, Electrical Standard for Industrial Machinery, comparative in scope to IEC/EN 60204-1.
64 Supply Circuit Disconnecting (Isolating) Means.
65 It's less common in North America for electrical switching and protective equipment, including passive components, to be inherently touch safe in their basic construction.

66 The various "Stop" categories from the IEC/EN and NFPA 79 standards need to be taken into consideration.
67 "Defeat Mechanism" = To intentionally bypass a safety interlock, usually with the aid of a tool such as a screwdriver.

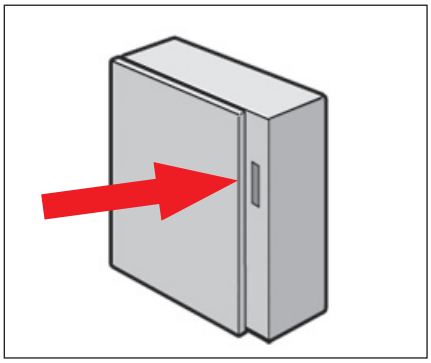


Figure 29: Typical North American enclosure with flange mount and side opening to accommodate "Vertical Motion Handles".

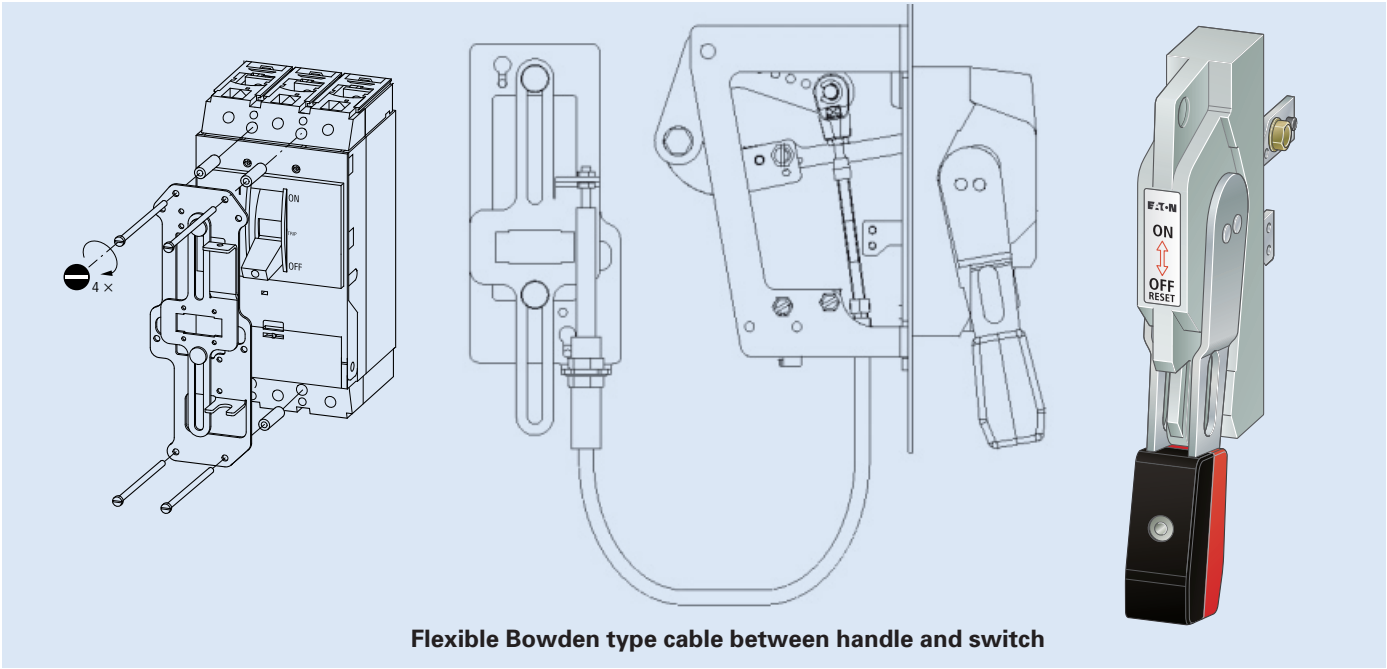


Figure 30: The vertical motion handle (pictured at right) is linked to the switch via cable and represents an operator design commonly found on North American supply circuit disconnecting means. The handle always remains in contact with the switch, independent of the door position. The flexible Bowden style cable is more often used in industrial control panels. The handle and enclosure typically interlock mechanically with the door.

interlocked with all control enclosure doors via latches and connecting rods. Eaton does offer a vertical motion operator[68] in the Main Catalog (**Figure 30**) that is linked to the switch via cable, and is available in different cable lengths. This particular style of operator does not fulfill all the relevant mechanical rigidity requirements spelled out in the IEC/EN 60947[69] standard for switch-disconnector handles, and is thus suitable for use only in North America. They do not bear a CE mark. Panel builders which work more commonly to the IEC/EN standards rarely see a demand for these style operators and enclosures and will typically only use them on special requests from their clients.

Switches installed in energy distribution assemblies tend not to be operated all that frequently. Toggle operated devices usually offer the most cost efficient option for those applications. The rotary style, door mounted handle is typically the most popular operator used in export based industrial control panels and assemblies [70]. The supply circuit disconnecting means in this case would likely feature a door mounted and interlocked operator with a high environmental rating, which would be used to operate the disconnect during normal operation with panel doors closed. Opening the control panel door positions the operator on the exterior side of the opened door, and in this position, the switch inside the panel no longer can be actuated without the use of a tool or special operating handle, which causes a conflict with North American requirements.

Eaton introduced years ago under the Moeller brand a very economical "maintenance" operating handle designed to mount directly on the disconnect shaft and be used by qualified personnel to operate the switch with the door in the open position. This was done to address a perceived need to furnish maintenance personnel with a better qualified tool for the operation, since the actuation of an open style mounted switch does come up occasionally as an issue within IEC/EN circles. A more complex version of a supplementary handle[71] was recently introduced to fulfill the "deliberate action"[72] requirements in place in the North American industrial machinery equipment standards. This new handle is presently being supplied as part of a supply circuit disconnecting means operator kit for these applications. It's designed to be assembled directly on the shaft of the enclosed disconnect switch. The new supplementary handle effectively prevents inadvertent closing of the switch when the panel door is open unless a qualified person undertakes a deliberate action which, per the Eaton solution, requires the handle to be initially moved appr. 20° to a position from which it can be simultaneously pushed in and turned clockwise to actuate the switch (**Figure 31**). Re-opening of the switch from that position can be done directly without any intermediary steps. The conscious decision to initially turn, and then combine a pushing and rotating motion to close the switch, constitutes the necessary "deliberate action" as required by the standards.

The Eaton brand thus offers the European market a unique rotary operator solution for this critical application, with many competitive advantages, since the door mounted portion of the handle can maintain its high environmental rating[73] with the enclosure and offer a comfortable and conventional way to operate the switch in full conformity with the requirements. A disconnecting means equipped with a certified supplementary handle in this fashion features two operating means, two distinct switch position indicators and two padlocking provisions, each of which is necessary to operate the switch in both the closed and open panel door positions, as the standard requires. This particular solution also lends itself to IEC/EN type installations, since the same concerns that fueled the design are also present outside North America.

68 e.g. NZM-XSHGVR12-NA, plus additional parts.
69 Tests to verify that the operator of a disconnect switch with (simulated) welded contacts cannot be readily be brought into an OFF position from which it could be secured with a padlock.
70 Control Panels for Industrial Machinery per UL 508A and NFPA 79.
71 Deliberate Action = An additional, intentional operative action imposed on the end-user by the design of the equipment.
72 e.g. NZM…-XHB-…-NA.
73 The environmental rating, or degree of protection, of is an important criterion in the approval of electrical equipment.

Control panel enclosures with a single door can easily be mechanically interlocked with the disconnect switch via the door-mounted handle. Qualified persons override this purely mechanical interlocking provision by the use of defeat mechanisms[74] designed for the purpose.

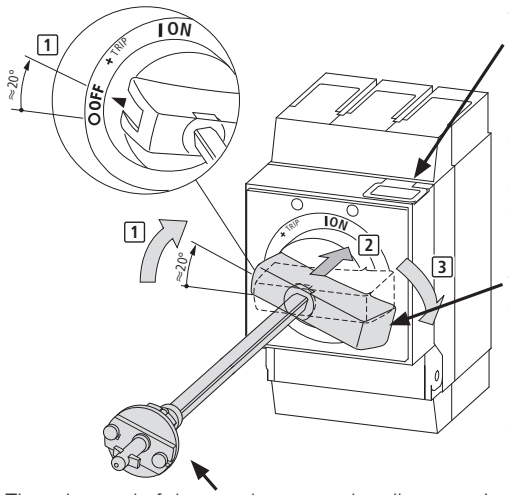
On the other hand, interlocking multiple door control panel enclosures in the same manner is not a practical approach. Alternatively, an appropriate electrical interlock must be introduced to supplement the overall interlocking provisions for the panel. This electrical interlocking provision is also able to be defeated by qualified persons. It must be automatically reactivated once the last door has been re-closed. Many of our clients use special limit switches equipped with a door fastening provision as an electrical interlocking means for this purpose, as opposed to simpler limit switch designs that are just mechanically actuated by the door. The use of specialized door fastening switches is one step closer to a fully mechanical door interlocking system and provides a high level of safety.

Door mounted rotary handle operators for North America

The *NZM…-XTVDV..* operators for *NZM* and *NS..-NA* switches, developed primarily for applications outside North America, are designed to mechanically interlock with the control panel door when the switch is closed, but release the interlock to allow the door to open as soon as switch and handle are brought to the "OFF" position. The *NZM..-XTVDV-NA* North American version of the same handle has an additional over travel position, slightly beyond OFF, that must be actuated by the user to release the interlock and open the door (**Figure 32**). This prevents the door from opening on its own once the handle has reached the OFF position, and is more in line with North American conventions. Both versions are UL/CSA certified.

74 Actuation of a screw on the operating handle with the use of a screwdriver.

Example: Supplementary handle for Types NZM2 switches



The lifting clamp on the rotary drive mechanism is a padlocking provision to allow lock out of the switch in the OFF position when the door is open.

The supplementary handle, with switch position indication, allows operation of the switch when the door is open.

The other end of the supplementary handle extension shaft terminates into the door handle coupling mechanism shown here. The coupling mechanism provides the link to the rotary handle mounted on the exterior door of the panel.

Figure 31: The new supplementarx handle requires a deliberate action (by qualified persons) before it can be engaged to operate the switch to the On position, should the control panel door be open (e.g. for maintenance purposes). The deliberate action consists of the following 3 operational movements:
1. The handle must first be turned clockwise appr. 20°.
2. At this 20° position the handle is pushed in to engage the shaft.
3. From this pushed-in position the handle can be turned all the way to ON to operate the switch.
From the On position, the switch can be turned back to OFF directly, without any intermediary manipulation. The switch can be locked in the OFF position with up to 3 padlocks using the padlocking provision on the switch housing. If the handle is not turned and pushed in simultaneously during an attempted operation, it simpy rotates unengaged up to the point at which its travel perceptibly reaches a preset stop point. The switch is not being operated in this case.

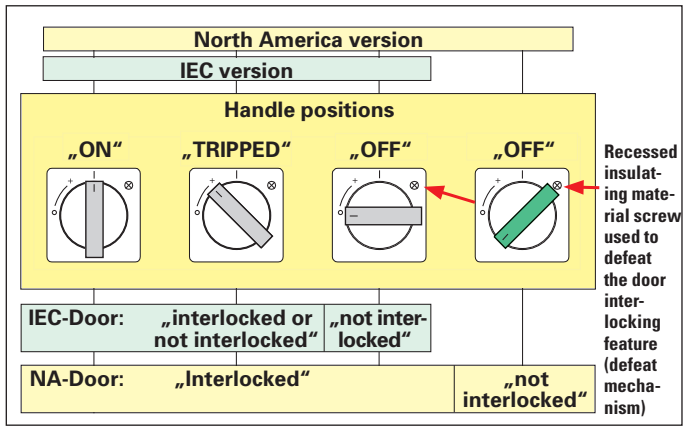


Figure 32: Description of various operating handle positions for main disconnect switches in North America. The three positions on the left are also representative of the IEC handles. In the OFF position, the control panel door can be opened. In the North American version, the handle in the OFF position remains interlocked with the panel door. A slight operational overtravel beyond the OFF position is necessary for the handle to release the interlock and allow the door to open. This is the preferred method in North America for these types of handles because it prevents the door from otherwise unintentionally opening on its own if the handle is in the OFF position. These handles are all equipped with an interlock defeater mechanism which can be accessed with a screwdriver by qualified persons.

FAZ Supplementary Protectors

These products are used in electrical equipment to provide a supplementary protective function (Supplementary Protectors per UL 1077 and CSA-C22.2 No. 235)[75]. They are often used in industrial control panels to provide additional protection in branch and control circuits but are not intended to provide branch circuit overcurrent protection required by the electrical codes. Supplementary protectors as a category of electrical products have a reputation for being often miss-applied as alternatives to circuit breakers and fuses. The protectors under the brand name Moeller have both AC and DC short circuit ratings provided on their nameplates and in product literature. They are thus suitable also for DC circuits up to the maximum voltage marked on the devices.

FAZ supplementary protectors are recognized components per UL standards. They are provided with fixed instantaneous tripping elements for short-circuit protection as well as fixed settings of bimetal trips used for overload protection. Eaton offers supplementary protectors under the Moeller brand in various tripping characteristics per IEC/EN standards. Selection of the proper trip characteristic is done in accordance with the type of load, as per IEC methodology.

FAZ supplementary protectors (**Figure 33**) are particularly well suited for fuseless protection of control circuits, and in the

75 Supplementary protectors provide additional protection to load side components in branch circuits on the load side of the branch circuit protective device (BCPD).

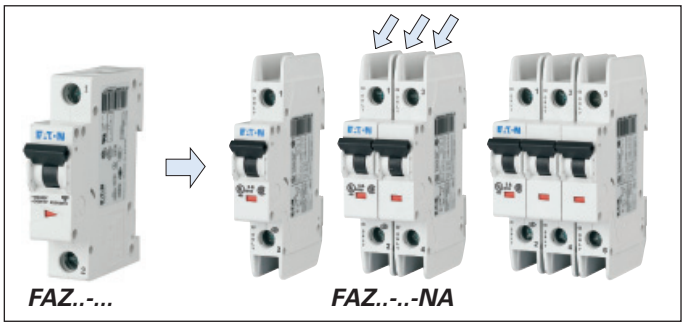


Figure 33: The conventional European miniature circuit breaker and North American supplementary protector (FAZ, UL 1077 and CSA-C22.2 No. 235) is modified with larger electrical clearances in the field termination area to allow certification as a molded case circuit breaker *(FAZ..-...-NA)* per UL 489 and CSA-C22.2 No. 5-09.

secondaries of control circuit transformers. They are also permissible as primary side protective devices for control circuit transformers, but are not suitable for the protection of power transformers.

FAZ...-NA, FAZ...-RT miniature style, UL/CSA molded case circuit breakers

FAZ...-NA and *FAZ...-RT* circuit breakers are a derivative of the *FAZ* supplementary protector line. The *FAZ...-NA* and *FAZ...--RT* both have larger electrical clearances at their field wiring terminations (**Figure 33**). They are certified as molded case circuit breakers per UL 489 and CSA-C22.2 No. 5-09. They are "Listed" per UL, and "Certified" per CSA. They are provided with fixed instantaneous tripping elements for short-circuit protection as well as fixed settings of bimetal trips used for overload protection. They are additionally certified as "current limiting" and marked accordingly. They are rated in amperes (A), have marked short circuit interrupting ratings in kA and auxiliary contact accessories that are pilot duty rated. In addition to AC ratings they are suitable for DC, with 48 V single pole and 96 V double pole DC ratings[76].

These miniature style circuit breakers are suitable as protective devices for both feeder and branch circuits. The *FAZ...-NA* and *FAZ...-RT* line up to 32 A is suitable for solidly grounded networks at a maximum voltage rating of 480Y/277 V, and is fully rated at 240 V for currents > 32 A. The type suffix *"-RT"* stands for "Ring Tongue" termination. In this particular variation the terminal screw can be fully unwound to allow the connection of ring type cable lugs.

FAZ...-NA and *FAZ...-RT* breakers are offered in 1, 2 and 3 pole configurations, and in B, C and D trip characteristics to IEC/EN standards. Selection of the proper trip characteristic is done in accordance with the type of load, as per IEC methodology. Available accessories include auxiliary contacts, voltage trips and bus connector links, all suitably constructed with larger electrical clearances.

76 Certified devices rated 125 VDC single pole and 250 VDC two-pole, please inquire.

Classification	**Contact Rating Designation** at maximum voltage values			**Thermal Continuous Current**	**Switching Ratings**				
AC	**600 V**	**300 V**	**150 V**	**A**	**Volts V**	**Make A**	**Break A**	**Make VA**	**Break VA**
Heavy Duty	A600 A600 A600 A600	A300 A300 - -	A150 - - -	10 10 10 10	120 240 480 600	60 30 15 12	6 3 1.5 1.2	7200 7200 7200 7200	720 720 720 720
Standard Duty	B600 B600 B600 B600	B300 B300 - -	B150 - - -	5 5 5 5	120 240 480 600	30 15 7.5 6	3 1.5 0.75 0.6	3800 3800 3800 3800	360 360 360 360
	C600 C600 C600 C600 - -	C300 C300 - - D300 D300	C150 - - - D150 -	2.5 2.5 2.5 2.5 1 1	120 240 480 600 120 240	15 7.5 3.75 3 3.6 1.8	1.5 0.75 0.375 0.3 0.6 0.3	1800 1800 1800 1800 432 432	180 180 180 180 72 72
DC									
Heavy Duty	N600 N600 N600	N300 N300 -	N150 - -	10 10 10	125 250 301 - 600	2.2 1.1 0.4	2.2 1.1 0.4	275 275 275	275 275 275
Standard Duty	P600 P600 P600 Q600 Q600 Q600	P300 P300 P300 Q300 Q300 -	P150 - - Q150 - -	5 5 5 2.5 2.5 2.5	125 250 301 - 600 125 250 301 - 600	1.1 0.55 0.2 0.55 0.27 0.10	1.1 0.55 0.2 0.55 0.27 0.10	138 138 138 69 69 69	138 138 138 69 69 69
	- - -	R300 R300 -	R150 - -	1 1 -	125 250 301 - 600	0.22 0.11 -	0.22 0.11 -	28 28 -	28 28 -

Table 12: Control Circuit contact ratings in AC and DC circuits

Selection and application guidelines for North American power fuses used in Feeder and Branch Circuits								
Suitable for use in:		UL/CSA Standards	Characteristics	SCCR	Typical ranges in Amps	Applications		Comments
USA	Canada							
Class H „Code“	Class H No. 59 „Code“	UL248-6/7 C22.2 248-6/7	Fast-Acting	10 kA/250 V AC 10 kA/600 V AC	0…600	Residential, Commercial, Industrial		Class H, K and No. 59 „Code“ fuses are physically interchangeable and fit in the same fuseholders. Refer to comments below under Class K.
Class CC	Class CC	UL248-4/ C22.2 248-4	Fast-Acting & Time Delay	200 kA/300 V AC	0.5…30	Fast-Acting: Protection of resistive and inductive loads. Appliances, Heaters, Lighting, Mixed loads in Feeders and Branch Circuits.	Time Delay: Protection of inductive and highly inductive loads. Electrical Motors, Transformers, Lighting...	Extremely compact size! Current limiting per UL/CSA Standards!
Class G	Class G	UL248-5/ C22.2 248-5	Fast-Acting Time Delay	100 kA/480 V AC	21…60			Compact size! Current limiting per UL/CSA Standards! Non-interchangeable with any other fuse class.
				100 kA/600 V AC	0.5…20			
Class J	Class J HRCI-J	UL248-8/ C22.2 248-8	Fast-Acting & Time Delay	200 kA/600 V AC	1…600			
Class K K1, K5	Class K K1, K5	UL248-9/ C22.2 248-9	Fast-Acting & Time Delay	50 kA, 100 kA, 200 kA/600 V AC	0…600			Not marked current limiting per UL/CSA Standards! That's why Class K fuses are often substituted by rejection -type Class RK... fuses. Current limiting per UL/CSA Standards! Non-interchangeable with any other fuse class.
Class L	Class L	UL248-10/ C22.2 248-10	Fast-Acting & Time Delay	200 kA/600 V AC	601…6000			
Class R RK1, RK5	Class R HRCI-R RK1, RK5	UL248-12/ C22.2 248-12	Fast-Acting & Time Delay	50 kA, 100 kA, 200 kA/600 V AC	0…600			Current limiting per UL/CSA Standards! Types RK1, RK5 and HRCI-R fit in the same rejection-type fuseholders, and are non-interchangeable with any other fuse class. RK1 fuses have lower let through values than RK5 fuses.
Class T	Class T	UL248-15/ C22.2 248-15	Fast-Acting	200 kA/300 V AC 200 kA/600 V AC	0…1200		-	Extremely compact size! Current limiting per UL/CSA Standards! Non-interchangeable with any other fuse class.

The characteristics and application guidelines mentioned above provide a general overview only. Most fuse types also carry DC ratings per UL and CSA standards.

Table 13: Selection and application information on North American fuses suitable as feeder and branch circuit protective devices

Certification of switching and protective electrical equipment for applications in North America

Conventional designs in North America historically featured products that tended for the most part not to be modifiable by the customer once they were produced, labeled and applied in the field. In Europe the tendency earlier on in product development was to cater more towards flexibility for the customer, by introducing more modularity into the designs of parts such as auxiliary contacts, shunt and undervoltage trips and additional accessories in order to make them more suitable for field installation. This more flexible design approach can now be accommodated without compromising full UL and CSA certification for the products. The concept even extends to modifications in the power circuit, such as in field exchangeable termination kits for circuit breakers. The area of terminations can be particularly significant, since maintaining proper electrical clearances at all times, for all possible combinations, is always critical. All variations must, of course, be tested, documented and certified. Terminations that are field installable must be marked on the product nameplate. Installation instructions provided with the device must be strictly followed, and any piece supplied loose as part of a kit cannot be carelessly left out simply because their functional purpose is not immediately recognizable. Insulating plates, barriers and covers can prevent dangerous conditions from occurring, such as phase to phase flash-overs under short circuit conditions, and generally enhance safety by making components in an installation more secure against accidental touch from a hand or finger.

The added functionality afforded to electrical components such as contactors, circuit breakers, manual motor starters, limit switches and pilot devices by the introduction of more modular design concepts[77] has greatly expanded the application range of these products and proven itself globally over many years, both technically and economically. The modular approach provides manufacturers and end-users alike the ability to streamline production more efficiently, keep inventories at a minimum, and achieve optimal solutions to application requirements in a more timely fashion.

The electrical ratings of auxiliary contacts appearing in technical data sections of catalogs and on the components themselves ("Pilot Duties") are standardized current and switching duty classifications for AC and DC circuits appearing in the product standards. They are shown in **Table 12** under the heading "Auxiliary contact ratings in AC and DC circuits". Auxil-

77 Introduced into the Moeller line of control circuit devices and contactors in 1984, and somewhat later in motor protective switches.

iary devices in the Eaton line are mostly rated for "Heavy Pilot Duty", although some are "Standard Pilot Duty" rated. More details on these ratings are provided in the technical data sections of the catalog for each respective component. Some of the product rating nameplates carry a designation such as "600 V, same polarity". This means that adjacent circuits of an auxiliary contact block or module must be fed from the same source at that same potential.

Fuses and fuse holders

1) Assuming that proper component selection guidelines, as highlighted in previous sections, have been followed, the choice of fuseless based solutions using circuit breakers and suitably certified manual motor controllers can offer significant advantages over fuse based engineering:

   a) Only North American fuses are considered suitable for applications in North America. The use of IEC/EN type fuses is not accepted.
   b) Fuse bases for certain types of fuses, e.g. Class R, are relatively large, and take up a lot of panel room. Combining such fuses with contactors and overload relays does not usually lead to optimal utilization of available space.
   c) An *NZM* inverse time circuit breaker combines the functions of isolator, short circuit protection, overload protection and trip signalization all in one device, and is often smaller and more economical than a comparable fusible disconnect device.
   d) It's possible in certain cases to mix incompatible fuses and fuse bases. The use of additional markings indicating the correct type of fuses is necessary to avoid mishaps.
   e) Machine exporters often complain of long delivery times and high prices when sourcing North American fuse equipment in Europe.

On the other hand it's important to note that fuses are usually quicker at clearing fault currents than circuit breakers, since the process requires melting only of a fusible element, and does not otherwise involve any movement of mechanical parts. This can often lead to more desirable short circuit current rating levels (SCCR) for components using fuse based systems.

2) Generally speaking, fuseless based engineering will minimize the need for available spare parts and eliminate fuse exchangeability problems. In the event that fuses are necessary, the following selection guidelines would need to be taken into consideration:

   a) North American fuses are classified per size, interrupting rating, and characteristic. There is a group of UL standards (UL 248-…) used to certify each class type. **Table 13** provides a general overview of each classification and their distinctive features.
   b) *Motor branch circuits:*
      When using time-delay fuses[78]:
      Maximum fuse rating = 1.75 x Motor Full Load Amps (A larger fuse rating not exceeding 2.25 x Motor Full Load Amps is allowed as an exception).
      When using quick acting fuses[79]:
      Maximum fuse rating = 3 x Motor Full Load Amps (A larger fuse rating not exceeding 4 x Motor Full Load Amps is allowed as an exception).
   c) *Non-motor loads:*
      Follow manufacturer's instructions for the type of load involved. The same holds true for variable-speed drives. If the manufacturer instructions do not specify the type and size of fuse refer to the respective electrical codes for guidance.
   d) Power circuit components
      Information on proper fuse requirements for components requiring fuse protection will be marked on the component, and also provided in the technical data section of the main catalog. Short-circuit protection requirements of Eaton non-combination starters (contactor + overload relay) are also provided in the main catalog.

It is recommended to choose the smallest fuse size fulfilling criteria 2b), 2c) and 2d) in order to insure a proper running start for motor loads, as well as provide short circuit protection of all power components in the branch circuit. Quick acting fuses can sometimes be more helpful in achieving higher branch circuit short circuit ratings (SCCR) than the use of fuseless based motor protective devices.

***T* Rotary cam switches, *P1* and *P3* switch-disconnectors**

These components are certified in North America as Industrial Control Equipment (per UL 508 and CSA-C22.2 No. 14-05). *P1* and *P3* switch-disconnectors are 3-phase devices and feature two switching positions (**Figure 34**). They are primarily used in industrial control panels or as individually enclosed switches. They are HP rated and marked in amperes (A), and their auxiliary contacts are pilot duty rated. These components do not offer any protective function and are applied as motor disconnect switches in association with upstream branch circuit fusing. They can be used to switch motors and non-motor loads directly across-the-line and their auxiliary contacts are rated for control circuit duty. *T* type rotary cam switches can be equipped with up to 11 separate contact chambers[80] and can be configured in multiple switching positions. They are used primarily as control

78 "Dual Element time delay fuses" or "Time delay fuses".
79 "Non-time delay fuses".

80 11 contact chambers for a total of 22 contacts.

Figure 34: T rotary cam switches, and *P1* and *P3* switch-disconnectors are certified as industrial control equipment per UL 508 and CSA-C22.2 No. 14-05 and additionally evaluated as motor disconnects. They can be used as individually enclosed isolating disconnect switches local to the motor when installed on the load side of the motor branch circuit protective fuse. A line side motor disconnect switch must be certified per energy distribution standards such as UL 489 and CSA-C22.2 No. 5-09.

Figure 35: The new line of *DC1* and *DA1* variable frequency drives are world market products and certified for the North American market.

circuit switches, e.g. multi-positional circuit selector switches, instrumentation (voltmeter/ammeter) switches, step switches etc…but are also HP rated, so they can be used in power circuits to switch motors directly across-the-line and in manually operated reduced voltage starting applications.

These types of controllers can be additionally evaluated as "Motor Disconnects" per UL 508 and CSA-C22.2 No. 14-05 and applied on the load side of branch circuit protective devices as enclosed isolator switches local to the motor. They will be marked as such or a marking will be provided on the documentation supplied with the device. *T* and *P* switches from Eaton fulfill all motor disconnect requirements and rating information on appropriate upstream protective devices to be used for the application appear in the catalog as well on the device nameplate or in accompanying documentation supplied with the switches.

DS7 Softstarters

Softstarters are treated very much the same way as regular contactors in North American standards, which is also the case per IEC/EN 60947 product standards. The devices are constructed, tested and certified as industrial control equipment per UL 508 and CSA-C22.2 No. 14, and also meet the requirements of CSA-C22.2 No. 0-M91. Short circuit protection is provided conventionally by either circuit breakers or fuses. Motor overload protection in the branch circuit would be provided by a separately mounted overload relay. Alternatively, softstarters or solid state motor controllers can also be tested and combined with Type E manual self-protected controllers to create Type F combination motor controllers, similar to the Type F controllers built with conventional magnetic motor contactors. Information on proper sizing requirements for branch circuits equipped with soft starters is provided in table form in the main catalog.

The DS7 softstarters from Eaton are rated for a maximum supply voltage of 480 V 50/60 Hz (full voltage rated). They are UL listed and CSA certified and are applied as controllers in motor branch circuits. The softstarters are designed to be shorted out by an internal bypass circuit once the motor has completed its starting sequence. This reduces the overall heat losses of the starter and lessens the burden on the thyristors. Possible shorts arising in the branch circuit would also flow through the bypass circuit instead of the thyristors. This raises the overall operational safety of the softstarters. Certain models feature 2 phase switching with the third pole allowed to conduct unswitched. A competitive advantage of Eaton softstarters lies in the fact that their field terminations are adapted to those of the protective devices with which they are applied (**Figure 35**). Devices rated 41 A and up have the same connectors as the molded case circuit breakers in that range and also share certain termination accessories from the line.

DC1 and *DA1* variable frequency drives

Drives are constructed, tested and certified per the UL 508C and CSA-C22.2 No. 14-05 product standards (**Figure 35**). Short circuit protection is provided conventionally by either circuit breakers or fuses. Type E motor starters can be used for protection if the variable frequency drive has been tested together with the type E starter. Certainly, close attention must be paid to the manufacturer's supplied product instructions as it applies to the short circuit protection requirements of any drive. The motor overload protective requirements in the case of a single motor hook-up can be provided by the drive itself. In multiple motor applications (group applications) and in bypass circuits each motor should be equipped with individually provided motor overload protection.

Drives are applied in motor branch circuits. The Eaton drives are rated for a maximum supply voltage of 480Y/277 V, 50/60 Hz. The restriction to a slash rating in this case relates to built-in surge protective devices, which rely on the use of a solidly grounded distribution network with separately provided neutral conductor. Eaton now offers 2 fully new ranges of adjustable speed drives for 3 phase motors. They carry the type designations *DC1* and *DA1*. The DC1 series covers a range of motors up to appr. 11 kW@400 V or 15 HP@480Y/277 V and the *DA1* is used for larger motors, up to appr. 250 kW@400 V or 350 HP@480Y/277 V. Sizing and selection of the proper drive is usually done per rated motor currents rather than kW or HP rating.

Measures to reduce electro-magnetic interference (EMI or EMC) in the drive power system (PDS = Power Drive System)

Figure 36: The *easy500* and *easy700* series are a fully integrated line of certified programmable control relays with common software and operational features that offer intelligent solutions for modern machinery and equipment. The certified *MFD-Titan* is an attractive multi-function display unit which features a monochrome, backlit screen design and keypad. All available with IP 65 and UL/CSA Type 4X environmental ratings, in AC and DC versions.

Figure 37: Eaton offers a comprehensive range of certified transformers, reactors and power supplies for machinery and equipment exports to North America. Transformers can be used to build specific energy distribution networks and establish appropriate voltage levels for equipment. They can be used to create solidly grounded distribution systems and enable the use of power devices with slash ratings.

are not yet specifically defined in North American standards. It is, therefore, proper to implement the same EMC recommendations and measures outlined in the IEC/EN 81600-3 standard for noise-free operation in all machinery controls or assemblies incorporating drives and destined for export to North America.

Easy relay and *MFD-Titan*

The *easyRelay* line of programmable control relays and the *MFD-Titan* multi-function display units (**Figure 36**) are fully certified to UL 508 and CSA-C22.2 No. 142. They have additionally been certified under CSA-C22.2 No. 213-M1987(R2208)[81] for use in hazardous locations (Class 1, Division 2).

Complete technical information for the North American market, including data supplied in conventional North American units such as inches, lbs, ^{0}F, are provided in the main catalog as well as in product supplied handbooks and installation instruction documentation. The output relays have B300 and R300 Pilot Duty ratings. 24 VDC is also the commonly used voltage in North America to actuate electronic components and systems.

easyRelay and *MFD-Titan* are programmed using conventional ladder diagram programming. The easySoft software can also produce North American ANSI style circuit symbols. The *easyRelay* line of programmable control relays and *MFD-Titan* multi-function display units are thus ideally suited for applications in North America.

Transformers and power supplies

Eaton offers a very comprehensive selection of power and control circuit transformers (**Figure 37**), and a range of industrial control power supplies, all certified for the North American market. Power and control transformers typically have isolated primary and secondary windings. Matching transformers are also offered. They can be especially useful in stepping down the voltage, e.g. in Canada, from 600 V down to 480 V, because not all available power circuit components have a full 600 V rating. Transformers with separate windings used with machinery allow the formation of solidly grounded networks on their secondary side, e.g. 480Y/277 V. This type of power distribution network opens the door to modern European components (e.g. *FAZ-NA* molded case circuit breakers, Type E self-protected starters and Type F combination controllers, smaller *NZM..-..-NA* breakers) that have this rating. Since transformers can get costly if they are used for this purpose, particularly in the case of machinery with large power requirements, it may be worthwhile in certain cases to separate out the portion of the machinery which can benefit from the installation of slash-rated devices, and only use transformers to generate the desired voltage configuration for that particular section.

Environmental degrees of protection (Types) for enclosures and cover mounted operators

1) The requirements for enclosures in the US with respect to construction and environmental protection degrees are outlined in the UL 50(E) product standards, as well as in the NEC = NFPA 70 (Environmental Types table). In Canada, the applicable standards are CSA-C22.2 No. 14-05 and CSA-C22.2 No. 94. The environmental type ratings outlined in the UL/CSA standards are identical to the "NEMA" types which may still be appearing in product specifications. However, UL/CSA type ratings are third party certified and NEMA ratings are not, and this has greatly diminished the impact of straight NEMA ratings that are not accompanied by certification marks. The presence of UL/CSA marks for verification of the environmental protection level afforded by the electrical equipment has now become a strict requirement of most approval authorities. Thus, the use of products which carry UL/CSA verification of environmental ratings is highly recommended for all export applications.

2) The enclosure ranges offered by Eaton have full acceptance in North America since they are UL/CSA type rated and fulfill all the requirements of corrosion protection, complete protection against contact with live parts and protection against the ingress of liquids and solid particles. Consult the main catalog in the product section and in the technical data pages for more detailed information on all environmental degree type ratings achieved by the enclosures.

3) The IP enclosure environmental rating codes established per the IEC/EN 60529 [13] standard contain requirements that verify an enclosure's ability to resist the ingress of solid particles and water. The comparable standards in North America contain additional requirements against the ingress of oil and cold weather liquids as well as corrosion protection, and thus determine more precisely the environmental conditions present at the installation site corresponding to the ratings. **Table 14** provides an overview of North American enclosure type ratings and a comparison to the IEC IP Codes. The table references English/German definitions assigned to each type. Both systems are not readily comparable when it comes to defining the environmental ratings assigned to each enclosure rating.

4) IP Code ratings on enclosures and electrical equipment do not have any real significance in North America. They are certainly not adequate as substitutes for missing NEMA/UL/CSA type ratings and are useful for reference purposes only. Generally speaking, NEMA/UL/CSA environmental types fully cover the requirements of comparable IP Code ratings, but not the other way around.

5) The enclosure environmental type rating must appear on the enclosure nameplate or on a separately provided label, ideally

81 Non-incendive Electrical Equipment for Use in Class 1, Division 2 Hazardous Locations.

Enclosure environmental protection ratings per NEC (NFPA 70), UL, CSA, NEMA UL/CSA Types are likely to cover IEC/EN IP ratings, but not the other way around. A direct comparison is also not possible, because test criteria in both standards are different.			
UL/CSA Type 1	general purpose	Indoor use	**IP 20**
UL/CSA Type 2	driptight	Indoor use	**IP 22**
UL/CSA Type 3	dusttight, raintight	Outdoor use	**IP 55**
UL/CSA Type 3R	rainproof, sleet and snow resistant	Outdoor use	**IP 24**
UL/CSA Type 3S	dusttight, raintight, sleet, snow and ice resistant	Outdoor use	**IP 55**
UL/CSA Type 4	dusttight, watertight, raintight	Indoor or Outdoor use*	**IP 66**
UL/CSA Type 4X	dusttight, watertight, raintight, corrosion resistant	Indoor or Outdoor use*	**IP 66**
UL/CSA Type 5	driptight, dusttight	Indoor use	**IP 53**
UL/CSA Type 6	raintight, watertight, temporarily submersible	Indoor or Outdoor use*	**IP 67**
UL/CSA Type 12	industrial purpose, driptight, dusttight	Indoor use	**IP 54**
UL/CSA Type 13	oil-tight, driptight, dusttight	Indoor use	**IP 54**

* Observe additional manufacturer markings and rating information!

Table 14: Rough comparison between IEC/EN Protection Degrees for enclosures and Environmental Types commonly referenced in NFPA, UL, CSA and NEMA standards.

on the outside surface of the enclosure where it will be visible to local inspectors.

Determination and verification of proper environmental type ratings for enclosures and cover mounted equipment must be treated as a major priority item in the overall design of controls and assemblies for export to North America. That is also the case for non-standard enclosures, such as openings or cavities in machines specifically designed to house electrical components mounted directly on the machinery. Inspectors will pay particular attention to the environmental integrity of the overall equipment in their overall evaluation. The need for subsequent improvements made on installed equipment in this regard is a common occurrence. Such changes are usually both costly and time consuming. It is strongly recommended, therefore, to select appropriately rated enclosures and equipment ahead of time, i.e. during the planning and engineering stages of a project. Every subsequent opening and re-closure of an enclosure opening for the purpose of installing new equipment will be subject for review with respect to the enclosure environmental rating. Type ratings will be maintained as long as closure of the opening is made with a component rated equal to, or better than, the original rating. An example of that would be the installation of cover mounted pilot devices or handle operators with comparable or better ratings than the enclosure type rating. One must be careful also to properly close all openings, especially those that may be blocked from view by other parts. The panel builder will usually be able to tell exactly where the weak points are in terms of workmanship and adherence to the requirements. To purposely avoid those on the basis that they may not come up during inspections may just be inviting much larger problems to surface down the road. These can be especially costly at the end-user installation site, particularly if new wiring is involved. It may not always be possible for the manufacturer to make improvements on his own, since local labor conditions at the installation site may force him to hire outside contractors to perform the work, pushing costs even further upward. In those situations, the manufacturer can at best assume the role of supervisor. The enclosure type ratings touched upon in this chapter relate to the installation of electrical equipment in non-hazardous locations, i.e. applications not subject to explosive gases and atmospheres.

Steel enclosures and installation techniques

Steel enclosures are the principal housing for nearly all types of industrial control panels. The use of metal conduits as a protective means of enclosing conductors throughout an electrical installation is still very popular in North America. Individual conductors, more so than multi-conductor cables, are pulled through the conduits. It is still permitted to use the metal casing of the conduit as the grounding conductor, in which case ground continuity is maintained whenever the conduit is attached to individual enclosures via conduit hubs or metal flanges. The enclosure in this case becomes an active part of the grounding path. Steel enclosures with metal or plastic flanges can also be hooked up to non-metallic conduit, and terminations are made with hubs or non-metallic conduit attachment hardware suitable for the purpose. In this case, a separate grounding conductor would be routed through the conduit for grounding continuity purposes. Use of separate grounding conductors, rather than relying on the steel conduit casing for grounding purposes, is now the preferred method used in modern installations involving industrial machinery. The supply connections to the control panel main disconnect switch in modern machinery installations are often the only ones that are encased in metal conduits. It is worth noting that the supply connections to industrial control panels in North America are often made through the top. Strict attention to the wiring guideline requirements in the local electrical codes with respect to the physical protection, routing and loading of conductors in wiring trays and channels, as well as in cable ducts inside control panels, is highly recommended. Generally speaking, the allowable loading of conductors per North American electrical codes is much less than what is typically encountered in corresponding IEC/EN norms. This aspect will often come under the critical eye of the local approval authorities and is worth taking into consideration early on during the design stage. Special consideration must be afforded to areas where cables and conductors cross or overlap each other. Comprehensive requirements in the codes are in place for cable channels and/or trays mounted on walls and surfaces so it is equally recommended to firmly and appropriately fasten all cables and conductors mounted on the machinery itself. All aspects of the electrical system related to grounding of the equipment are extremely

important and will always be closely scrutinized during the approval phases of the installation. Adherence to the grounding provisions of the electrical codes is very often a source of problems and misunderstandings. It is absolutely crucial to obey the minimum sizing requirements of all grounding conductors and terminations. It's important also to consider the insulation protection of conductors that are routed through openings or are subject to movement during normal operation of the machinery. Machinery mounted cables and conductors that are subject to particular protection against physical damage and/or whose insulation need to be oil resistant per IEC/EN standards should naturally be offered the same level of protection in export related assemblies destined for North America. Machinery mounted cables and conductors, as well as all the parts that are associated to cable entries and fastening means, must be certified, and their certification must be locally verifiable. Strict adherence to local codes with respect to installation and sizing of equipment is an absolute must.

The requirements for internal power and control wiring in control panels, specified in the NFPA 79 and UL 508A standards for industrial machinery assemblies, must be strictly followed. Included in these are functional color coding requirements of individual conductors, sizing of conductors in AWG[82] resp. kcmil[83] cross-sections, specific wire marking guidelines and the proper separation and identification of certain critical circuits. Please note: The wiring ends of power circuit conductors in North America are typically not terminated with wiring ferrules, as is the case in Europe. This wiring practice is, as we note, very common in modern machinery assemblies designed per IEC/EN standards. Guidelines on the proper use of wiring ferrules in North American control panels, especially as it affects the overall short circuit rating of control panel assemblies, are thus currently being formulated in North America by the major standard making authorities and, at the time of this writing, were headed towards a positive resolution with respect to export assemblies.

82 AWG = American Wire Gauge.
83 kcmil = thousand circular mils, e.g. 250,000 circular mils = 250 kcmil = 250 MCM.

Figure 38: The *CS* enclosure series is a line of wall mounted steel enclosures certified for the US and Canadian marketplace. Up to 44 different enclosure sizes are available, ranging from 250 x 200 x150 mm to 1200 x 1000 x 300 mm. The enclosures are UL/CSA Type 1 and 12 rated, for industrial indoor usage.

CS wall-mounted steel enclosures

Eaton is now offering a newly certified range of *CS* steel enclosures for the North American market (**Figure 38**). These are wall mounted enclosures available in 44 different sizes ranging from 250 x 200 x 150 mm (H x W x D) up to 1200 x 1000 x 300 mm (H x W x D). The smaller enclosures are ideally suited as individual housing for small motor starters, adjustable speed drives or softstarters and associated motor branch circuit components. The larger enclosures can be used to house small to medium sized control panel components for industrial machinery control requirements. It is recommended to mount the panel directly to the machine, unless there are shock or vibration issues associated to the machinery which would make surface mounting more problematic. Mounting the panel directly to a machine can be advantageous with respect to functional testing of the assembly, and the ability to connect it more quickly to the power source. Strict adherence to the installation requirements of the local electrical codes are to be followed in cases where the enclosures need to be wall mounted adjacent to the machine. The enclosures have a IP 66 environmental code rating per IEC/EN standards, and a UL/CSA rating of Type 1 and 12 for indoor industrial use. The inner frame profile and gasketting design of the enclosure protects the contents against the ingress of liquids, such as water and oil, and mitigates the entry of dust particles inside the enclosure when the door is opened. A textured powder paint application process on the surface of the enclosures provides for abrasion-proof corrosion resistance. The mounting plates used in the enclosures are made of zinc-plated or galvanized metal. Metal bottom plates for customized wire entry configurations are included with the product. The enclosure can be rotated 180^0 to accommodate wire entry from the top or bottom, and door hinging can be easily modified in the field to fit either method accordingly.

CI-…-NA Insulated material enclosures

The *CI-…-NA* line of polymeric enclosures is UL/CSA certified and fulfills the constructional and environmental rating requirements spelled out in the US based product standards UL 508(A) and Canadian standard CSA-C22.2 No. 14-05. All versions with suffix *"-NA"* in their part numbers have been specially developed for the North American market. This makes them suitable as housing for individual motor starters as well as small to medium sized industrial control panels for machinery and general usage. Their inherent resistance to corrosion due to their non-metallic construction makes them highly desirable for applications involving damp and/or environmentally aggressive atmospheres. They can be easily connected to both metal and non-metal conduit using appropriate hubs and fittings. The concept of "Total Insulation" propagated by Eaton in product documentation as it relates to grounding and the use of non-metallic enclosures is not recognized as such by the electrical codes in North America. For this reason, grounding of the equipment inside the enclosure and grounding continuity between enclosures must be done in full conformity with the grounding provision requirements of the electrical codes, which is also described in the installation instruction documentation supplied with the product.

The *CI-…-NA* line of enclosures is certified both with and without the use of insulated material flanges. A complete selection of the UL/CSA certified lines of insulated material enclosures, incl. the smaller *CI-K* line of product dedicated insulated enclosures, the larger *CI* individual enclosures, as well as the enclosures used in *CI* type distribution board, can be found in the

main catalog. A comprehensive listing of certified enclosures accessories is also provided in the same section.

SASY60i, Busbar system

Compact and versatile busbar systems have long been an important component of modern industrial control panel designs in the IEC/EN world, whereas they are still a relatively new concept in North America. Instead, the use of distribution blocks[84] still dominates in North American designed panels as the preferred means to distribute power to panel feeder and branch circuit components. The *SASY60i* busbar system has been upgraded to full UL Listing and CSA certification. Please refer to the component identification markings in the appropriate section of the main catalog for more details. Use of listed rather than recognized systems was an important step, since it meant that the busbar system termination elements were now suitable for field installation and wiring. In addition, panel builders no longer needed to incur the additional cost of having the complete, previously recognized only system described in their control panel file and procedure pages for usage. An update to Table SA1.1 in supplement SA of UL 508A relative to busbar systems will be included in the next edition of UL 508A to reflect the current availability of Listed busbar systems.

Initially, North American ampacity levels of the busbar system were based on the formula which roughly equates to 1000 A per square-inch of surface area. Unfortunately, this rather conservative calculation led to ampacity levels that were about half of the corresponding IEC/EN ampacity numbers. The busbars have since been tested and certified to the exact ampacity values corresponding to the IEC/EN ratings. That was a significant step in helping panel builders of industrial machinery controls, who design and export world-wide, to better achieve a more uniform layout for all their global panel requirements. Eaton offers the *SASY60i* busbar system in rated currents up 1600 A in both flat and profiled copper busbar designs. The system includes a comprehensive assortment of busbar supply terminations for field wiring, as well as busbar shoe adapters to facilitate direct bus connection of top-mounted components such as motor starters, circuit breakers and molded case switches.

It is necessary in North American control panels to differentiate between feeder and branch circuits in order to determine the proper selection and configuration of busbar system components (see **Figure 9**). The larger electrical clearances, which are required in feeder circuits of control panels per the North American standard UL 508A, have been incorporated into the busbar system component designs. As an example, Type F combination motor starters mounted on busbar adapters would require specially designed busbar holders and an insulated bottom plate in order to satisfy the electrical clearance requirements of feeder circuits. Components with "smaller" electrical clearances are considered sufficient for installation in branch circuits. Thus, standard IEC/EN busbar adapters and parts are normally fine for applications in branch circuits (**Figure 39**).

Summary

The paper attempted to highlight key certification topics in North America, and provided an overview of the application and conformity of Eaton electrical components under the scope of

Figure 39: *SASY 60i* is a modular busbar system designed for optimum distribution of electrical energy in industrial control panels - safe, and space saving -. The use of busbar adapters and component shoes allow for quick and efficient mounting of incoming and outgoing power components as well as many varieties of motor starters. The photo shows an array of mounted and wired components (IEC/EN).

relevant North American electrical codes and product standards. Eaton offers a more extensive look into the requirements of industrial machinery controls per the NFPA 79 and UL 508A standards through comprehensive seminar presentations and the availability of a number of technical papers focusing on specific topics related to equipment certified for the North American market. This paper, as well as the additional documentation we provide on the subject, does not purport to totally replace the need for individual study as a means to achieve greater understanding of North American codes and standards.

There are still many exporters who claim that compliance of their equipment with North American standards is not a necessity. There certainly are documented cases in which assemblies have been quickly approved by local inspection authorities without much fuss or scrutiny, or maybe even rare situations encountered in which compliance with North American codes and standards was not strictly enforced. These isolated cases, however, should be considered as the exception and not the rule, even if one did have the good fortune of experiencing a "free pass" from local approval authorities. In reality, conformity with local electrical codes needs to be regarded as a manufacturer's legal obligation of compliance with North American regulatory laws and practices. It would be wrong and careless to assume that the experience of a lax enforcement in one particular state or province, at one time or another, will manifest itself equally so in other parts of the country, and at all times. Eaton supplies components that are in strict compliance with product certification standards and thus strongly recommends strict adherence to all the relevant North American installation codes and standards. The availability of Eaton technical papers on the subject can be looked upon by our clients as a very valuable informational resource in this regard.

There are many more examples of cases in which machine manufacturers and panel builders have been flagged and red tagged by local approval authorities when their equipment was inspected and deemed to be lacking in conformity with local electrical code requirements. That scenario is indeed a much more common occurrence. Often, the regulatory issues identified by the inspectors are grave, and exporters find themselves desperate in their search for solutions since they are ill equipped to handle the ensuing consequences. The outcome usually involves much higher commissioning costs, long delays and loss of image for the manufacturer. In some cases, depending on local labor laws, the manufacturer will not be able to carry out the corrective work directly but will need to rely on hired contractors for assistance. Rarely an enviable position.

84 Power Distribution Blocks are terminal blocks with an incoming supply side that accommodates large cross-section feeder conductors and an outgoing side featuring multiple smaller cross-sectional termination points for current distribution to connected loads.

Figure 40: This paper was prepared in conjunction with improvements made in the presentation of North American certified equipment in the new international main catalog.

The paper has dealt solely with issues directly related to the electrical equipment of industrial machinery and assemblies. It is worth noting that there are separate machinery standards touching on other aspects such as machinery construction, functional safety, risk assessment and manufacturing processes. Industrial machines exported to North America are generally more expensive than comparable IEC/EN machinery produced for the IEC world. We have deemed it our responsibility in this regard to better inform our staff and clients on the peculiarities of export machinery and its associated equipment, so that they may have a deeper understanding and greater appreciation of the higher cost structure normally associated with this market segment. Our staff has also been technically schooled on the difficult questions that clients often bring up, such as the type of power distribution network involved or the need for overall short circuit ratings, and which often have a direct bearing on cost related issues. They are thus well prepared to clarify these points directly with clients and provide qualified answers and solutions to their problems.
It may be more advantageous for firms, which only seldom supply the North American market and have no desire to expand in this sector, to seek assistance from more experienced panel builders and assembly suppliers for their export needs. These specialized firms, also clients of Eaton, have a great deal of expertise in the design of electrical equipment per North American codes and standards requirements and have an excellent track record of providing labeled and certified assemblies that have been successfully approved and locally commissioned for service. Eaton does not itself offer planning engineering assistance as a service in order to avoid entering in direct commercial conflict with our customers. Many of our clients appreciate our market philosophy in this respect.

The information provided in this technical paper was thoroughly and dutifully researched by the author. The contents reflect the status of available equipment at the start of 2010, and the paper references relevant portions of North American codes and standards valid at that time. The informational content provided in original North American codes and standards remains binding, as does the technical data on equipment provided by Eaton in the main catalog (**Figure 40**), on component nameplates and supplier provided documentation, as well as in certification reports. Local electrical inspectors base their equipment evaluations mostly on ratings and certification information provided by manufacturers through equipment markings, labels and nameplates. Any unauthorized modifications done on equipment, e.g. by end-users or contractors, can void the equipment's original certification and possibly the certification of the entire assembly into which it has been installed.

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http://www.i2ps.de

References:

[1a] ***„Schaltgeräte und Schaltanlagen für den Weltmarkt und für den Export nach Nordamerika"***
„Components and Systems suitable for World Markets and Export to North America"
Moeller GmbH, Bonn, 11/2006
German: VKF0211-563D, Article No. 110188
http://www.moeller.net/binary/vkf_salessupport/vkf563de.pdf
English:VKF0211-563GB, Article No. 110189
http://www.moeller.net/binary/vkf_salessupport/vkf563en.pdf

[1b] Dipl.-Ing. Wolfgang Esser
„Motorstarter und „Special Purpose Ratings" für den nordamerikanischen Markt"
„Motor starters and „Special Purpose Ratings" for the North American market"
Moeller GmbH, Bonn, 04/2006
German: VER1200+2100-953D, Article No. 106648
http://www.moeller.net/binary/ver_techpapers/ver953de.pdf
English: VER1200+2100-953GB, Article No. 106649
http://www.moeller.net/binary/ver_techpapers/ver953en.pdf

[1c] Dipl.-Ing. Wolfgang Esser
„Sammelschienenadapter für die rationelle Motorstartermontage – jetzt auch für Nordamerika –„
„Busbar Component Adapters for modern industrial control panels"
Moeller GmbH, Bonn, 02/2007
German: VER4300-960D, Article No. 110774
http://www.moeller.net/binary/ver_techpapers/ver960de.pdf
English: VER4300-960GB, Article No. 110775
http://www.moeller.net/binary/ver_techpapers/ver960en.pdf

[1d] Dipl.-Ing. Wolfgang Esser
„Besondere Bedingungen für den Einsatz von Motorschutzschaltern und Motorstartern in Nordamerika"
„Special considerations governing the application of Manual Motor Controllers and Motor Starters in North America"
Moeller GmbH, Bonn, 05/2008
German: VER1210+1280-928D, Article No. 267951
http://www.moeller.net/binary/ver_techpapers/ver928de.pdf
English: VER1210+1280-928GB, Article No. 267952
http://www.moeller.net/binary/ver_techpapers/ver928en.pdf

[1e] Dipl.-Ing. Wolfgang Esser
„Schutz von Steuertransformatoren für den Einsatz in Nordamerika"
„Protection of Control Transformers for use in North America"
GmbH, Bonn, 02/2007
German: VER1210-951D, Article No. 105221
http://www.moeller.net/binary/ver_techpapers/ver951de.pdf
English: VER1210-951GB, Article No. 105222
http://www.moeller.net/binary/ver_techpapers/ver951en.pdf

[1f] Dipl.-Ing. Wolfgang Esser
„Hauptstromkreise sicher unterbrechen, mit Lasttrennschaltern N oder mit Molded Case Switches NS"

"Safe Isolation of Main Circuits with Switch-Disconnectors N or with Molded Case Switches NS"
Moeller GmbH, Bonn, 11/2007
German: VER1230-950D, Article No. 105223
http://www.moeller.net/binary/ver_techpapers/ver950de.pdf
English: VER1230-950GB, Article No. 105224
http://www.moeller.net/binary/ver_techpapers/ver950en.pdf

[1g] Dipl.-Ing. Wolfgang Esser
„Exportrelevante Spannungsangaben und Netzformen in Nordamerika"
„Export relevant voltage information and mains forms in North America"
Moeller GmbH, Bonn, 02/2008
German: VER4300-965de, Article No. 116834
http://www.moeller.net/binary/ver_techpapers/ver965de.pdf
English: VER4300-965en, Article No. 116835
http://www.moeller.net/binary/ver_techpapers/ver965en.pdf

[1h] Dipl.-Ing. Wolfgang Esser
„Erfolgreicher nach Nordamerika exportieren – durch approbierte Komponenten"
„Be more successful in exports to North America – With the use of properly certified equipment"
Moeller GmbH, Bonn, 02/2008
German: VER4300-962de, Article No. 116836
http://www.moeller.net/binary/ver_techpapers/ver962de.pdf
English: VER4300-962en, Article No. 116837
http://www.moeller.net/binary/ver_techpapers/ver962en.pdf

[1i] Dipl.-Ing. Wolfgang Esser
„Hauptschalter mit Drehgriffen konform mit NFPA 79 und UL 508A einsetzen"
„Supply circuit disconnecting means with rotary handles in compliance with NFPA 79 and UL 508A"
Moeller GmbH, Bonn, 07/2008
German: VER1230-966 de, Article No. 118892
http://www.moeller.net/binary/ver_techpapers/ver966de.pdf
English: VER1230-966en, Article No. 118893
http://www.moeller.net/binary/ver_techpapers/ver966en.pdf

[1j] Dipl.-Ing. Wolfgang Esser
„2-Komponenten-Motorstarter für den Einsatz in Nordamerika"
„2-Component Combination Motor Controller solutions for North America"
Moeller GmbH, Bonn, 07/2008
German: VER1200+2100-967de, Article No. 118982
http://www.moeller.net/binary/ver_techpapers/ver967de.pdf
English: VER1200+2100-967en, Article No. 118983
http://www.moeller.net/binary/ver_techpapers/ver967en.pdf

[1k] Dipl.-Ing. Wolfgang Esser
„Leistungsschalter für den Einsatz in Nordamerika"
„Molded case circuit breakers for applications in North America"
Moeller GmbH, Bonn, 09/2008
German: VER1230-939de, Article No. 285780
http://www.moeller.net/binary/ver_techpapers/ver939de.pdf
English: VER1230-939GB, Article No. 285781
http://www.moeller.net/binary/ver_techpapers/ver939en.pdf

[1l] Dipl.-Ing. Wolfgang Esser
„SCCR – Overall Panel Short Circuit Current Rating – gemäß NEC und UL Standards –"
"SCCR – Overall Panel Short Circuit Current Rating – per NEC and UL standards –"
Moeller GmbH, Bonn, 01/2007
German: VER0211-959D, Article No. 110101
http://www.moeller.net/binary/ver_techpapers/ver959de.pdf
English: VER0211-959GB, Article No. 110102
http://www.moeller.net/binary/ver_techpapers/ver959en.pdf

[1m] Dipl.-Ing. Jörg Randermann
„Frequenzumrichter auf dem nordamerikanischen Markt"
„AC Variable speed drive systems for the North American market"
Moeller GmbH, Bonn, 09/2008
German: VER8230-964de, Article No. 119898
http://www.moeller.net/binary/ver_techpapers/ver964de.pdf
English: VER8230-964en, Article No. 119899
http://www.moeller.net/binary/ver_techpapers/ver964en.pdf

[2] ***„Schaltungsbuch 2008, Automatisieren und Energie verteilen"***
„Wiring Manual 2008, Automation and Power Distribution"
Moeller Fachbuch,
Moeller GmbH, Bonn, 2008
German: FB0200-004DE, Article 116412
http://www.schaltungsbuch.de
English: FB0200-004EN, Article 119816
http://www.wiringmanual.com/

[3] ***"2008 National Electrical Code"****, NFPA 70*
ISBN: 0-87765-790-4
ISBN13: 978-0-87765-790-3
Author: NFPA
Publisher: NFPA

"NFPA 70®: National Electrical Code® (NEC®) Handbook, 2008 Edition"
Authors: Mark W. Earley, Jeffrey S. Sargent, Joseph V. Sheehan, and E. William Buss
Publisher: NFPA
NFPA No.: 70HB08
ISBN-10: 0-87765-793-9
ISBN-13: 978-0-87765-793-4
Library of Congress Control No.: 2007938657

[4] ***"Canadian electrical code, part I (21st edition), safety standard for electrical installations"***
Publisher: CSA International
Product Name: C22.1-09
Product ID: 2020257

[5] ***"Industrial Control Equipment"***
Publisher: CSA International
Product Name: CAN/CSA-C22.2 No. 14-05
Product ID: 2417576

[6] ***"UL Standard for Safety for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489"***
Eleventh Edition, Dated September 1, 2009
Stand: 01.09.2009

[7] ***"UL Standard for Safety for Industrial Control Equipment, UL 508"***
Seventeenth Edition, Dated January 28, 1999
Standard contains revisions through and including September 19, 2008.
Stand: 19.09.2008

[8] ***"UL Standard for Safety for Power Conversion Equipment, UL 508C"***
Third Edition, Dated May 3, 2002
Stand: 12.02.2010

[9] ***"UL Standard for Safety for Supplementary Protectors for Use in Electrical Equipment, UL 1077"***
Sixth Edition, Dated July 14, 2005
Stand: 05.10.2009

[10] ***"UL Standard for Safety for Industrial Control Panels, UL 508A"***
First Edition, Dated April 25, 2001
Stand: 04.02.2010

[11] ***"NFPA 79 Electrical Standard for Industrial Machinery, 2007 Edition"***
National Fire Protection Association
http://www.nfpa.org/catalog

[12] ***"Molded-case circuit breakers, molded-case switches and circuit-breaker enclosures"***
Publisher: CSA International
Product Name: CAN/CSA-C22.2 No. 5-09
Product ID: 2417576

[13] IEC/DIN EN 60529, Klassifikation VDE 0410 Teil1 **"Schutzarten durch Gehäuse (IP-Code)"**,
September 2000
IEC/DIN EN 60529 "Degrees of Protection Provided by Enclosures (IP Code)
September 2000

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