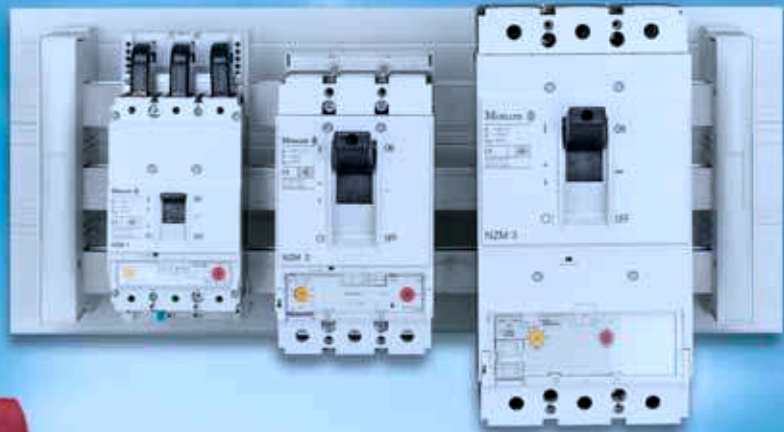


Busbar Component Adapters for modern industrial control panels



xEnergy

Circuit-breakers
N2M

Circuit-breakers
IZM

Switchboard systems

xStart

Contactors DIL

Motor-protective
circuit-breakers PKZ

Motor-starters MSC

Technical Paper
Dipl.-Ing. Wolfgang Esser

MOELLER 

We keep power under control.

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Differences abound in the types of engineered assemblies encountered throughout the market

Busbar Component Adapters – for modern industrial control panel assembly in full compliance with North American market requirements –

Different kinds of switching cabinets

The demands placed on modern engineered assembly designs, including mounting and wiring techniques, down to the way in which current within the assembly is distributed, are very varied. Major differences are encountered as a result of:

- The end-use application of the assembly.
- Its configuration, geometrical layout and type of housing.
- Its maximum rated current,
- and of course, the physical size of the components to be mounted within.

Generally speaking, they can be broken down into two distinct groupings

- Energy Distribution assemblies, or
- Electrical apparatus for machinery (Machines and machine tool controls, with integrated power switching and protective components)

Additional structural differences are noted in energy distribution assemblies falling under the DIN EN 60439-1 [1] standard, such as those found in:

- Industrial and commercial applications, as well as in
- the infra-structure of residential living complexes.

In turn, these various types of engineered assemblies generally feature a different approach with respect to the way in which current or energy is distributed within their housing or enclosure groupings. Typical for energy distribution assemblies would involve a number of sections, each reflecting a high degree of standardization in order to more easily fulfill the requirements of TSK¹- resp. TTA²-Type tested assemblies (Refer to Table 1). In industrial applications, a greater mix of motor starter content and/or serial groupings of smaller components addressing lesser loads are often encountered in energy

Type testing for Type tested assemblies (TSk) per IEC/EN 60 439-1

- Verification of the short circuit withstand strength,
- Verification of temperature-rise limits,
- Verification of the continuity of the protective circuit,
- Verification of clearances and creepage distances,
- Verification of the dielectric properties,
- Verification of mechanical operation,
- Verification of the degree of protection
- And additional verifications.

Table 1: Necessary Type testing per IEC/EN 60 439-1 can be made easier for manufacturers of switchgear assemblies by standardizing on distribution board content.

distribution sections. Assemblies which mainly feature motor starters make use of a withdrawable drawer design system in a high density configuration, from which one or even two loads per unit can be effectively controlled (MCCs³-Motor Control Centers). This design features complete drawer units directly plugged into a set of feeder vertical busbars. This technology allows for quick replacement of damaged units in down time critical applications such as is encountered in the chemical or raw material processing industries.

Assemblies with an inherently higher content of control circuit functionality (e.g. Electrical apparatus for industrial machinery) are more likely to require individual and customized design engineering since there is often the need for those particular applications to take into account specific and safety oriented requirements. These would be spelled out in relevant electrical design standards for machinery, such as IEC/EN 60 204-1 [2] in the IEC world and NFPA 79 (Electrical Standard for Industrial Machinery) in North America. These particular assemblies, commonly referred to as Industrial Control Panels and Industrial Control Panels for Industrial Machinery very often need to place higher demands on the design and application versatility of their installed components, particularly in the case of serially built machinery. It's quite common for those to be built and warehoused ahead of time, before an

¹ TSK = Typ Tested Assemblies in accordance with EN 60439-1

² TTA = Type Tested Assemblies

³ MCC = Motor Control Center

order is actually placed and the final end-use destination can be determined. This puts a premium on the availability of components which incorporate the essential features necessary to make them fully compliant with pertinent approval agencies world-wide and thus insure their global application without restriction. Variations in standardized

design should be avoided whenever and wherever possible, if anything so that administrative costs can be kept down to an absolute minimum. The busbar systems and adapters described in the following pages are optimally designed to provide modern and rational solutions for industrial control panels used in those applications.

We often see today a differentiation between centralized and de-centralized control and energy distribution concepts. These 2 approaches place different requirements on associated housings and are usually configured differently with respect to the number of components per enclosure, as well as to the magnitude of current levels

Application possibilities for energy distribution systems as a function of the size, space requirement and functionality of the equipment			
Assembly concept Arrangement of power switching and protective devices	Centralized electrical equipment		De-centralized electrical equipment
Arrangement spacious and functional	Grouped as a unit	spacious and/or functionally separate (e.g. load centers)	Close to load, load based arrangement
Examples:	Machinery equipment	Water treatment equipment	Conveyor belt or roller technology
Power rating [kW] per Unit (Enclosure)	Large power demand, with many loads, some of which can be particularly large	Lesser power requirements, smaller number of loads, noticeable amount of load centers in some cases	Mostly small individual loads, often of the same type
Energy supply	Single point supply source via cable or bus system	Single point supply source via cable or bus system	Distributed supply source via solid or flexible busway system
Current distribution in individual enclosures	Preferably via busbar system, partly supplemented with bus link connectors	Preferably via busbar system, partly supplemented with bus link connectors	Direct supply of motor starters, starter groupings will also feature bus link connectors
Mounting of motor starters up to 15 kW	On busbar adapters, or mounting rails, or mounting rail adapters	On busbar adapters, or mounting rails, or mounting rail adapters	On mounting rails, or mounting rail adapters
Motor protective switch and circuit breaker mounting	On busbar adapters, possible up to 550 A, or on mounting and modular plates	On busbar adapters, possible up to 550 A, or on mounting and modular plates	On mounting rails or mounting rail adapters, or mounting plates
Arrangement of actuating, input and display devices	Local, application oriented	Local, application oriented	Often integrated in decentralized enclosures, also additional centralized operator and display station present
Information- and Signalling exchange	Increasingly via communication bus system	Increasingly via communication bus system	Primarily via communication bus system
Special advantages	Optimum clarity of design, reduced demands on enclosure methods	Optimized cabling requirements, higher degree of flexibility for changes	Higher level of standardizing, especially useful in cabling requirements, higher degree of flexibility for changes, plug technology for all electrical connections is common

Table 2: There is more discussion today on the subject of centralized vs. decentralized installation designs. Besides the usual systematic pro and con breakdown of aspects from both, a conceptual solution can also be influenced by the way in which varying energy distribution methods and mounting systems can be applied.



Photo 1: The latest networking system Smart Wire from Moeller is used primarily to replace conventional control circuit wiring in motor starters, such as actuation of contactor coil and status indication of contactor energization. The connection of individually mounted starter units, which can also be mounted on busbar systems, is established via pre-assembled flat ribbon cable connectors with suitable end plugs.

for the connected loads. (Table 2). There is also a marked increase in the need for these assemblies to possess networking capabilities, not only at the energy distribution level but also in the afore-mentioned area of custom

electrical controls for industrial machinery. The demands of each tend to vary with respect to the cycling speed of the communication process, and the information content [4]. A networking capability is a crucial component in the

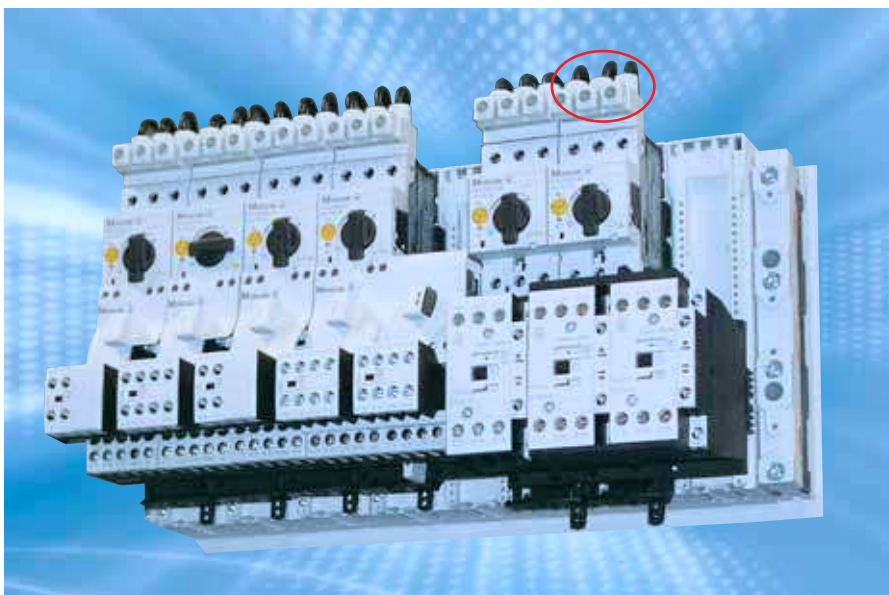


Photo 2: Motor starter mounting on busbar adapters can either be completed by the customer or ordered assembled from Moeller by specifying appropriate control voltage supply. Busbar equipped motor starters represent the next step in the rationalization of modern industrial control panel assembly. The motor starter adapters are offered in both an IEC and a UL/CSA version. The difference lies in the provision of the large spacing incoming supply terminal block on the motor protective switch.

establishment of a modern and decentralized engineered assembly concept.

The new *System SmartWire* from Moeller brings networking functionality to busbar adapter mounted motor starter combinations from the *System xStart* line [5] [14] (Photo 1). This very simple networking system serves mainly as replacement for control circuitry wiring (used for energization and signaling) and can be equally functional in both larger decentralized power circuit configurations and centralized custom control panel assemblies. The capability of a quick component exchange is fully maintained using this type of networking design. Indeed, the rapid exchange of parts was a design goal. In the ensuing pages the paper will focus predominantly on electrical machine controls for applications in North America (Emphasis: *Industrial Control Panels for Industrial Machinery*, per the requirements of NFPA 79 [3] and UL 508A [6]); additional information on general differentiation between engineered assemblies can be referenced in a further paper paper [7].

SASY 60i Busbar systems and Adapters help to rationalize industrial control panel assembly

In panel assembly, particularly in the case of custom engineered machine tool controls for which, as previously indicated, the internal current flow distribution requirements are different than those of power energy distribution assemblies, the effective usage of busbar adapters equipped with fuseless motor starter combinations has long been established (Photo 2). In fact, it's hard to imagine any modern panel assembly without them. The internal space, which always needs to be there anyway for current distribution within the panel, can now be used to additionally occupy switching and protective components. There is now a growing trend to mount full fledged combination motor starters as well as compact molded case circuit breakers and switches directly on these busbar adapters (Photo 3), rather than just busbar mounted fuses, which had been previously the convention. Switches mounted on busbar adapters

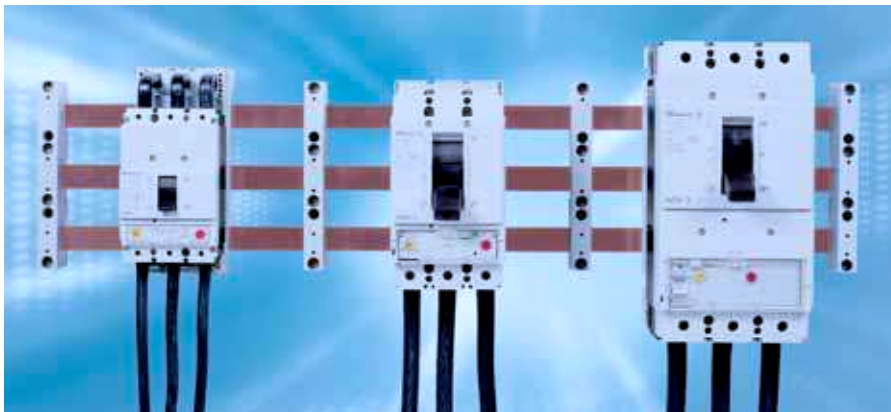


Photo 3: It has become possible in the meantime to design adapters which allow mounting of circuit breakers or molded case switches, rated up to 550 A and used in incoming or outgoing circuits, directly onto the busbar system. The actuation possibilities for the switches can also be varied, from manual means to remote switching via an electrical motor operator, or even through a flex cable and side handle accessory typical of North American installations.

serve mainly as incoming feeder or branch circuit components and can accommodate loads in the vicinity of 550 to 600 A.

Current levels in machine tool controls and industrial control panels are generally lower, and the significance of protective functions tends to be somewhat less critical, than for typical energy distribution assemblies. On the other hand, requirements for load switching devices are comparatively greater and more varied. Contactors facilitate automatic and remote switching of power loads and thus fulfill an additional, and vital, role for those assemblies. In short, electrical control panels such as those for industrial machinery and the like will be associated with a greater need for innovative component mounting and wiring means. Moeller raises the functionality of busbar adapters in industrial control panels to new levels by making factory assembled and connection ready busbar adapter sets equipped with top mounted combination motor starters readily available as off-the-shelf components (**Photo 2**). This virtually eliminates the mounting and wiring time which would have been necessary in the local panel shop or at the end-use location, and thus drastically cuts down the amount of potentially costly errors which often occur in those types of assemblies. The task of providing a control panel short circuit rating (Short Circuit Current Rating, **SCCR** [8]), which represents a new feature in North American industrial control panels, is made a whole lot easier by the availability

of these fully rated and approved multi-function modules from a single manufacturer. These multi-function units go a long way in efficiently fulfilling current distribution, protection, switching and signalling functions, all in one package. They can even go further towards the establishment of an optimum solution by incorporating accessories to enable padlocking and networking capabilities.

Special busbar system requirements for applications in North America

World wide, demands for busbar systems with respect to nominal current carrying capacities, voltage levels, and short circuit ratings, have been on the increase, even in the domain of industrial controls and machinery. A high fault short circuit withstand rating, a relatively high nominal current rating of 550 A for an adapter mounted circuit breaker, a 600 V, 60 Hz voltage rating for Canada and an even higher 690 V 50 Hz rating for applications per IEC standards have posed absolutely no problems for these busbar system innovations.

A number of challenging design changes to the IEC version of the busbar adapter needed to be addressed before a successful introduction into the North American marketplace could be contemplated. As **Photo 4** illustrates, the bus itself, the adapters, and the terminal connector block on the incoming side of the motor protective switch mounted on the adapter lie mostly in the feeder circuit of Industrial Control Panels. In North America, this particular area of the circuit generally

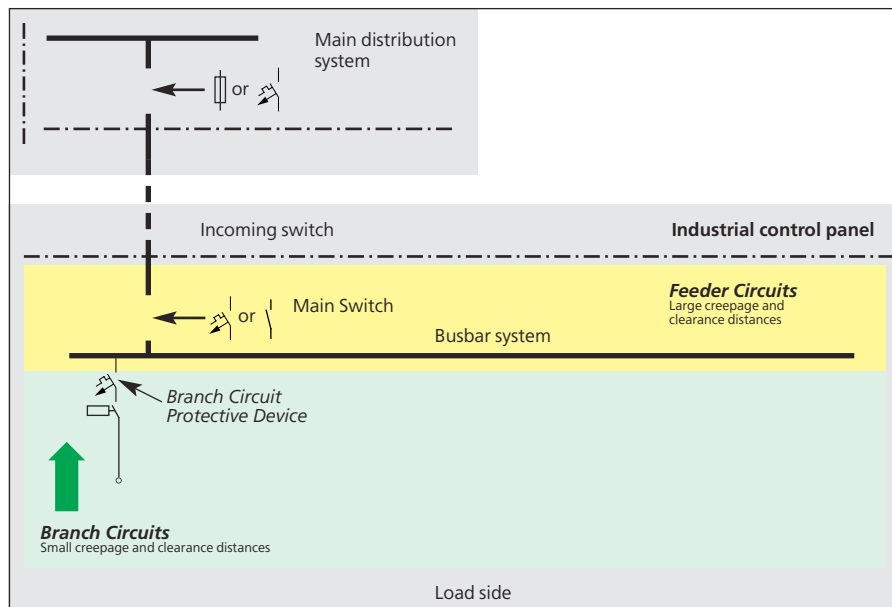


Photo 4: The knowledge of a few key definitions is necessary in order to properly understand the application of electrical clearances in North America. Every installation includes a supply circuit network referred to as the "Feeder Circuit", which starts at the point of supply after the service (e.g. the distribution panel in a house, or the supply to a machine as shown above), and ends on the load side of "Branch Circuit Protective Devices". The area is indicated in yellow in the diagram and is subject to the application of large distribution spacings (Distribution Equipment). In the example shown above, the busbar system and adapters are effectively located in the feeder circuit. Only in the "Branch Circuit" portion of the circuit (shown in green) would the smaller industrial control clearances per UL 508 be allowed (Industrial Control Equipment).

requires larger distribution electrical clearances on component field terminations, i.e. distances of an 1" (1 Inch = 25,4 mm) through air and 2" (2 Inches = 50,8 mm) over surface between terminals and points of opposite polarity for circuits up to 600V. A clearance over surface of at least 1" would also be required between uninsulated live parts and any grounded metal surface such as a mounting plate or an enclosure wall. Those are the typical clearances encountered in energy distribution equipment and which subsequently became part of the construction requirements for Type E and Type F Combination Motor Controllers, described in greater detail later in the paper. A number of changes in the North American electrical standards had helped establish more comprehensive testing of IEC style manual motor starters and enabled better utilization of their protective characteristics in that market. Part of these developments required the larger clearances typically found on the terminations of molded case circuit breakers per UL 489 [9] to become part of the UL 508 [10] component standard Table 76.3 for those components. Busbar systems and adapters described herein are typically installed in Industrial Control Panels per UL 508A and are thus generally covered under the UL 508 Industrial Control component standard. Some of their internal design aspects may not fully meet the full construction requirements of energy distribution assemblies such as Panelboards (UL 67 [11]) and Dead-Front Switchboards (UL 891 [12]) and thus they are normally considered unsuitable for those applications.

Design engineers involved with busbar systems should be mindful that not all assemblies available on the market today carry the necessary approvals to insure a trouble-free installation in North America, and furthermore, that the process of selecting the right busbar system for the application is not always so readily apparent. Busbar systems which are neither approved nor certified should be immediate taboo to any international machine manufacturer and panel builder (OEM) with export plans to North America. Moeller's main line of busbar systems and adapters is deemed to be a "World Market"

⁴ OEM = Original Equipment Manufacturer

offering, since it encompasses all of the pertinent approvals necessary for global markets. Because of varying production cost levels, Moeller still does offer a line of busbar holders and component equipped bus adapters which are not specifically approved for North America. However, it's definitely worth considering whether a doubling of the inventory with unapproved parts would make any sense economically, given that the approved model provides the additional, and risk minimizing, benefit of being universally acceptable in all markets. Standardizing on world-market components also eliminates any potential mixup of parts from occurring in a given shipment, which in itself could prove to be very costly.

The challenge presented to the manufacturer by the need to provide larger electrical clearances on components was solved easily enough through constructive changes, albeit at a substantial cost when taking into account the investment in component re-design and the associated follow-up testing necessary to validate the changes. Although the design engineer must still consider certain factors peculiar to North American installations, such as larger clearances between live parts and grounded metal in the control panel enclosure, he is at least helped by the fact that, through extensive type testing, the ampacity levels of the bus system are able to be matched up exactly with corresponding IEC ratings.

In the US, busbar ampacities which have not otherwise been established through testing can be conservatively determined

by the equivalence of 1000 A/Inch², or roughly 1,55 A/cm², using metric measurements. The formula has been in place for years and can also be found in the UL 508A standard for Industrial Control Panels. Unfortunately, the ampacity values determined by using this formula often turn out to be very conservative, leading to large discrepancies between permissible UL and IEC bus ampacity levels. However, this differential can be overcome through comprehensive testing of the bus assembly. The advantages of reaching parity between UL and IEC values can be significant, enabling machine design and panel layout, at least from the bus system's point of view, to be uniform and applicable in both markets. A vital consideration for machine manufacturers who export world-wide!

In order to maintain proper electrical clearances in industrial control panels specifically designed for applications in North America, or indeed to insure full acceptance for assemblies world-wide, bus systems installed in the supply (feeder) circuit need to include a bottom plate between the bus and the grounded mounting plate below. (**Refer to Photo 5**).

Compact and modern control panel bus systems of today, those with a standardized 60mm distance between phases and a range of available bus cross-sections, can reach maximum current ratings of upwards to 2500 A. (High current levels are sometimes achievable by means of special bus profiles). Moeller currently offers 60 mm design based bus systems in either



Photo 5: Busbar holders with UL/CSA certification for world-wide applications. Use of an additional bottom plate is necessary in North America in order to establish the appropriate electrical clearances between the bus and the mounting plate.

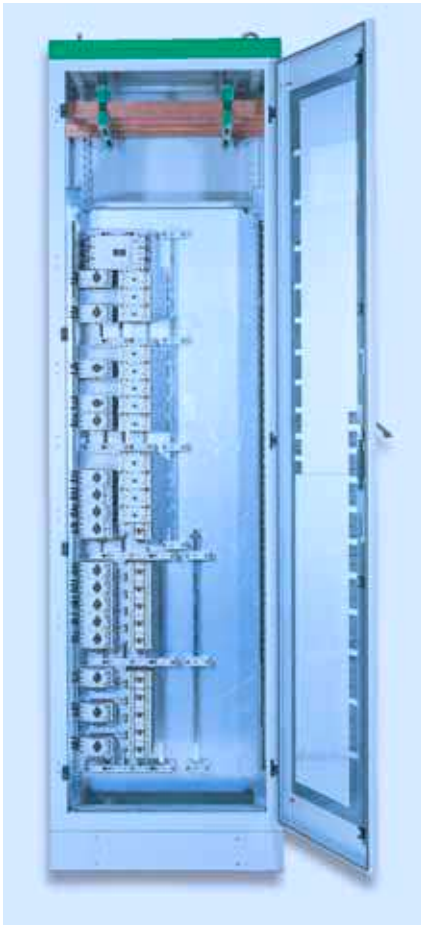


Photo 6: Motor starter section from an engineered product assembly featuring a vertically mounted busbar array to accommodate a large number of motor starters.

flat copper or special profile configurations for current levels up to 1600 A.

A comprehensive selection of accessories facilitates the incoming supply connections and enhances shock hazard protection. Unused sections of exposed bus reserved for subsequent circuit additions can be safely and easily covered. It's also possible today, in addition to the use of bus adapters for components such as motor starters, to mount compact *NZM* molded case circuit breakers and *PN*, *N* oder *NS* molded case switches in similar fashion directly onto busbar systems. These can reach current levels on the order of 550 A and can be used either as incoming supply disconnecting means or for the protection and/or isolation of outgoing circuits. It is recommended that the incoming switch, in spite of it being mounted directly onto a bus system, also be equipped with an incoming line terminal shield, which is readily

available as an accessory for such purposes. For North American assemblies it's also a good idea to provide adequate spacing between the supply disconnecting means and outgoing feeder and motor starter circuits, as a means to visually distinguish between incoming and outgoing power circuits.

Molded Case Circuit Breakers, when subjected to hefty fault currents, can blow out through their top and bottom end. Adequate blow-out space, in accordance with manufacturer specifications, must also be taken into consideration and strictly adhered to when devices are mounted directly onto a busbar system. In the case of a 500 A breaker, for example, copper cross-sections will tend to be large to accommodate the loading. When bringing in supply conductors of that size it's especially important to leave sufficient room for cable entry and wire bending clearances.

A vertically based component mounting arrangement, and thus a bus system with more space available along its width, provides for a more economical panel layout simply by allowing a greater number of motor starters to be mounted (**Photo 6**). This partly accounts for the fact that today's panel will generally feature more bus

than what would normally be required for conventional energy distribution within the panel. This is done simply to take greater advantage of the many features offered by panel designs featuring branch circuits equipped with bus mounted motor starters.

Moeller's offering of motor starter components for the North American market has been optimally designed and co-ordinated for these applications and should be considered an excellent fit for modern industrial control panels featuring greater use of bus systems in their overall design layout. This is especially noteworthy in view of the generally greater restrictions imposed on the proper application of switching and protective devices in that market [13]. The proper co-ordination of bus bars, bus holders, adapters, as well as the switching and protective components mounted on them, is assured through comprehensive certification testing which covers the complete assembly. The task of North American inspectors (AHJ⁵), who are entrusted per Code with the approval of electrical equipment in that market, is made easier by the ability to verify the suitability of the array by seeing the resultant listing or certification mark on the assembly. If need be, access to a manufacturer's certification report,

North American concepts for power circuits: Feeder Circuit and Branch Circuit		
	Feeder Circuit Supply circuits	Branch Circuit Load (outgoing) circuits
Definitions The BCPD is the final Branch Circuit (Overcurrent) Protective Device for individual load circuits	All conductors and equipment located between the energy supply source and the final Branch Circuit Overcurrent Protective Device (BCOPD oder BCPD).	Conductors and equipment located on the load side of the final BCPD protecting the circuit.
Suitable protective devices	<ul style="list-style-type: none"> • Fuses per UL 248 Class G, H, J, K, L, R or T, • Circuit Breakers per UL 489 	<ul style="list-style-type: none"> • Fuses per UL 248 Class CC, G, H, J, K, L, R or T, • Circuit Breakers per UL 489, • Type E und Type F Devices for individual motor circuits
Required creepage and clearance distances	Larger, distribution spacings	Smaller industrial control spacings, on the load side of the BCPD

Table 3: Important North American concepts: Feeder Circuit and Branch Circuit. These differences are not part of the IEC standards.

⁵ AHJ = Authority Having Jurisdiction

in which all components of the assembly are detailed, can be provided for a more complete verification. This makes the whole process much more transparent for the inspector, as the availability of components from a single manufacturer and their inclusion in one report is certainly more evident to the process than the combination of parts from multiple sources.

Busbar systems for applications worldwide

The basic elements of Moeller's *SASY 60i* busbar system consist of 3 phase bus holders with various cross-sections of copper busbars to accommodate a range of ampacity requirements. As an adjunct to that are 1 and 2 pole bus holders for *N*, *PE* or *PEN* bus conductors. Moeller offers these systems at somewhat different price levels, depending on whether or not the system carries the necessary approvals for installation in North America. Busbar type *BBS-3/FL-NA* are certified for use in North America and can accommodate busbar widths of 12, 20 or 30 mm, each with either 5 or 10 mm thickness. Only slight changes are necessary to adapt each holder for the varying cross-sections. These can be easily realized without the use of a tool through a rather ingenious bus fitting design. These certified busholders can be used world-wide. The IEC variety additionally features busbar widths of 15 and 25 mm. Both busbar holders located at each respective end of a busbar system in the North American are capped with *ES-BBS-3/FL* end-covers to provide a finger safe design. The bus system is fed either through a circuit breaker or molded case switch mounted directly on it or via a terminal connector set. Touch safe terminal connector sets can accommodate supply conductors with cross-sections of up to 300 mm², as well as 32 x 20 mm Flexibus (flat and insulated laminations of flexible copper wire).

An additional 600 mm support holder is provided in the middle in order to maintain a high level of fault current withstand capability for the complete bus assembly. The short circuit rating of the system is very much influenced by the separation between each bus holder location. For North American

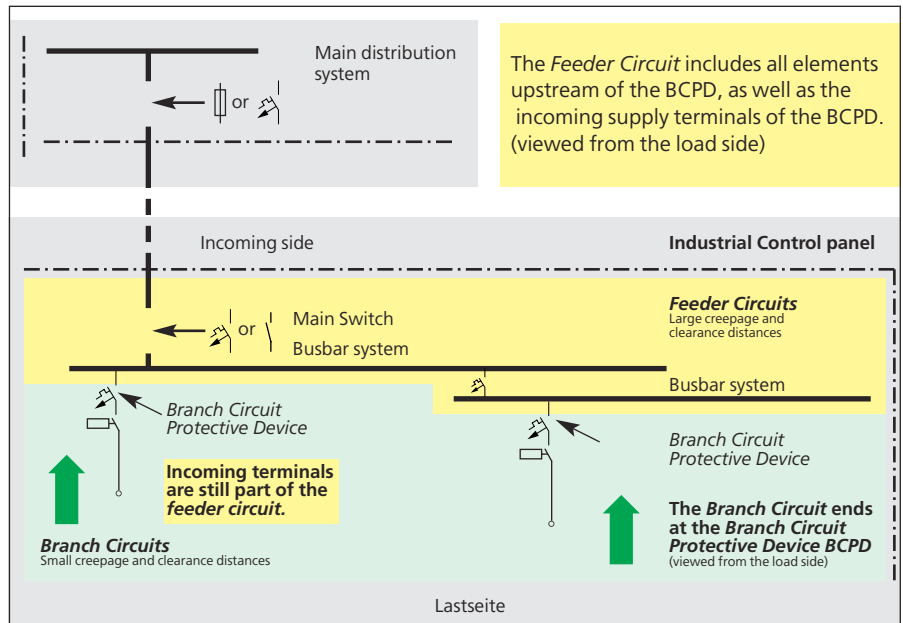


Photo 7: The line between Branch Circuit and Feeder Circuit appears at each branch.

installations an insulating bottom plate Type *BBC-BT-NA* is placed between the bus system and the metal mounting plate to maintain the necessary 1 inch (25.4 mm) electrical clearances. This North American type of assembly can of course be applied in industrial panels for all markets, including those which are strictly IEC based.

Explanation of key North American terms, which are pertinent for busbar systems suitable for engineered assemblies.

The North American standards differentiate between requirements for components which are deemed suitable for use in energy distribution systems

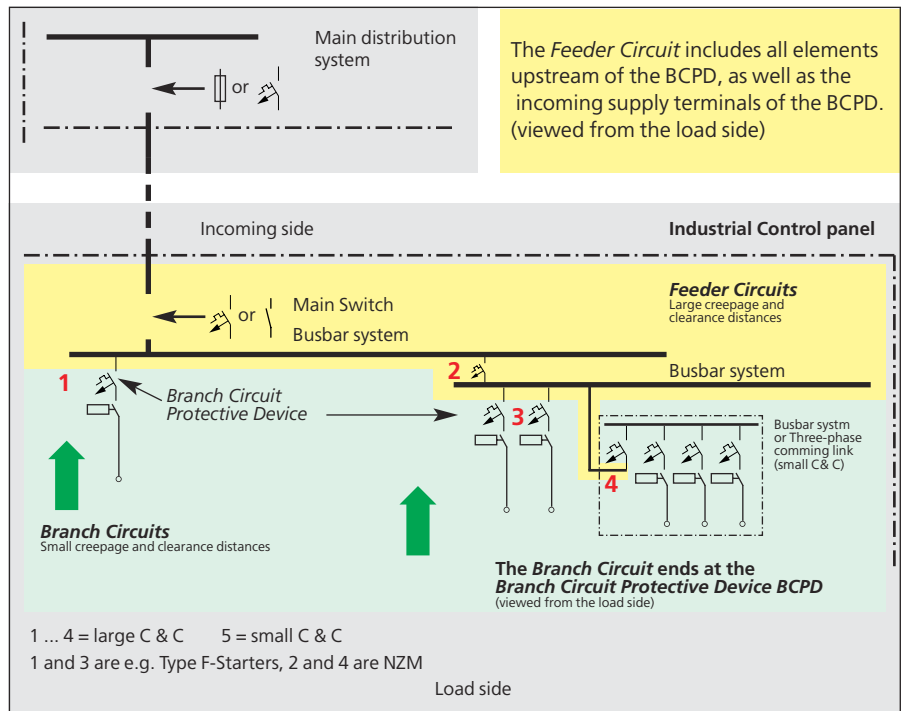


Photo 8: The photo shows an additional motor starter grouping. The bus bar system and adapters for it, or the connector links, are located in the branch circuit, whereas the incoming supply to the group back-up protective switch belongs to the feeder circuit. In this particular case, the small industrial control spacings would apply for the bus system and its components (with the exception of the protective switch).

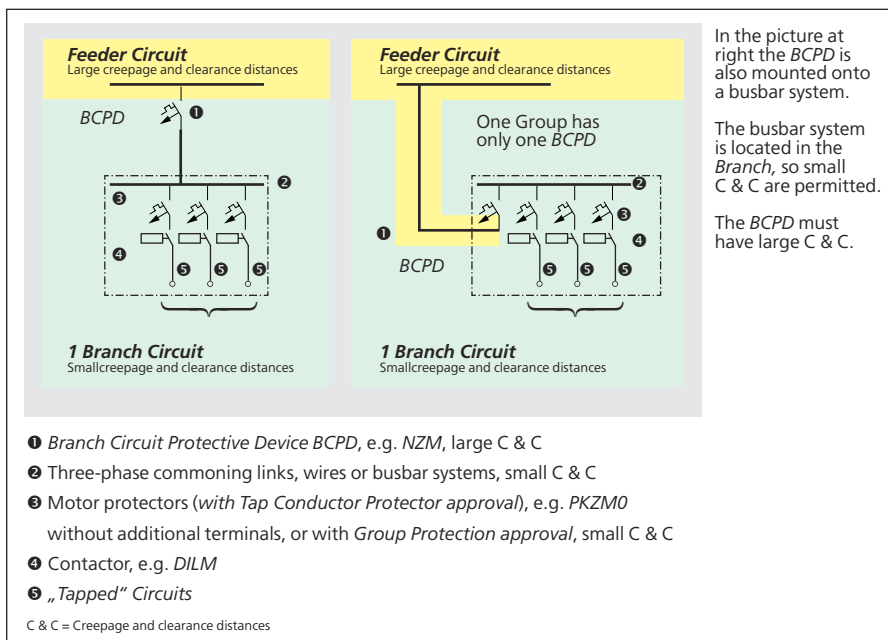


Photo 9: There is only one Branch Circuit Protective Device (BCPD) in group motor starter installations per the NEC/CEC. The entire grouping is part of a single branch circuit. The outgoing loads are referred to Tapped Circuits in this case. The BCPD with large distribution spacings on its field wiring terminals can be part of a bus system with the smaller industrial control spacings.

(e.g. Molded Case Circuit Breakers per UL 489) versus those for industrial control (Industrial Control Equipment per UL 508). Differing construction requirements are applied for switching and protective devices, particularly in the area of electrical clearances pertaining to component design. A more detailed analysis of these aspects can be found in a separate technical paper [13]. This type of differentiation is not known in IEC markets. There is yet an additional and fundamental difference in the North American electrical landscape which is not recognized in the IEC world. As a consequence of their respective NEC⁶ and CEC⁷ electrical Codes, there is a need in the US and Canada to differentiate between supply (Feeder Circuits) and outgoing (Branch Circuits) circuits. Refer to **Table 3**. This separation can also be seen to have a direct impact on component design, as well as on resultant electrical clearances throughout a circuit network. As a consequence, these differences can impact subsets of engineered product design work, be it a straight-forward energy distribution assembly such as a panelboard or a switchboard, or an industrial control panel built in accordance with the UL 508A standard. As a general assessment, it can be said that this type of differentiation is not

well understood in the IEC world, and is often the underlying culprit for fundamental errors conducted in electrical design engineering of assemblies for the North American market, as well as the root cause of ensuing problems from local inspection authorities during on-site commissioning of installations.

Diagram 4 shows a simplified example of a typical pathway through the supply and outgoing portions of an electrical

power circuit. It can be inferred from the diagram that in the majority of cases, bus systems will be installed in the feeder portion of the circuit. In that case, the larger energy distribution electrical clearances would be required on the system from the point of connection all the way through to the incoming terminals of the Branch Circuit Protective Device. If one wants to eliminate the need for an additional back-up protective device in motor starter assemblies there is always the possibility of providing UL 508 Type F combination motor starters (later described) which come equipped with a special connector terminal on their supply side to provide for the larger electrical clearances required (**Photo 2**).

Diagram 7 shows that the line between Feeder and Branch Circuit portions is easier to locate when looking at it from the reference point of each outgoing (Branch) circuit. In effect, the quickest way to identify a branch is to trace it from the load all the way to its respective overcurrent protective device.

Diagram 8 shows an application which may not be as common with the use of bus systems and adapters, but which is nevertheless fully plausible and legitimate. In this case, the bus array is located fully in the branch and the components make up an assembly of motor starting devices falling under the group protection provisions of the North American electrical Codes

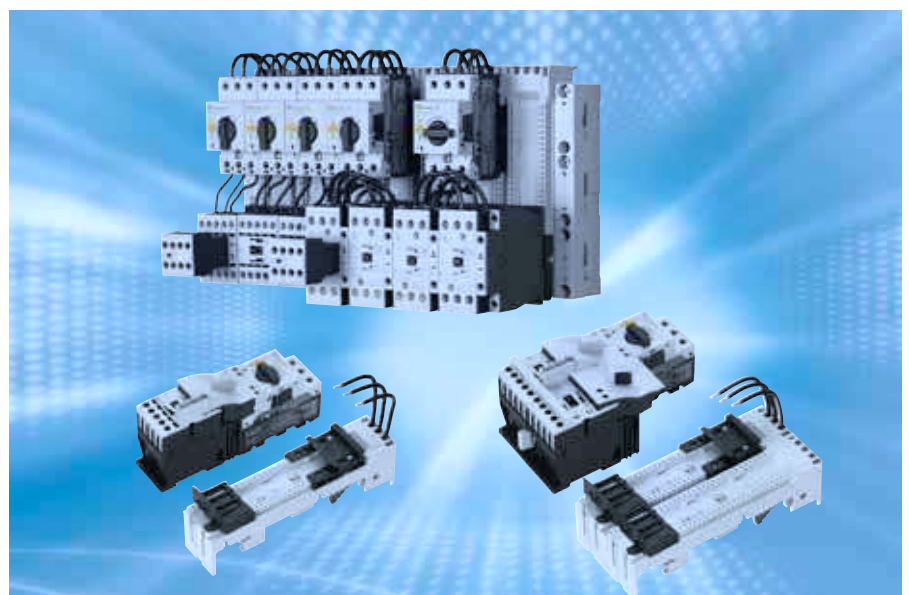


Photo 10: The motor starters as shown in Photo 10 and which are part of a group installation per the NEC/CEC are not required to have the larger distribution clearances. The additional large spacing terminal block is not required in this case. The photo doesn't show the group back-up branch circuit protective device.

⁶ NEC = National Electrical Code (USA)

⁷ CEC = Canadian Electrical Code

Type	Country	as	S.C. ratings
Type E COMB. MTR. CNTRL PKZMO + BK25/3-PKZO-E	USA	Manual Self Protected Combination Motor Controller	up to PKZMO-10 = 50 kA 600V/347 Vac PKZMO-16 = 42 kA 480V/277 Vac PKZMO-25 = 18 kA 480V/277 Vac PKZMO-32 = 18 kA 480V/277 Vac
MAN. MTR. CNTRL PKZMO-...	Canada	Self-Protected Combination Motor Controller	
MAN. MTR. CNTRL PKZMO-...	USA	Suitable for TAP Conductor Protection in Group Installations	
MAN. MTR. CNTRL PKZMO-...	Canada	Self-Protected Combination Motor Controller	50/100 = 18 kA 600V/347 Vac DILEM 60/A/M = 18 kA 600V/347 Vac DILM7/9/12/15 = 18 kA 600V/347 Vac DILM7/9/12/15 = 50 kA 480V/277 Vac DILM17/25/32 = 18 kA 480V/277 Vac DILOM = 18 kA 480V/277 Vac
TYPE F COMB. MTR. CNTRL PKZMO + BK25/3-PKZO-E	USA	Type F Combination Motor Controller When used with Moeller contactors indicated at right:	

A COMB. MTR. STARTER MADE OF PKZMO, DILM AND PKZMO-XD(R) M12(12)
For Typ PKZMO Designation see Frontside

For H.P. ratings and listing mark see other side

WARNING
TO MAINTAIN OVERCURRENT, SHORT-CIRCUIT AND GROUND-FAULT PROTECTION THE MANUFACTURERS INSTRUCTIONS FOR SELECTION OF OVERLOAD AND SHORT CIRCUIT PROTECTION MUST BE FOLLOWED TO REDUCE THE RISK OF FIRE OR ELECTRICAL SHOCK. IF AN OVERLOAD OR AN FAULT CURRENT INTERRUPTION OCCURS, CIRCUITS MUST BE CHECKED TO DETERMINE THE CAUSE OF INTERRUPTION. IF A FAULT CONDITION EXISTS, THE CONTROLLER SHOULD BE EXAMINED AND REPLACED IF DAMAGED TO REDUCE THE RISK OF FIRE OR ELECTRIC SHOCK.

3408 LOTUS

Photo 11: Moeller PKZM 0 Motor Protective Switches are additionally evaluated for group installations (Group Protection) and tap conductor protection (Tap Conductor Protectors). These evaluations are referenced on its rating label. Appropriate Short Circuit Current Ratings (SCCR) for the device and combinations can also be seen on the right hand side of the label and can be used in the overall SCCR determination of an industrial control panel.

(Motor Group Protection). In this assembly, the upstream back-up protection device is effectively the branch circuit overcurrent protective device (BCPD) and the entire array of tapped motor starter circuits and conductors (*tapped Conductors*) make

up only one Branch Circuit per Code (Photo 9). The smaller industrial control electrical clearances apply in this case and thus the motor starters are not required to feature the additional large spacing terminal block (Photo 10). Note that there are additional requirements

to be fulfilled when grouping devices under North American Code sanctioned group motor protection provisions such as, for example, the need for the components to be listed for such applications [13]. It's highly likely that in such arrangements, and in view of the relatively smaller current load draws, the more economical way to proceed in terms of the mounting and wiring hardware would be to use available accessories such as the bus connectors shown in Photo 13, rather than the more expensive bus system setup. Moeller Type PKZM 0 Motor protective switches have also been evaluated by UL as Tap Conductor Protectors (Photo 11) and enjoy, therefore, the more advantageous 1/10th vs. 1/3rd rule Code provisions with respect to tapped group motor arrangements.

Busbar adapters

Bus bars and bus bar holders provide the fundamental hardware structure

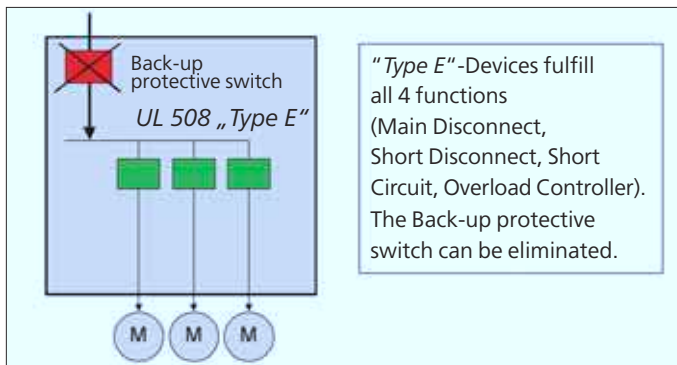


Photo 12: 3 UL 508 Type E- Motorstarters (Manual Type E Self-Protected Combination Motor Controller), shown here as a small grouping with bus link connectors for use e.g. in a decentralized automation process. Of particular interest is the large spacing terminal block BK25...-E, which in this particular array would only need to be used once to provide the larger electrical clearances for the incoming supply. This terminal must be provided on each individually equipped motor starter adapter destined for export to North America.

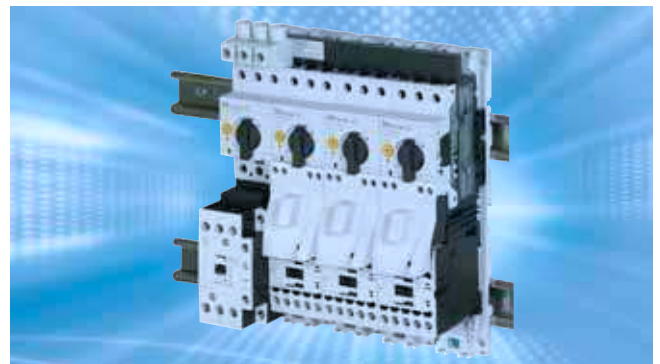
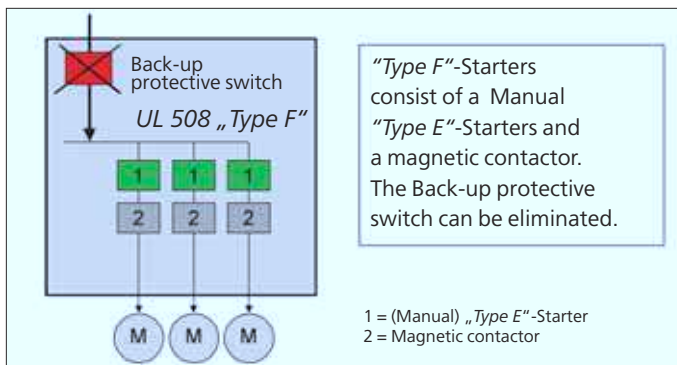


Photo 13: 4 UL 508 Type F- Motorstarters (Type F Combination Motor Controller), shown here as a small grouping with bus link connectors mounted on DIN (mounting) rails, are made up of self-protected manual motor controllers combined and tested with a magnetic contactor. Type F-Motorstarters can also be mounted on busbar adapters, in which case the large spacing terminal block BK25...-E would be required for each starter branch when exporting to North America.

Busbar adapters, 3-pole, for bus systems with 60 mm phase to phase bus separation
for 5 mm or 10 mm bus thickness









	For Direct-on-Line Starters				Cage clamp	For Motor Protective Switch		General Usage
	Screw type terminations					Screw type terminations		
I_e	25 A	32 A	63 A	63 A	16 A	63 A	63 A	25 A
U_e	690 V	690 V	690 V	690 V	690 V	690 V	690 V	690 V
Conductors	AWG 12	AWG 10	AWG 8	AWG 8	AWG 14	AWG 8	AWG 8	AWG 12
	~ 4 mm ²	~ 6 mm ²	~ 10 mm ²	~ 10 mm ²	~ 2.5 mm ²	~ 10 mm ²	~ 10 mm ²	~ 4 mm ²
Application per	UL 508A	UL 508A	UL 508A	UL 508A	UL 508A	UL 508A	UL 508A	UL 508A
Width	45 mm	45 mm	55 mm	72 mm	45 mm	54 mm	72 mm	45 mm
Length	200 mm	200 mm	260 mm	260 mm	200 mm	200 mm	200 mm	200 mm
Busses	1	2	2	2	2	1	1	2
for	PKZM0	PKZM0	PKZM4	PKZ2	PKZM0-C	PKZM4	PKZ2	General Usage
Type	BBA0-25	BBA0-32	BBA4L-63	BBA2L-63	BBA0C-16	BBA4-63	BBA2-63	BBA0-25 /2TS
Combained with								
DILM7	•				•	DILMC7		
DILM9	•				•	DILMC9		
DILM12	•				•	DILMC12		
DILM15	•				•			
DILM17		•	•	•				
DILM25		•	•	•				
DILM32		•	•	•				
DILM40			•	•				
DILM50			•	•				
DILM65			•	•				
MSC-D-0,25-M7 bis MSC-D-16-M15	•							
MSC-D-16-M17 bis MSC-D-32-M32		•						
								

Table 4: Busbar adapters for Direct-on-Line starters, individual Motor Protective Switches or general usage, with one or two mounting rails

Busbar adapters, 3-pole, for bus systems with 60 mm phase to phase bus separation
for 5 mm or 10 mm bus thickness



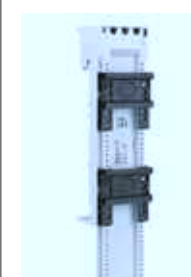
	For Reversing Starters			Empty adapter without electrical connectors	
	Screw type terminations		Cage clamp		
I_e	25 A	32 A	16 A		
U_e	690 V	690 V	690 V	690 V	690 V
Supply conductors	AWG 12	AWG 10	AWG 14	-	-
	~ 4 mm ²	~ 6 mm ²	~ 2.5 mm ²	-	-
Application per	UL 508A	UL 508A	UL 508A	UL 508A	UL 508A
Width	90 mm	90 mm	90 mm	45 mm	54 mm
Length	200 mm	200 mm	200 mm	200 mm	200 mm
Mounting rails	1	2	2	2	2
for	PKZM0	PKZM0	PKZM0-C	General usage	General usage
Type	BBA0R-25	BBA0R-32	BBA0RC-16	BBA0/2TS-L	BBA4/2TS-L
Combined with:					
2 x DILM7-01	•		2 x DILMC7-01		
2 x DILM9-01	•		2 x DILMC9-01		
2 x DILM12-01	•		2 x DILMC12-01		
2 x DILM17-01		•			
2 x DILM25-01		•			
2 x DILM32-01		•			
MSC-R-0,25-M7 bis MSC-R-12-M12	•				
MSC-R-16-M17 bis MSC-R-32-M32		•			
					

Table 5: Busbar adapters for Reversing starters or empty modules without any electrical connectors, with one or two mounting rails


Busbar adapters, 3-pole, for bus systems with 60 mm phase to phase bus separation for 5 mm or 10 mm bus thickness			
	For circuit breakers, Switch Disconnectors, Molded Case Switches		
I_e	160 A	250 A	550 A
U_e	690 V	690 V	690 V
Supply conductors	Integrated flexibus	Taking advantage of the device's rear connection capability	
Applications per	UL 508A	UL 508A	UL 508A
Width	90 mm	106 mm	140 mm
Length	200 mm	190 mm	270 mm
Type	NZM1-XAD160	NZM2-XAD250	NZM3-XAD550
Combined with:			
NZM 1	•		
PN1 (IEC-Version)	•		
N1 (IEC-Version)	•		
NS1	•		
NZM 2		•	
PN2 (IEC-Version)		•	
N2 (IEC-Version)		•	
NS2		•	
NZM3			•
PN3 (IEC-Version)			•
N3 (IEC-Version)			•
(NS3) in Arbeit			•
Rear connection necessary	-	+	+
			

Table 6: Busbar adapters for Circuit Breakers, Switch-Disconnectors and Molded Case Switches

adapters, onto which components are mounted, is what truly completes the modern bus system in its overall functionality and makes it ideally suited for industrial control panel applications. The adapters provide, in effect, the intelligence behind the system, and the refined aspects of its design offer the end-user a host of useful and functionality driven features, like the ability to make rapid module exchanges in the event of a significant fault in the downstream portion of the branch circuit, or when last minute updates in the sizing of motors would necessitate a quick change in the motor starter component selection. All such adapters, designed to accommodate advantageous, and fuseless, motor starter combinations, are suitable for world markets since, in addition to the availability of third party approvals, each is equipped with conductors sized to North American AWG⁸-Cross-sections and provided with appropriately rated insulation thicknesses and ratings common in that market. The motor starter adapters are easily snapped onto the busbars manually without the use of any tools, and establish a reliable and solid connection through spring loaded fastening clips. Larger adapters, designed to accommodate heavier and larger current carrying components, such as molded case switches and circuit breakers, come equipped with captive and integrated fastening screws to further secure the component's placement and connection with the bus system. One screw per phase is all that is necessary to secure a fully reliable electrical and mechanical bond. Whereas individually mounted motor starter units are normally fed and connected through the top with flexible wires from the adapter's incoming supply side, a rear connection capability proves to be particularly advantageous for larger load carrying components like circuit breakers. This type of connection option provides for a touch safe, and especially compact solution. Accordingly, **Tables 4** and **6** show the adapters to be available in various widths and current loading component mounting capabilities. The motor starter adapters, depending on the type and variety of components for any particular motor starter configuration, are available with either 1 or 2 mounting rails. The second rail,





Moeller Type suffix for part number	Typ of certification	Approval marks	
		in USA „Listing Marks“	in Canada „Certification Marks“
-NA	The device is fully <i>UL</i> listed resp. <i>CSA</i> certified as a stand-alone component		
		„Recognition Marks“	
-CNA	The device is component recognized by <i>UL</i> and its application is subject to certain Conditions of Acceptability (See Table 9) eingehalten werden. The device is <i>CSA</i> certified as a component	 (marking is optional)	

Tabelle 7: Commonly encountered approvals and corresponding certification marks on component rating labels, also identifiable with a Moeller suffix in the part number. The yellow fields indicates stand-alone approvals for components, whereas the blue denotes there are additional Conditions of Acceptability to observe in the US for proper application of the component (Table 9).



which is extendable, facilitates mounting and wiring of larger starters by allowing the use of specially designed interconnecting links between the motor protective switch and contactors of various sizes.

Motor Starters per UL 508 and CSA-C22.2 No. 14 standards

Busbar adapters from the Moeller *SASY 60i* System described herein are in complete conformity with the more stringent approval requirements in effect for applications in North America. As previously mentioned, the incoming supply wiring to the motor protective switch consists solely of listed and properly sized conductors with AWG cross-sections. But the necessary requirements go much more beyond that. The supply side of individually mounted combination motor starters suitable for branch circuits resides in the feeder, and the motor protective switch must thus be listed as a "*UL 508 Manual Type E – Self-protected Combination Motor Controller*" (**Photo 10**) which, when combined with a conventional magnetic motor contactor for remote operation of the starter, can be additionally evaluated as a so-called "*UL 508 Type F-Combination Motor Starter*" (**Photo 13**). The alphabetical Type E and Type F descriptions are not Moeller terms but rather a part of an informative short hand method by which the construction types of various

combination motor controller configurations currently available in the North American market are identified in the UL 508 Industrial Control standard. These latest, and specialized, Combination Motor Starter varieties are comprehensively described in a Moeller technical paper [13]. The background behind the need to create these types is based on the fact that North American standards do not recognize the inherent capability of conventional IEC type manual motor starters to provide both the overcurrent protective and isolating function for motor branch circuits, as is the case in IEC dominated markets; as simple manual motor controllers they are able to fulfill switching and overload protective duties only. *Type E* and *Type F-Combination Motor starters*, in addition to undergoing special testing to verify their ability to protect against short circuits and to fulfill the main disconnect function to the motor branch circuit, are equipped with an additional terminal block on their incoming supply side to provide the larger distribution electrical clearances (similar to UL 489 products) required for connections in the feeder circuit. These larger supply side spacings are also obviously required when mounting these starters on busbar adapters in approved assemblies. All components, busbars, adapters and the incoming supply side of the Type E manual motor protective switch thus feature the large clearances in order to permit their installation in the feeder portion of the circuit.

⁸ AWG = American Wire Gauge, kcmil = thousands circular mils

Listed Industrial Control Equipment Without restriction	Recognized Component Industrial Control Equipment Subject to Conditions of Acceptability
<ul style="list-style-type: none"> Devices listed for "field wiring" "factory wiring" is covered by "field wiring" provisions <p>i.e.</p> <ul style="list-style-type: none"> Suitable for industrial control panels, and considered complete for field wiring, incl. factories, panel shops and on site. Component sale in the US is unrestricted and not subject to any special acceptability considerations, other than they must be applied to per the installation recommendations of the local electrical Codes. 	<ul style="list-style-type: none"> As components, devices are subject to "factory wiring" provisions <p>i.e.</p> <ul style="list-style-type: none"> Components must be supplemented with additional equipment in order to be properly applied in the end product. Component selection was conducted by qualified persons in accordance with application considerations and relevant acceptability conditions. Components are suitable for use in industrial control panels which are designed, assembled and tested by technically qualified persons in appropriate factories and panel shops.
Mark: 	Mark: 

Approval doesn't always mean approval- Subtle differences, which also apply to busbar adapters

In North America, switching and protective devices are subject to third party certification and verification markings. **Table 7** describes various forms of approvals which can be encountered, as well as their significance. The type of approval has an impact on the requirements of protective and switching devices and can influence their selection, procurement and, ultimately, the manner in which they can be applied. In this paper the terms approval and certification are often used in the same context. The certification is the official and independently verified confirmation, that an evaluated component or assembly has met that country's application and safety related standards. The afore-mentioned UL and CSA standards are often representative of the country's officially recognized standards amongst international standard making bodies, such as is the case for UL and ANSI⁹ in the United States.

Table 8: In the US, industrial control equipment evaluated per UL 508 can be categorized as "Listed Industrial Control Equipment" and "Recognized Component Industrial Control Equipment".

UL 508 Type F Combination Motor Controllers Suitably listed without contactor as a UL 508 Manual Type E Self-Protected Combination Motor Controller										
Maximum HP Ratings 3-phase, 60 Hz				Set Current ranges		Short Circuit Current Rating SCCR		Supply side terminal block (always required)	Motor Protective Switch	Magnetic- Contactor
208 V (200 V)	240 V (230 V)	480 V ¹⁾ (460 V)	600 V ¹⁾ (575 V)	Thermal (Adjustable)	Magnetic (Fixed)	200 V 240 V 480 V ¹⁾	600 V ¹⁾			
HP	HP	HP	HP	A	A	kA	kA	Type	Type	Type
				0.2 - 0.25	3.4	50	50	BK25/3- PKZ0-E	PKZM0-0,25	DILM7
				0.3 - 0.4	5.6	50	50		PKZM0-0,4	DILM7
				0.4 - 0.63	8.8	50	50		PKZM0-0,63	DILM7
		½	½	0.6 - 1	14	50	50		PKZM0-1	DILM7
		¾	1	1 - 1.6	22	50	50		PKZM0-1,6	DILM7
½	½	1	1½	1.6 - 2.5	35	50	50		PKZM0-2,5	DILM7
1	1	2	3	2,5 - 4	56	50	50		PKZM0-4	DILM7
1½	1½	3	5	4 - 6	88	50	50		PKZM0-6,3	DILM7
3	3	7½	10	6.3 - 11	140	50	50		PKZM0-10	DILM9
3	3	7½	-	8 - 12	168	50	-		PKZM0-12	DILM12
3	5	10	-	10 - 16	224	50	-		PKZM0-16	DILM15
5	5	10	-	16 - 20	280	18	-		PKZM0-20	DILM25
5	7½	15	-	20 - 25	350	18	-		PKZM0-25	DILM25
7½	10	20	-	25 - 32	448	18	-	PKZM0-32	DILM32	
3	5	10	-	10 - 16	224	50	25	BK50/3- PKZ4-E	PKZM4-16	DILM17
7½	7½	20	-	20 - 25	350	50	25		PKZM4-25	DILM25
10	10	25	-	25 - 32	448	50	25		PKZM4-32	DILM32
10	10	30	-	32 - 40	560	50	25		PKZM4-40	DILM40

¹⁾ Suitable only for use in grounded supply networks rated 480 Y/277 V 60 Hz resp. 600 Y/347 V 60 Hz .

Table 9: Short circuit rating of Moeller combination motor starters mounted on busbar adapter. Selection data for the North American market, with individual part numbers shown for field completion of assembly on appropriate bus systems by customers and installers.

⁹ ANSI = American National Standards Institute

UL 508 Type F Combination Motor Controllers, mounted and wired on busbar adapters
Short Circuit Rating of the combination when mounted on appropriate busbar system

Suitably listed without contactor as a UL 508 Manual Type E Self-Protected Combination Motor Controller

Maximum HP Ratings 3-phase, 60 Hz				Set Current ranges		Short Circuit Current Rating SCCR		Completed busbar adapter (For IEC-Versions, see note in right side column) Type	Supply side terminal block (always required for UL) Type: BK25/3-PKZ0-E
208 V (200 V)	240 V (230 V)	480 V ¹⁾ (460 V)	600 V ¹⁾ (575 V)	Thermal (Adjustable)	Magnetic (Fixed)	200 V 240 V 480 V ¹⁾	600 V ¹⁾		
HP	HP	HP	HP	A	A	kA	kA		
				0.2 - 0.25	3.4	50	50	MSC-D-0,25-M7(24VDC)/BBA	
				0.3 - 0.4	5.6	50	50	MSC-D-0,4-M7(24VDC)/BBA	
				0.4 - 0.63	8.8	50	50	MSC-D-0,63-M7(24VDC)/BBA	
		½	½	0.6 - 1	14	50	50	MSC-D-1-M7(24VDC)/BBA	
		¾	1	1 - 1.6	22	50	50	MSC-D-1,6-M7(24VDC)/BBA	
½	½	1	1½	1.6 - 2.5	35	50	50	MSC-D-2,5-M7(24VDC)/BBA	
1	1	2	3	2.5 - 4	56	50	50	MSC-D-4-M7(24VDC)/BBA	
1½	1½	3	5	4 - 6	88	50	50	MSC-D-6,3-M7(24VDC)/BBA	
3	3	7½	10	6.3 - 11	140	50	50	MSC-D-10-M9(24VDC)/BBA	
3	3	7½	-	8 - 12	168	50	-	MSC-D-12-M12(24VDC)/BBA	
3	5	10	-	10 - 16	224	50	-	MSC-D-16-M17(24VDC)/BBA	
5	5	10	-	16 - 20	280	18	-	MSC-D-20-M25(24VDC)/BBA	
5	7½	15	-	20 - 25	350	18	-	MSC-D-25-M25(24VDC)/BBA	
7½	10	20	-	25 - 32	448	18	-	MSC-D-32-M32(24VDC)/BBA	

¹⁾ Suitable only for use in grounded supply networks rated 480 Y/277 V 60 Hz resp. 600 Y/347 V 60 Hz .

Table 10: Short Circuit Rating of combination motor starters mounted on Moeller busbar system. Selection data for the North American market, with part numbers shown referring to the motor starter equipped and connection ready busbar adapter.

In the US, Industrial Control Equipment per UL 508 [10] as well as equipment for energy distribution (e.g. UL 489 [9]) can be encountered with either full stand-alone certification (e.g. UL Listed) or under the more restrictive recognition category (*Recognized Components*). Different laboratory marks apply to both types. Fully Listed equipment (typically denoted by the suffix "-NA" for certain Moeller components) can be installed with virtually no restrictions, as long as they are applied within their ratings and capabilities per the Electrical Codes. "*Recognized Components*" (with Moeller suffix "-CNA" in their part numbers) are by themselves considered incomplete, and often need to be combined with additional components in order to be applied properly. These application considerations are always covered and described in the manufacturer's certification report under the heading "*Conditions of Acceptability*" and must always be followed in order to insure full compliance with installation Codes. Based on a UL statistical analysis of rejections encountered in the evaluation of electrical installations throughout North America, a large

majority of the issues could be traced to the misuse and misapplication of devices with component recognition only, which were either improperly combined with other components, or simply not applied per their intended evaluation. As a consequence, approval authorities tend to place a greater emphasis on the proper selection and combination of recognized only components with other devices and elements in the circuit, as well as the need for their assembly in an enduse product to be performed and monitored in an approved manufacturing location. Approved assembly factories and workshops are subject to routine and regularly scheduled inspections from the approval authorities to monitor their work and compliance with appropriate standards (*Follow-up-Service*). The manufacturer's report and procedure pages describe in detail what type of assembly can be performed in each respective location. Only approved manufacturing locations are entitled to apply listing marks to component combinations and assemblies.

In Canada, the approval authorities have always paid the same type of attention to this issue albeit without

the same type of officially publicized differentiation afforded to *Recognized Components* in the US. In a further development to this effect, CSA has now begun to introduce a special symbol on components to denote their special, "recognized only" status. A yellow triangle will be placed on products with a known history and track record of mis-application in Canada. This will be done in order to better alert the approval authorities to the need of insuring that the product is being applied in conformity with local installation Codes.

Note: An approval without restriction (e.g. *UL-LISTED* or *CSA-CERTIFIED*) in no way implies that these components can be readily used and applied in the same manner as they are in the IEC world. The suitability and functionality of a fully listed product or assembly are established by the approval authorities through the evaluation process and are subsequently documented in a report. Apart from the additional restrictions placed on "*Recognized Components*" as described in **Table 8**, the validity of a stand-

alone listing or certification is only meaningful with its relevance to North American installation Codes, and products so listed and certified must be applied accordingly.

Applications for which these devices are suitable (Energy distribution or control panels, motor starters, elevator controls etc..) and for which required ratings were obtained and documented in a report, must always be reflected and covered by the rating labels provided on the product or, when allowed, in accompanying documentation supplied with the product.

Adapters equipped with motor starters

Moeller offers bus adapters fully equipped for combination motor starters. These adapters are suitable for use in the IEC world as well as in North American branch circuits. When installed with their incoming supply in the feeder circuit, these motor starters must be additionally equipped with the aforementioned *BK25/3-PKZ0-E* large spacing terminal block. Fully equipped adapters, with type suffix „-NA“, will be possible for customer specific North American motor starter combinations in large volume. Whereas, generally speaking, not much attention is focused on whose motor protective devices and contactors end up mounted and wired on busbar adapters in the IEC world, the situation with respect to North American exports is decidedly more complicated.

Empty busbar adapters, i.e. those without any components mounted, cannot be listed as stand-alone equipment in North America since they must be completed in some form or another in order to be installed and achieve proper functionality in power circuits. Such adapters, therefore, fall under the *Recognized Components* category.

As previously alluded to, a component recognition for these accessories will likely require them to be combined and tested with specific components, and also possibly subject them to additional conditions of acceptability. The entire assembly, along with any such

stipulations, would then be detailed in a manufacturer's certification report. This would also include a description of the busbars, bus holders and any other related hardware, as well as all of the significant power circuit components. Indeed, all vital elements of the busbar system, including all motor starter power circuit components, need to be included in overall testing in order to insure the viability of the entire assembly, particularly under fault conditions. At this point it should become clear to anyone involved in specifying or installing such systems that it would be very difficult to obtain written validation of the expected performance, under overload or fault conditions, of components which were obtained from 2 or 3 different suppliers, and randomly assembled together as a complete unit. A certificate for each individual component may be easy enough to secure, but there is a much lesser likelihood of securing verification for a complete assembly, as it properly should be the case. Obtaining fully tested bus adapter combinations, such as those from Moeller, would be the safest, and most advantageous, way to go, since a certification report for the complete assembly would be readily available. That in itself is already a lot more than just simply taking advantage of the mounting and wiring features of a busbar and bus adapter based system. That is especially the case today for assemblies in compliance with the industrial control panel standard UL 508A, which mandates the establishment of an overall Short Circuit Current Rating based on the SCCRs of all power circuit components included in the assembly.

In terms of component ratings, it makes absolutely no difference in Moeller equipment whether the electrical connections between the motor protective switch and the associated contactor are made with specially designed, pre-fabricated connectors (e.g. Type *PKZM0-XM32DE*), or with a direct plug-in connection design, which is considered just as technologically modern and comfortable in terms of installation. All Moeller combinations are tested together and evaluated with the bus system as an assembly, and the results are summarized and tabulated in the certification report. In addition,

the rating labels of each motor protective switch are marked to indicate the respective contactors with which they were tested as a combination. In North America, a great deal of work is required on the part of manufacturers with respect to the description of permissible component combinations which can be applied. As long as there is strict adherence to the overall assemblies that have been comprehensively described in a manufacturer's certification, and their associated ratings, the panel builder is free to combine the components on his own as best suits the application (**Table 9**). If the panel in question is meant to be suitable for world markets, then it would be necessary to equip the motor starter adapters, fed directly from a feeder circuit, with the additional large spacings terminal accessory (**Table 10**). Type E und Type F-Combination motor starters in North America are rated for grounded wye type distribution networks. Consult the Moeller catalog for appropriate frame sizes and nominal current and voltage ratings (e.g. 480Y/277 V or 600Y/ 347 V). For IEC markets only, the use of the additional spacings terminal on the bus adapter mounted motor starters is not necessary.

Summary

Mounting motor starters and molded case circuit breakers on busbar adapters in industrial control panels is not as widely practiced in North America as it is in the the IEC world. Nevertheless, machine manufacturers from Europe and overseas are helping to propogate this modern and effective technology in North America through their exports. As a tool to help expand and promote the concept even further, this paper outlines the necessary measures which need to be undertaken in order for the technology to be in conformity with pertinent North American safety standards and applicable electrical installation codes.

Smartly designed busbar systems and adapters are not only useful in saving precious mounting and wiring time, but they contribute greatly by default towards a more refined and effective use of space, as well as an overall much cleaner panel component layout. All the features combine to provide a highly

esthetic and modern look while guaranteeing maximum levels of mechanical robustness and electrical safety. Moeller components from the Busbar System *SASY 60i* have the necessary features to fulfill all of the essential requirements for world market applications, including the unique demands of the North American market. Moeller improves on the efficacy of the system by making connection ready motor starter equipped bus adapters available for most applications. It's much quicker and less error prone to perform essential mounting and wiring of units in a factory setting rather than on a shop floor, or worse, at the installation site. Of particular importance is the certification report, in which all of the system elements are properly described, and which makes it much easier to accurately determine the short circuit rating (SCCR) of the overall control panel. The availability of such a report greatly facilitates the entire approval process of the assembly in North America. The provision of an overall short circuit rating (SCCR) on the nameplate of control panels for industrial machinery (*Control Panels for Industrial Machinery*), indeed all control panels, became a requirement of UL 508A in April of 2006. [8]. Similarly, Article 409 of the NEC mandates *Short Circuit Current Ratings (SCCR)* for all industrial control panels since the beginning of 2005. This additional, and broad reaching, requirement has certainly caused its share of major headaches amongst panel builders throughout the industry. The advent in the market of connection ready, and short circuit rated, component equipped busbar adapters falls exactly in line with this concept, and should make the ones available from Moeller that much more attractive to the panel builder. In particular, the short circuit levels achieved for the Moeller units can be categorized in the "very high fault" category, which will not be the case with unevaluated assemblies made up of individual components, the maximum ratings of which could be capped at relatively low levels of short circuit current ratings. (The UL 508A standard has a provision to assign values for unevaluated and unmarked components on average in the range of 5kA to 10kA, depending on the component.) Fully equipped adapters with customer specific combinations in larger volumes

can be made available. For North American installations, *Type E* or *Type F* combination motor controllers must be fitted with a distribution spacing terminal block on their incoming supply side. The mounting of molded case circuit breakers and switches up to 550 A should be of particular technical, as well as economical, interest. Apart from the components presented herein, the Moeller busbar system *SASY 60i* also encompasses provisions for bus mounted IEC fuse assemblies, as well as North American fuses. New, additional rationalization potentials are on tap featuring simple networking (eliminating control circuit wiring) using Moeller *System Smart Wire* technology.

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- Saving space and main circuit wiring
- Saving control circuit wiring and PLC I/O

+ Tool-less plug connector
+ SmartWire

+ Three-phase commoning link

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- Saving power supply wiring

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