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WHITEPAPER
MATERIALS FOR ELECTRIC BUSWAYS

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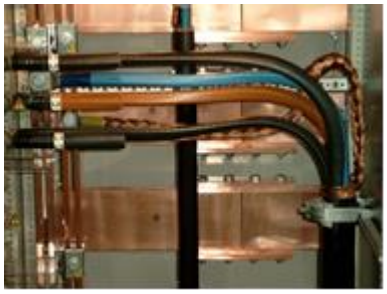
SUMMARY: NUMEROUS REASONS TO CHOOSE COPPER


Busbars, busducts, and busways using copper conductors have several advantages compared to their counterparts fabricated from other materials.

The main advantages of copper arise from its high electric conductivity (low electric resistance). These characteristics make it possible to create busways with the same current carrying capacity but that are smaller and/or more energy efficient.

In addition, the use of copper results in highly durable connections that can resist strong mechanical forces.

Cost of the conductor should not be the only consideration when evaluating the cost of a busway. The cost of the mechanical support systems, the energy losses over the lifetime of the installation, and the scrap value of the material at its end-of-life must all be taken into consideration in order to gain an accurate picture. When this is done, it becomes clear that the initial price of copper has only a minor influence on the total life cycle cost of the busway.

COPPER BUSWAYS MORE COMPACT AND/OR MORE ENERGY EFFICIENT

Copper has a conductivity of 58 MS/m (at 20 °C), which is the second highest conductivity to be found in nature (after silver). The conductivity of aluminium is 35 MS/m (at 20 °C), or approximately 60% that of copper.

The high conductivity of copper can be used to advantage in two situations:

1) A copper busway has a **higher energy efficiency** than an aluminium counterpart of the same width. This brings with it the obvious financial and environmental benefits, such as reduced energy costs and reduced CO_2 emissions. Higher conductivity also reduces the voltage drop on the busway, which has a positive influence on the reliability of electrical appliances in the network. Furthermore, higher energy efficiency means less loss through heat dissipation, allowing busways to be installed closer to one another.
2) When the energy efficiency of a copper busway is identical to that of its aluminium counterpart, the copper busway will have a smaller cross section. This **compactness** adds several advantages:
    i. Less space required for support mechanisms and for the structures housing the busway. These structures will also be less expensive.
    ii. No additional labour and handling effort is required to install a copper busway because of its higher weight, as this is compensated by its smaller size and the smaller size of its supporting structures.

It is also possible to achieve both the energy efficiency and compactness advantages to a lesser degree.

TAKING HARMONICS INTO ACCOUNT

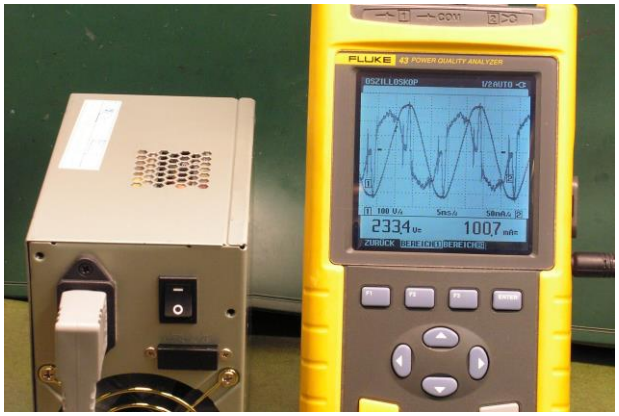
The connection of non-linear single-phase loads will result in harmonic currents flowing through the neutral and phase busways. In this event, the width of both phase and neutral busways has to be upgraded by the following factors:

Non-linear load/linear load	Upgrading factor
0.00	1.000
1.00	1.155
1.25	1.233
1.50	1.323
1.75	1.422
2.00	1.527

Source: GE Energy Industrial Solutions, brochure on Spectra Series™ Busway

The busway will have to be wider in order not to compromise on voltage drop, heat dissipation, and energy efficiency.

As a result, the difference—in absolute value—between the minimum width for aluminium busways and that of their copper counterparts becomes even larger.

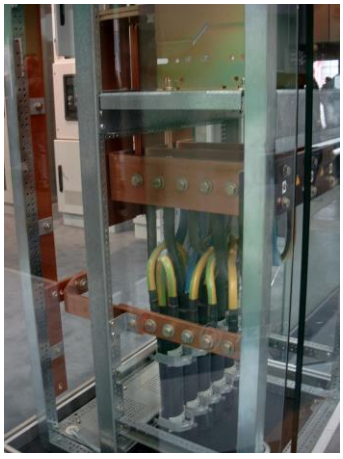


If the width of an aluminium busway was calculated without taking non-linear loads into account, one way to incorporate the de-rating factor of non-linear loads in a later phase of the project is to switch from aluminium to copper, keeping the same busway width.

EASY, EFFICIENT, AND DURABLE CONNECTIONS

A busway made out of copper is smaller than its aluminium counterpart with a similar current carrying capacity. The same is true of busway connection systems. Its compact size makes the installation of a copper busway and the addition of new connections easy and convenient. In the case of an interior system where space is limited, the use of copper will often be crucial to the design of the installation. A copper busway will sometimes enable an additional connection where a complete new installation elsewhere in the building would otherwise be required.

Copper busways are not only easy to install, they also last for a long time. Connections to a copper busway can withstand temperature cycles caused by load variations without significant degradation. Forces are evenly distributed at the joint of a copper cable to a copper busway. This results in low energy losses, low temperature variances, and a durable connection. This contrasts with aluminium and most of its alloys. Aluminium connections deteriorate over a number of load cycles due to loss of contact force.



RESISTING AGGRESSIVE ENVIRONMENTS

Busways that are used in aggressive chemical environments of industrial production sites will be subject to accelerated corrosion. The use of copper as a conductor is the only guarantee that corrosion will remain limited and will not affect the electrical properties, energy efficiency, and mechanical strength of the busway.

RESISTING MECHANICAL FORCES OF SHORT CIRCUIT CURRENTS

In the event of a short circuit, a high current will flow inside the busway before a circuit breaker cuts it. Those currents bring along high tensile forces that risk the complete destruction of the installation. In a sandwich type busway, those forces are restrained by the housing structure. However, in other types of busways, it is the conductor material itself that should be strong enough to withstand it.

Half-hard copper has a tensile strength of 260 up to 300 N/mm^2. The value for annealed copper is slightly lower, ranging between 200 and 250 N/mm^2. The tensile strength of aluminium only ranges between 50 and 100 N/mm^2.

Consequently, the copper version will withstand higher short circuit currents when the same mechanical support systems are used for a copper busway as for its aluminium counterpart.

Likewise, if an aluminium busway has to withstand similar short circuit currents as its copper counterpart, it requires more and stronger mechanical support systems, driving up the total cost of the installation.

TAKING ALL COST ASPECTS INTO ACCOUNT

When comparing the cost of different busway materials, it is not just the investment cost that needs to be taken into account. All of the various cost factors over the complete economic life cycle of the system, recalculated to present time values must be considered. These factors include:

- **Energy losses**: The cost of energy losses depends upon the load on the busway and the electricity tariff for a given rated current and busway material conductivity. The high conductivity of copper will result in low energy losses. Note that a more precise calculation of these losses requires using the load and electricity tariff at each moment in time, rather than averages. As high loads tend to happen during moments of peak tariff, such a calculation will reveal a higher annual cost of energy losses.
- **The cost of support materials, surrounding structures, and busway connections**: The wider the busway, the more expensive these systems will be.
- **Scrap value:** One of the most intriguing aspects of copper is that it is a 100% recyclable material with a high scrap value at the end of life of the busway. The market prices of all electrical grade copper scrap are close to the prices of new copper.

ROUND UP

When choosing the conductor material for a busway or busbar, the cost over the complete life cycle of the system must be taken into account, as well as a few critical technical aspects.

A copper busway will be smaller and/or more efficient than its aluminium counterpart. The reduced width makes the copper busway easier to install and reduces the size and cost of supporting structures. Higher energy efficiency brings obvious financial and environmental advantages. These advantages become even more pronounced when non-linear loads are expected, requiring an upgrade of the busway width. A calculation of the life cycle cost should also take into account the scrap value of the material at the system end-of-life. Market prices for electrical grade copper scrap are usually high and close to the value of new copper.

The use of copper as a busway material has additional advantages. Connections of copper cables to copper busways are durable, withstanding load and temperature cycles. A copper conductor can also withstand aggressive industrial environments without excessive corrosion. And last but not least, the tensile strength of copper is high, making it able to withstand the high mechanical forces caused by short circuit currents.