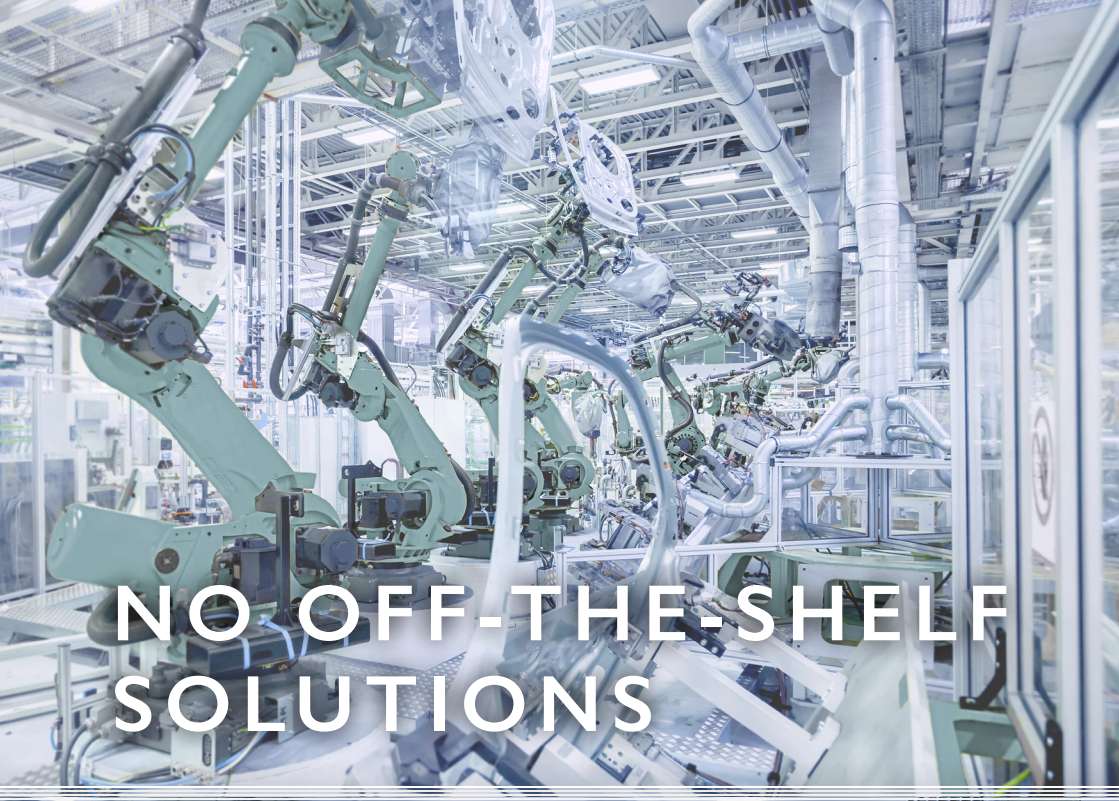


NO OFF-THE-SHELF SOLUTIONS

ROBOTICS

MUCKENHAUPT & NUSSELT

Company

Since its foundation in 1926, MUCKENHAUPT & NUSSELT has concentrated on developing and production of cables.

We are a special cable production company with around 100 employees, developing tailored solutions for our customers as a development partner and constantly putting innovations into practise. This applies both for the materials we use and the functions of our cables.

For each project, our work begins with accurately determining the customer's requirements and the individual application. On this basis, we are able to select or develop cables that do not compromise on functionality, quality and lifespan.

Areas of application: very varied

Our cables can be used for many applications and in a wide range of industries. Whether it's about long-lasting flexibility, specific wear resistance, industry-specific certifications or individual combinations of data and energy cables: We develop and produce exactly the cables that you need – for example, for the following industries:

- Elevators/ conveyor technology
- Automation
- Crane/lifting technology
- Lighting industry
- Robotics
- Event technology

Our expertise

Production: flexible and fast

Our manufacture of cables in Wuppertal is exceptionally flexible. A diverse plant, based on short set-up times, enables quick production of customer-specific cables in the desired quantities.

We can produce both sample quantities (incl. less than 500 m) and large orders with short supply times for you.

Quality and sustainability

MUCKENHAUPT & NUSSELT works efficiently and guarantees high product quality. The cables are tested with required loaded in the company's own laboratory and test department.

As well as quality in all processes, we pay attention to ecologically contractual production. This is documented by the certifications in accordance with DIN EN ISO 9001 and DIN EN ISO 14001.

MUNFLEX® – a brand that stands for high-quality cables

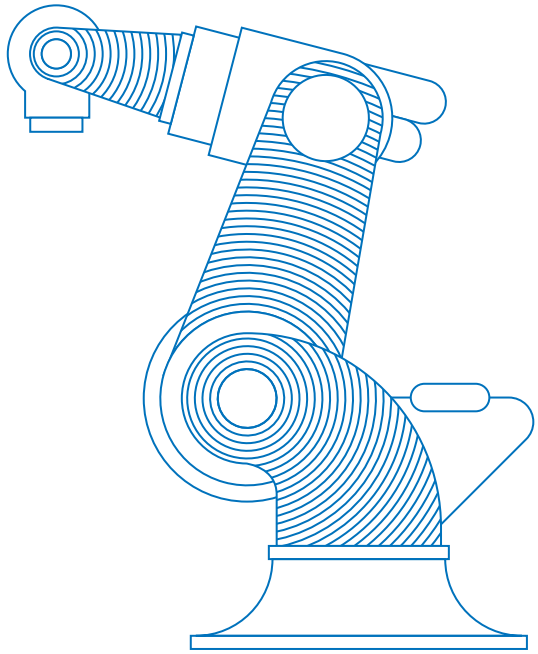
For many projects, we can depend on the standard cables in our comprehensive MUNFLEX® range – and on the experience of more than 45,000 constructions. The cables from our brand are available in numerous varieties, incl. control and data cables and special cables (MUNFLEX®-Special).

Industrial robots: a success story – today and in the future

The global inventory of industrial robots is growing significantly. The "World Robotics Report 2017" calculated that between 2017 and 2020 alone, around 1.7 million new units will be installed. This corresponds to annual average growth of 14%*.

The reasons for this are clear: The international competitive pressure in industrial production continues unabated, as does the compulsion towards as much automation as possible. At the same time, the markets and characteristics of the robots are changing. They are becoming more flexible, are adapting to changing requirements and can thus economically manufacture or assemble smaller quantities, down to unique details. This also contributes to a strong increase in the number of industrial robots.

**(Reference: World Robotics Report of the International Federation of Robotics / September 2017)*



Trending: division of labour between humans and robots

A new trend is emerging from the new kinds of co-operation between humans and robots. Both are working increasingly hand-in-hand, without separating safety guards, whereby robots are relieving humans of monotonous and exhausting work. These collaborative robots ("Cobots") have opened the doors to new applications and tasks for robotics – also and especially in middle-sized industrial companies.

Torsional loads pose special demands

In energy and signal transfer in robotics, cables perform combined three-dimensional movements. From the perspective of cable engineers, this means: There are not just switch bending loads, as with applications of energy chains, but also torsional loads.

Conventional cables that are used in such applications can quickly become deformed. This results from the fact that due to the constant change in a cable's diameter, individual cores are released from the core stranding and rub against both the centre and the outer sheath. The consequences are broken strands and cable outages.

No "off-the-shelf" solution

Cables for robotics must be designed and developed according to application and requirements: Because requirements are individual and challenging, there are no off-the-shelf solutions.

That's why our experienced experts will work with you to identify all requirements, operation conditions and, if necessary, special requests, before they are all realised. For that they can draw from a database of more than 45,000 special products. The flexible assembly in our productions creates the conditions for short delivery times, even for customer-specific robotic cables.

Flexibility and reliability in three dimensions

Robotic cables from MUCKENHAUPT & NUSSELT have been developed, from the ground up, for use under torsional and bending loads. Included among the design features of our twistable cables are, among others, special types of stranding, the use of filling elements or special slideable wrapping, as well as the use of abrasion-resistant sheath materials.

As a result, the cables are best-prepared to achieve a long service life, even under changing torsional loads at radii up to +/- 360°, as motor, control, data or hybrid cables. This is how our cables keep your robots moving.

The same applies for robots that work with short cycle times. For example, handling robots in semiconductor manufacturing and plastic injection moulding machines sometimes operate with clock rates of a few seconds in confined spatial conditions. For a (realistic) cycle time of four seconds, that represents 7,200 three-dimensional movements carried out by a robot cable here – with a high speed and tight bending radii. With a 24/7 operation, that's already more than 50,000 cycles per week and more than 2.6 million per year. MUCKENHAUPT & NUSSELT develops robot cables for requirements similar to these.

Additional requirements: heat, moisture, small bending radii

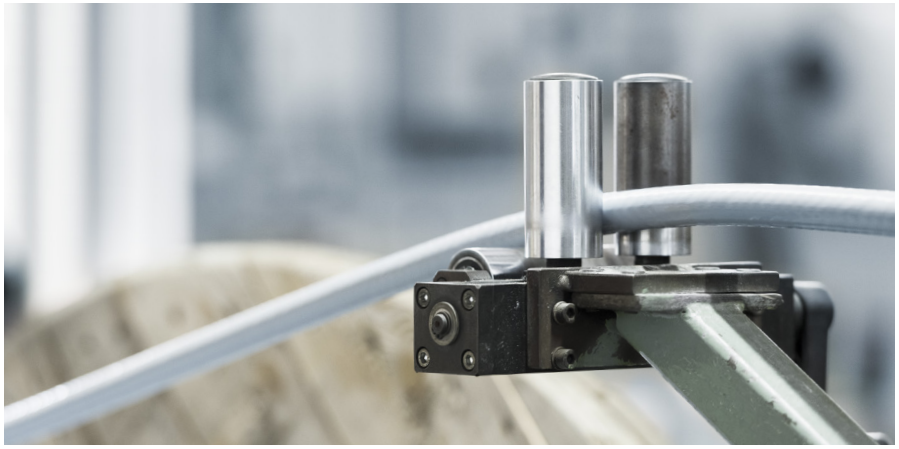
Depending on a robot's range of application and function, the cabling needs to meet even more requirements. Welding robots need cables that are heat resistant. Handling robots, e.g. in the semiconductor industry often perform highly-dynamic movements in very short clock rates, and the cables' bending radii are very small. Cables for underwater robots, meanwhile, need to be absolutely water tight. Tensile loads also affect cables in some applications.

Coating: the material makes the difference

Abrasion resistance plays a central role during the selection of sheath materials. Both in self-supporting applications and chain-guided, or robot cables guided in flexible pipes or joint axes, the stress on the sheath is very high. Depending on the application, other requirements, such as oil, UV or heat-resistance may be added. In most cases, we use highly abrasion-resistant polyurethane types for robot applications.

Developed from the ground up for robotics

In many robot applications, high demands are also placed on the interference immunity and thus on the shielding of the cables. Here we use specially-adapted wire. In terms of date throughput and transmission speed, we likewise adapt the robot cables according to our customer's high expectations, based on our many years of experience in automation technology and robotics.



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