NFPA 79
ELECTRICAL STANDARD FOR INDUSTRIAL MACHINERY

2021 EDITION

WHITE PAPER

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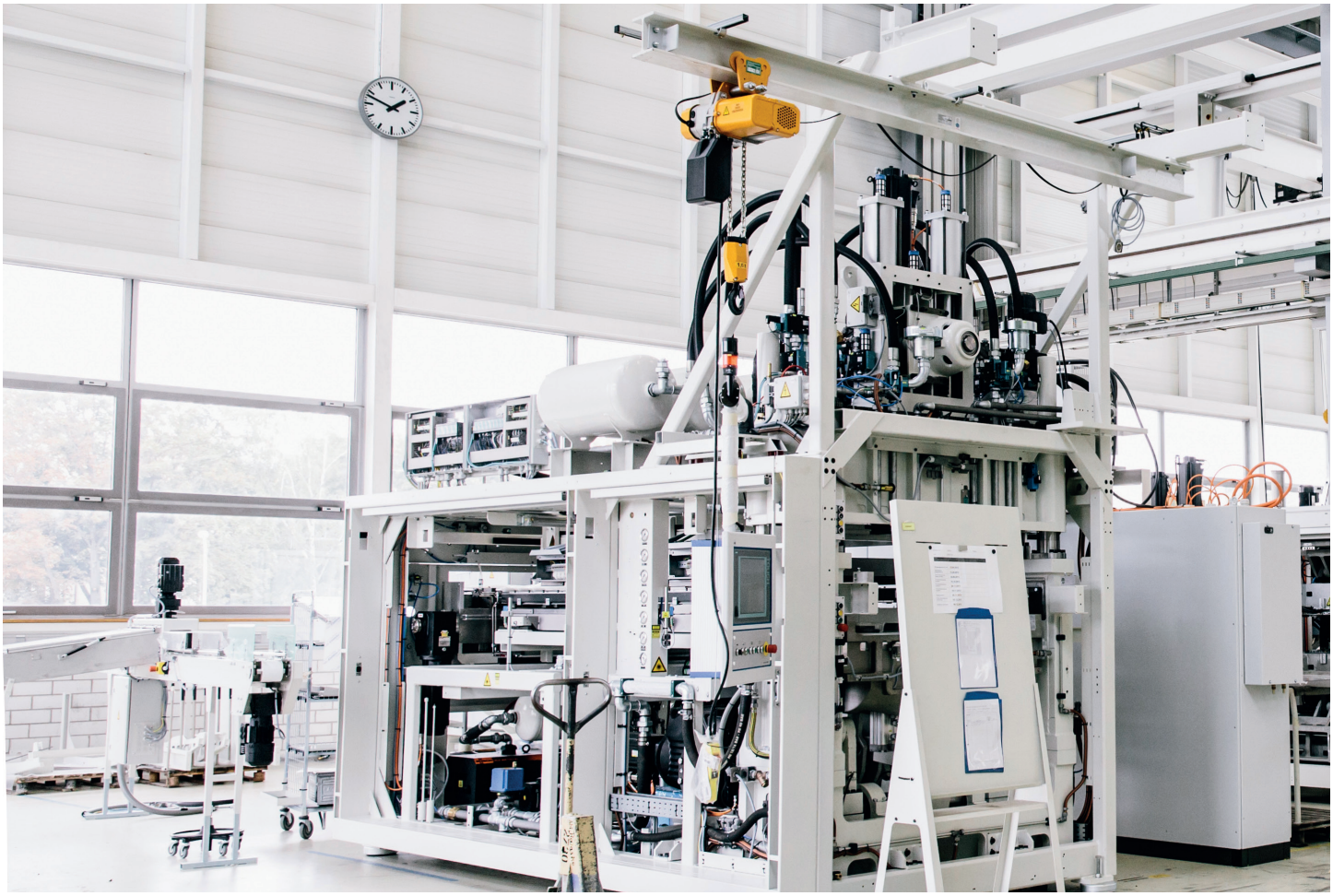

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THE INDUSTRIAL MACHINERY STANDARD: NFPA 79

NFPA 79 is the U.S. Electrical Standard for Industrial Machinery and is referenced by the National Electrical Code under Article 670. Specifically, NFPA 79 applies to the electrical equipment used within a wide variety of machines—and groups of machines—working together in a coordinated manner. Examples of industrial machinery include machine tools, injection molding machines, woodworking equipment, assembling machinery, material handling machinery, and inspection and testing machines. NFPA 79 encompasses all of the machines' electrical and electronic elements operating at 1000V or less.

With the new NFPA 79 2021 edition, the primary focus remains overall safety and promoting further harmonization with its European counterpart Standard, IEC 60204-1. These changes were driven primarily by the machine manufacturers' global necessity to ensure that their products were safety-compliant at both the domestic and international levels.

PROPER CABLE SELECTION SHOULD NEVER BE AN AFTERTHOUGHT

Perhaps one of the most overlooked items regarding the installation of equipment and machines in an industrial or commercial setting is selection of proper cables. This could be due to expenses surrounding the original purchase price of machines, equipment, and mounting hardware (conduits, trays, raceways), plus the labor costs necessary to complete the installation. Intentional or not, cable selection seems to be given a secondary degree of attention in the design and installation process. Unfortunately, this can prove to be very costly for the building contractor, machine fabricator, manufacturing occupant, and all others involved in the process. Today, with the ever-increasing prevalence of lawsuits and insurance liability issues, proper cable selection is more important than ever.

END USERS SHOULD UNDERSTAND FOREIGN CABLE AND WIRING DIFFERENCES

Many overseas suppliers now provide machinery for use in manufacturing facilities in the United States. As there are different codes and regulatory requirements that affect machine electrical installations both in the U.S. and overseas, ensuring proper cable selection has become increasingly more complex. Foreign manufacturers at times will include European or Asian cables with their machines, further complicating this issue. These wiring methods from overseas do not apply in the U.S. and can cause many problems for both the installer and end user. A worst case scenario may involve rejection from an inspector requiring that the cables be replaced or that a separate certification from a Nationally Accredited National Test Laboratory (NRTL) or safety test facility be provided. Both instances will cause delays resulting in time lost and significant increases in overall project cost. In an effort to help

DEFINITIONS

NFPA – The National Fire Protection Association (NFPA) has no power, nor does it undertake to police or enforce compliance with the contents of the National Electrical Code. The NFPA does not list, certify, test, or inspect products or design installations for compliance with the NEC. The NFPA also makes no guarantee or warranty as to the accuracy or completeness of any of the information published in the National Electrical Code.

NEC – The National Electrical Code (NEC) is considered purely advisory as far as the NFPA is concerned. It is made available for a wide variety of both public and private sector uses in the interest of life and property protection. These include for use both in law and regulatory purposes and in private self-regulation and standardization activities such as insurance underwriting, building and facilities construction, and product testing and certification.

UL – Underwriters Laboratories Inc. UL is an independent organization providing safety-related certification, testing, inspection, and training services. There are no laws specifying that a UL Mark must be used. However, in the U.S. there are many municipalities that have laws, codes, or regulations which require a product to be tested by a Nationally Recognized Testing Laboratory (NRTL). UL does not, however, maintain a list of the jurisdictions having such regulations.

Authority Having Jurisdiction (AHJ) – The organization, office, or individual responsible for approving equipment, materials, and installation or a procedure.

Listed – Equipment, materials, or services included in a list published by an organization that is acceptable to the Authority Having Jurisdiction for product evaluation and periodic inspection. Listing states that the equipment, material, or service either meets appropriate designated standards or has been tested and found suitable for a specific purpose.

Labeled – Equipment or materials that have been labeled with the identifying mark of an organization which is acceptable to the Authority Having Jurisdiction for product evaluation and periodic inspection of production of labeled equipment or materials. Labeled items indicate manufacturer compliance with appropriate standards or performance in a specified manner.

Industrial Platform – Industrial machines and their accommodating floor installation operations such as assembly lines etc.

Industrial Infrastructure – Building designed to accommodate industrial surroundings and the necessary conditions required for the operation of industrial machines such as where cable trays, raceways, etc. are used.

combat these issues, safety test agencies such as Underwriters Laboratories check products after leaving the cable manufacturer at the "downstream users" to verify compliance. For example, at retrofitting-type fabricators such as data assembly, wire harness, and cord set manufacturers. Products are being checked for areas of potential non-conformance and counterfeiting issues. This process provides validation of individual components used and helps to insure products performance at end user levels.

WHY AWM WAS BANNED IN 2007, ALLOWED IN 2012

Reasons for omission of AWM in the 2007 NFPA 79 ranged from its incorrect use in the building infrastructure, to fire resistance characteristic differences, to insulation material dissimilarities concerning electrical and temperature properties. In 2007 however, the ban of AWM unknowingly presented an interesting dilemma to industry as only listed cables could now be installed within the confines of the industrial platform. While listed cables utilizing standard generic type insulating compounds could be procured, those applications requiring a higher degree of performance inadvertently created a "Gray Area". Different compounds were required to support the performance levels required for these types of applications. As AWM cables were no longer acceptable, providing cables for these high performance applications became an issue (Example: Polyurethane, Highly flexible servo cables, etc.). It was extremely difficult to provide a listed cable utilizing these other types of insulation materials and meet the demanding performance requirements for these applications and maintain dimensional compatibility with AWM. Machine builders, installers, contractors, designers, etc., either had to risk rejection from an inspection, or were now being forced to pay a separate fee for listing of their AWM assembly. Either option had presented alternatives that for many reasons were logistically considered unrealistic. The inclusion of AWM with future editions of the NFPA 79 insures resolution of these "Gray Area" situations and the other above-mentioned issues for the industrial platform.

NEW CHAPTER OF NFPA 79 NOW INCLUDES CABLE

The NFPA 79 2018 Edition was the first edition to reference cable in Chapter 4 "General Requirements and Operating Conditions". Traditionally with previous NFPA 79 revisions any references to Wire and Cable was dedicated primarily to Chapters 12 and 13. Cable has been mentioned under Chapter 4 as it directly corresponds to the conditions surrounding Variable Frequency and Servo Drive Systems.

Specifically Chapter 4, Section 4.4.2.8 titled "Circuits Supplied From Power Conversion Equipment" states the following: "Electrical conductors and equipment supplied by power conversion equipment as part of adjustable speed drive systems shall be listed flexible motor supply cable marked RHH, RHW, RHW-2, XHH, XHHW, or XHHW-2 or selected based on the equipment manufacturers instructions".

Section 4.4.2.8 was created in the 2018 NFPA 79 edition as an effort to provide further clarification to users when they specify cable for adjustable speed drive systems. Unfortunately, misinterpretation by the general public due to inaccurate information in publications within the wire and cable industry itself actually created the opposite effect. Widespread confusion became prevalent as users were led to believe that only a few specific insulation rated cable types (RHH, RHW, RHW-2, XHH, XHHW or XHHW-2) were now permitted to comply within code confines and ensure that users adjustable speed drive systems would operate properly. To promote additional insult and confusion, users were also lead further astray and being told that if they did not comply with these cable types then they would be risking actual code violations and face further penalties.

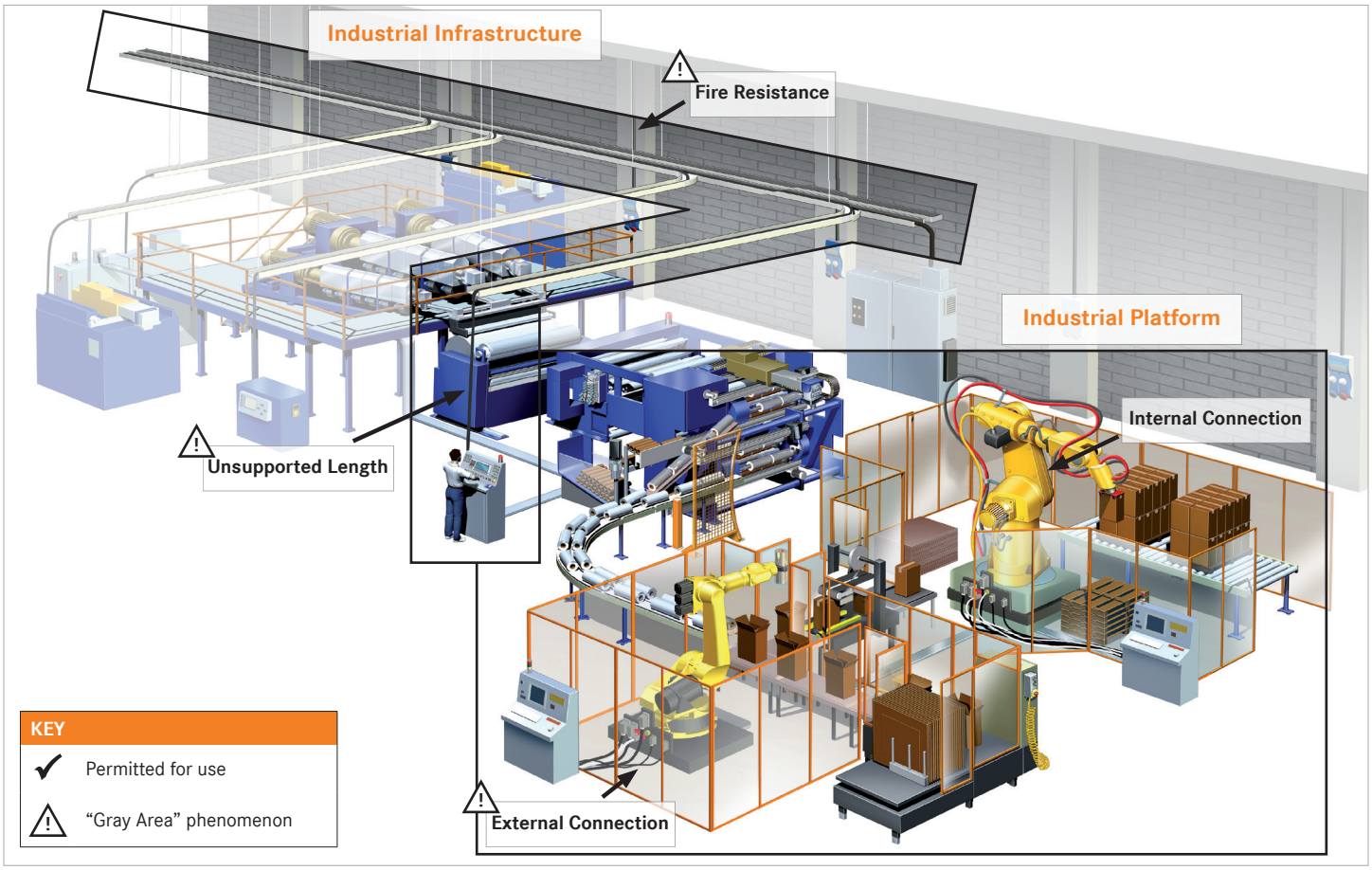
LAPP has always held a leadership role in the wire and cable industry, and quickly realized that something had to be done in an effort to halt this charade of erroneous perception. Soon after the NFPA 79 2018 was released, LAPP issued publications and provided training in the field offering and explanation that other cable options actually existed under 4.4.2.8. We understood that this was only a preliminary step forward and that further action would be required. LAPP proactively attended the NFPA 79 standard meetings and presented our findings to the technical committee members concerning the confusion and misinterpretation by industry. After several months of debate and subsequent discussions amongst the technical committee members, section 4.4.2.8 revised in the NFPA 79 2021 edition. This revision eliminated confusion as section 4.4.2.8 now reads as follows:

4.4.2.8 Circuits supplied from power conversion equipment

> **"Electrical conductors and equipment supplied by power conversion equipment as part of adjustable speed drive systems and servo drive systems shall be identified as suitable for the electrical power characteristics and in accordance with any instructions provided by the manufacturer(s)."**

Machinery utilizing high performance VFD and Servo motors manufactured overseas was being shipped to the US with AWM cables from Europe and Asia. This was done as part of the "complete package" to provide all the necessary components to complete the installation. There were no compliance issues when AWM cables were restricted to the industrial platform. The problems arose when these AWM cables were being extended from the industrial platform into cable trays throughout the building infrastructure to the control panels. Problems of higher severity also existed where these cables were being left "hanging" in an unsupported and unprotected manner when they were being installed from the control panel to the machine. As AWM is not a recognized cabling option permitted under the National Electrical Code a "Gray Area" resulted whenever

“GRAY AREA” PHENOMENON IN INDUSTRIAL APPLICATIONS



Product Approvals		Industrial Platform		Industrial Infrastructure	
		Internal Connection	External Connection	Fire Resistance	Unsupported Lengths (≤ 6 ft.)
NFPA 79 NEC 670	Appliance Wiring Material (AWM)	✓	⚠	⚠	⚠
		Open to different interpretation as AWM styles vary in ratings, construction and usage.		Not approved for applicable fire resistant requirements and unsupported lengths.	
NFPA 79 NEC 310 NEC670	Machine Tool Wire (MTW)	✓	✓	⚠	⚠
		Suitable for usage.		Not approved for applicable fire resistant requirements and unsupported lengths.	
NEC400	Flexible Cords (SJTO, SOOW, STOOW, etc.)	✓	✓	⚠	⚠
		Suitable for usage.		Not approved for applicable fire resistant requirements and unsupported lengths.	
NEC 800	Communications (CMX)	✓	✓	⚠	⚠
		Suitable for usage.		Not approved for applicable fire resistant requirements and unsupported lengths.	
NEC 336 NEC 725 NEC 727 NEC 800	Communications, Instrumentation, Power Limited, Tray Cable (TC, PLTC, ITC, CM or CMG)	✓	✓	✓	⚠
		Suitable for usage.		Suitable for usage; meets fire resistant requirements. Not approved for unsupported lengths.	
NEC 336 NEC 725 NEC 727	Exposed Run (TC-ER, PLTC-ER, ITC-ER)	✓	✓	✓	✓
		Suitable for usage.		Suitable for usage; meets fire resistant requirements. Approved for unsupported lengths.	

What is meant by the term “Gray Area” phenomenon and it’s applicability to the NFPA 79 and NEC 70?

This phenomenon refers to those areas where conformance guidelines are unclear and cannot be specifically determined but the field installation solutions provided are considered acceptable in the industrial market.

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the same AWM cable exceeded the confines of the industrial platform. To avoid this issue, a TC-ER rated cable solution would be able to fill this void resulting in resolution of this "Gray Area". The TC rating insures that the cables are highly fire resistant as compliance with large scale flame testing (UL 1277 Vertical Tray Flame or CSA FT4/IEEE 1202) is mandatory. The –ER rating (Exposed Run) indicates that the cables pass the severe crush and impact test requirements specified for type MC (Metal Clad) cable. Engineers are continually asked to design sophisticated machines that are very intelligent to serve the demands of an expanding market. It is important to remember that factors such as motor size, system voltage, ampacity requirements, environmental conditions, etc. are critical and all of these factors play a significant role in the correct cable selection. It is imperative that the correct cables are chosen the first time to ensure the electrical performance requirements necessary to support the precision and accuracy of equipment provided by the manufacturer.

In general for applications where precision control is vital, thermoset insulated VFD/Servo cables would be the choice recommendation. For those applications requiring extreme flexibility with smaller diameters, thermoplastic insulated VFD/Servo cables are recommended. Thermoplastic insulated cables will meet the physical and electrical performance requirements necessary to support VFD/Servo systems for these types of applications.

CONSIDERATIONS REGARDING EXPOSED CABLE

Another key section in NFPA 79 2021 is 13.1.6.1, which details that exposed cables installed along the structure of the equipment or system, or in the machinery chassis, are permitted. Exposed cables must be installed to closely follow the surface and structural members of the machinery. Section 13.1.6.1 permits cable to be installed without using conduit or raceways, enabling an economical, and expedient installation. During installation, the cable is also permitted to be dressed along the existing machine structures without the use of any special hardware. The time and labor saved during machine installation results in a huge cost savings over traditional installation methods requiring conduit or special cable mounting and routing hardware. Section 13.1.6.1 provides resolution and insures compliance to the previous "Gray Area" concerning these types of installations.

UL Listed cables meeting Exposed Run (-ER) requirements helps provide an additional level of protection under Section 13.1.6.1 type of applications. Cables complying with -ER requirements are subjected to severe crush and impact types of tests. Tray cables (TC) with the –ER (exposed Run) rating are further detailed under the National Electrical Code (NEC) Article 336. As cables with TC rating comply with large scale flame test requirements (UL 1277 or CSA FT4/IEEE 1202) usage is permitted in cable trays throughout the industrial infrastructure. The –ER rating validates that the cable has passed severe crush and impact test requirements allowing exposed run usage. TC cables with -ER provide an added benefit in that they are permitted to be run in unlimited length (provided they are supported as per NEC Article 336) from the cable tray to the associated equipment.

For those applications where the cables required on a machine are not addressed in NFPA 79 2021, Section 1.5 allows machine builders and installers to observe NEC Article 670; conversely NEC Article 670 also allows reference back to the NFPA 79. As an example, in communication applications, UL Type CMG is a cable type permitted under NEC Article 800, but it must meet the Stranding criteria referenced in NFPA 79 standard if used on the industrial platform. It is critical to remember that not all UL Listed cables automatically meet NFPA 79 requirements, especially the lower-priced commodity and more rigid generic types of products.

LAPP CABLE INNOVATIONS SET A NEW STANDARD FOR INDUSTRY

Cables used on the Industrial platform must be able to support a wide range of applications while being exposed to the extremes seen in the industrial environment. Cables must be able to also support application usage both nationally and globally. Along with numerous approvals, LAPP cables contain conductor stranding suitable for both North America (AWG) and overseas (MM^2) making them the perfect choice for domestic and foreign applications.

The industrial platform requires cables that can support either fixed or continuous flexing types of applications. The concept of AWM dealt more with continuous flexing cables which required the use of insulation and jacketing compounds other than the standard generic types that were being used. As the AWM allowance has been in effect since 2012 with the NFPA 79, cables could be provided for the industrial platform without fear of any regulatory compliance repercussions.

As an innovator in the wire and cable industry LAPP was determined to find a solution where one cable could be used both on the industrial platform and the accommodating building infrastructure. While products intended for static use in both types of areas did not present any issues, continuous flexing cables presented challenging prerequisites. Continuous flexing cables (such as ÖLFLEX CHAIN®, FD AUTO-X, FD VFD, SERVO FD 7TCE, etc.) require that other than generic type insulating and jacketing compounds be used to support the intended end use and electrical performance parameters.

Several innovative cable solutions were created by LAPP to resolve this dilemma for end users and insure compliance in the industrial platform and infrastructure to support both static and continuous flexing applications. The ÖLFLEX® 190/190CY cable series designed for both stationary and flexible application now maintains the superior TC-ER rating (previously MTW) allowing for use both on the industrial platform and in the infrastructure. In addition, the insulation

is comprised completely of PVC and no longer contains nylon. The removal of nylon provides for easier strip ability, quicker terminations, and greater flexibility. Cable dimensions remain unchanged from previous PVC/Nylon MTW design allowing the user to remain with their existing termination methods and hardware. The ÖLFLEX® 190/190CY provided by LAPP is a very unique UL Listed Tray cable solution that is not available from any other cable manufacturer in the world.

Cable product innovations, ÖLFLEX® VFD 2XL, VFD 2XL with Signal, and VFD 2XL SYMMETRICAL feature reduced diameter designs when compared to traditional 2000 volt Thermoset insulated TC rated cables. Specifically all these cables are tri-rated for 600/1000/2000 Volt use and maintain the same dimensions as 600 Volt Thermoset insulated TC cables. This exceptional insulation provides cables that are lighter in weight, easier to handle, and save space in tray installations while meeting the demanding voltage and power requirements for 2000 volt VFD/Servo systems. In addition, these cables are able to support 3x times the voltage withstand of 600 volt TC cables. As cable dimensions remain unchanged from 600 Volt TC-ER rated cables the end user may remain with their existing connectorization and termination methods. The ÖLFLEX® VFD 2XL, VFD 2XL with Signal and VFD 2XL SYMMETRICAL provide cable solutions exclusive to LAPP that are not available from any other worldwide cable manufacturer.

LAPP innovative cable designs ÖLFLEX® SERVO 7TCE and SERVO FD 7TCE address the need for precision control concerning stationary and continuous flexing VFD/Servo applications. As each cable is also tray rated (TC), providing multi-versatile usage for the industrial platform and infrastructure. The ÖLFLEX SERVO 7TCE and SERVO FD 7TCE were created to offer users a reduction in diameter versus other UL Listed thermoset insulated Tray cable types. These cables maintain the –ER rating for Exposed Run installations. These requirements were being promoted to support servo system installations from manufacturers such as Allen-Bradley (Rockwell Automation), Siemens, and other producers to provide the “one Cable” solution for both the industrial platform and infrastructure. As dimensions are similar to that of standard type generic PVC/Nylon cables no new retrofitting would be required concerning connectors, terminals, etc. The TC-ER rating ensures compliance with either NEC Article 336 or NFPA 79 requirements as one cable can be used to accommodate either installation. The ÖLFLEX® SERVO 7TCE and SERVO FD 7TCE provide very unique tray cable solutions that are not available globally from any other cable manufacturer.

CONCLUSION

In summary, it is of utmost importance to give as much close attention to the cables that will be used in equipment and machines as all other costs associated with an installation. Ignoring cable-specific requirements or consider them unimportant can be a very costly mistake and can ultimately result in unnecessary down time, or a potentially hazardous or life-threatening situation. With regard to industrial machine manufacturing and installation, the NFPA has taken a major step in addressing these issues by publishing its latest document, the 2021 edition of NFPA 79.

While AWM remains as a permissible wiring method in the NFPA 79 2021, manufacturers, installers, contractors, etc., must continue to remain vigilant to restrict its usage to the industrial platform. As AWM is not a recognized method of wiring per the NEC, it is prohibited for use anywhere in the industrial infrastructure, unless it has been dual rated with an appropriate UL listing (TC, PLTC, ITC, etc.). It is of utmost importance to always remember that upon an inspection any cabling used is subject to interpretation by the Authority Having Jurisdiction (AHJ). Only the AHJ has the experience and proper qualifications to provide final determination concerning cabling installation requirements. While LAPP USA can offer an opinion concerning interpretation of certain aspects of National Electrical Code (NEC) articles or NFPA 79 regulations, we are prohibited from providing any type of final determination.

LAPP UL LISTED PRODUCTS CONFORMING TO NFPA 79

PRODUCT	APPLICATION	KEY FEATURES
ÖLFLEX® 190 Shielded & Unshielded	Stationary Control	Highly flexible for ease of routing. Extremely oil resistant. TC-ER rated.
ÖLFLEX® TRAY II Shielded & Unshielded	Stationary Control	Tray rated for extended runs, no need for conduit. Highly flexible for ease of installation, saving time and money. Highly oil and chemical resistant. MTW all sizes.
ÖLFLEX® CONTROL TM	Stationary Control	Flexible and oil resistant tray and machine cable. MTW all sizes.
ÖLFLEX® CHAIN TM	Continuous Flex Control	Continuous flex and oil resistant tray cable. MTW all sizes.
ÖLFLEX® TRAY VTC	Stationary Control	Economical version of ÖLFLEX® TRAY II. In sizes 18 AWG and larger.
ÖLFLEX® AUTO-I	Stationary Control	Flexible tray cable with colored conductors for DC or AC control wiring.
ÖLFLEX® FD AUTO-X	Continuous Flex Control	Heavy duty ,continuous flex Power and Control Cable.
ÖLFLEX® VFD SLIM	Stationary VFD	Reduced-diameter VFD cable with a semi conductive insulation layer to withstand nonlinear power distortion.
ÖLFLEX® VFD with Signal	Stationary VFD	Based on ÖLFLEX® VFD SLIM with pair for brake or temperature.
ÖLFLEX® FD VFD	Continuous Flex VFD	Continuous flex VFD cable for moderate track applications.
ÖLFLEX® VFD 2XL	Stationary VFD	Both 600V and 2000V TC-ER rating. Extended performance with an XLPE (plus) insulation and a phthalate-free jacket.
ÖLFLEX® VFD 2XL with Signal	Stationary VFD	Based on ÖLFLEX® VFD 2XL with pair for brake or temperature.
ÖLFLEX® VFD 2XL SYMMETRICAL	Stationary VFD	ÖLFLEX® VFD 2XL cables in sizes 1 AWG and larger with three symmetrical bare copper ground wires.
ÖLFLEX® VFD 1XL	Continuous Flex VFD	Smallest diameter VFD cable on the market for fast and easy routing during installation
ÖLFLEX® VFD 1XL with Signal	Stationary VFD	Based on ÖLFLEX® VFD 1XL with pair for brake or temperature.
ÖLFLEX® SERVO 7TCE	Stationary Servo	Flexible Servo One Cable Solution (OCS) for equipment and cable tray. TC-ER rated, low capacitance, extremely oil resistant.
ÖLFLEX® SERVO FD 7TCE	Continuous Flex Servo	Continuous Flex Servo One Cable Solution (OCS) for equipment and cable tray. TC-ER rated, low capacitance, extremely oil resistant.
ÖLFLEX® SERVO FD 7FTC	Continuous Flex Encoder	Continuous flex feedback, one-cable solution (OCS) for equipment and cable tray. UL listed, lower capacitance, extremely oil resistant.

FREQUENTLY ASKED QUESTIONS

1. **What is meant by the term "Gray Area" phenomenon and it's applicability to the NFPA 79 and NFPA 70 (NEC)?**

   This phenomenon refers to those areas where conformance guidelines are unclear and cannot be specifically determined but the field installation solutions provided are considered acceptable in the industrial market.

2. **Does Underwriters Laboratories (UL) dictate what cables are being installed out in the field?**

   No, UL controls the construction and testing requirements of the cables which ensures that all electrical, physical, and environmental performance parameters are in compliance.

3. **Who controls the cables that are being installed in the field?**

   National Electrical Code Articles and NFPA 79 regulations are cited by the Authority Having Jurisdiction (AHJ), which is generally the office of the local electrical inspector.

4. **Does a machine have to meet NFPA 79?**

   Depending upon your application and whether your product is being installed in a building – yes. If you are not sure of the final destination of the machine it is always advisable to comply with NFPA 79 regardless to help insure compliance and safety, and to avoid any unnecessary litigation.

5. **If the cable is UL Listed is it allowable for use on a machine?**

   No, not necessarily. There are machines that use Listed cordage incorrectly, since these cable types are only intended for temporary applications. Even if your cables have a UL Listing, the minimum conductor stranding count required by NFPA 79 must be met.

6. **Is NFPA 79 a law?**

   No, this document is only a standard used by the machinery industry in the U.S. as the bench mark in safety compliance.

7. **What about FD products?**

   Depending on specific flexing applications there are different types of cable material blends that meet the NFPA 79 requirements and will hold up well in these types of environments.

8. **Is the industry going to become standardized with the latest edition of NFPA 79?**

   In the long run yes, due much in part to issues surrounding liability and safety. In short, nobody will purchase an industrial machine that does not comply with the latest edition of NFPA 79, as doing so could expose them to liability.

9. **If my cable is MTW, can it be run in the industrial infrastructure?**

   No, it has to be dual marked with another UL Listing such as "TC" which indicates the cable complies with a very high fire resistance rating. MTW requirements mandate that a cable only meets a minimal type of flame test, UL VW-1.

10. **Can the cable be left exposed when going from the machine to the cable tray?**

    No, unless the cable has an Exposed Run (-ER) approval such as TC-ER (according to UL 1277).

11. **Are MTW cables required to be oil resistant?**

    Yes, all MTW cable must meet the requirements of the UL Oil Res I test due to the demanding requirements that are associated with industrial machine environments. In those applications that require exposure under the most severe conditions, Oil Res II test is also a permitted option for cable manufacturers which provides extra durability.

12. **What is unique about the MTW Listing?**

    MTW requires that the cable be flexible and yet have a high degree of mechanical durability so it can maintain performance under the challenging conditions surrounding the everyday use in the industrial platform.