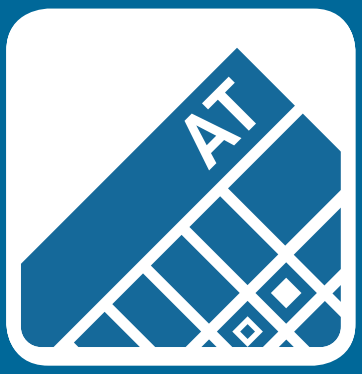
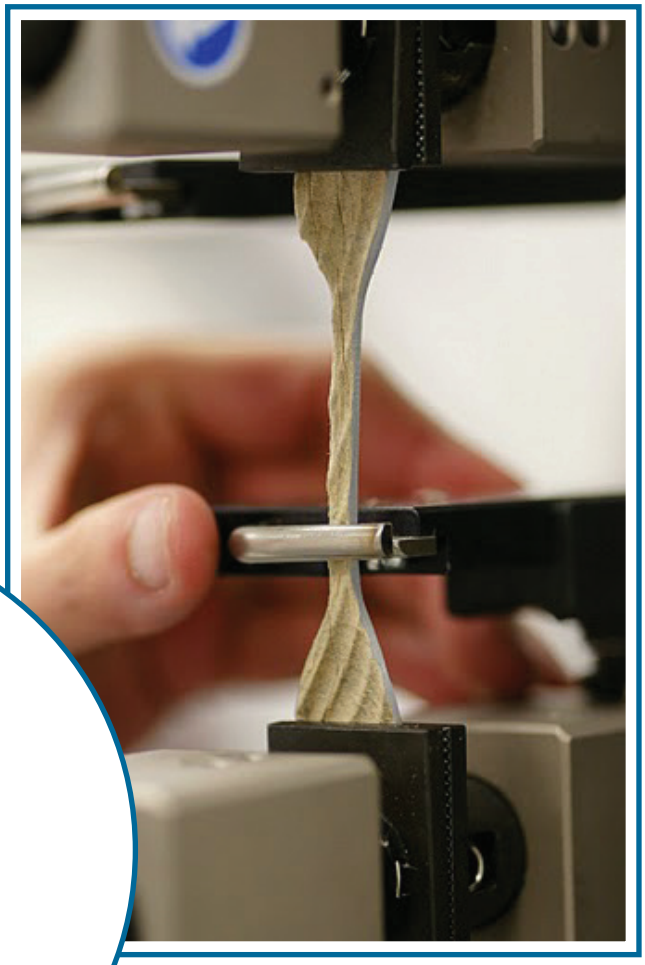
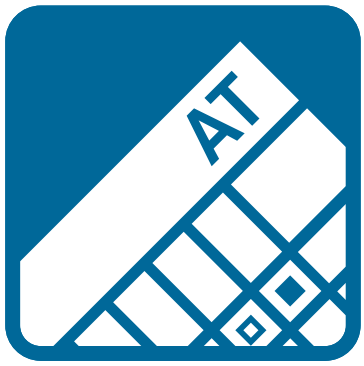
Appendix
Technical Data & Part Number Index






ÖLFLEX® FOR

Technical Data



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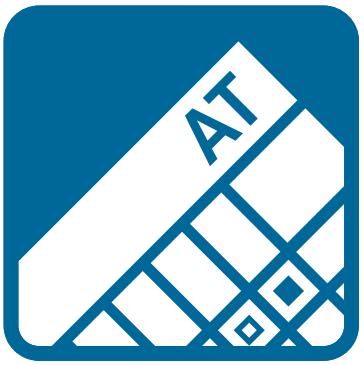
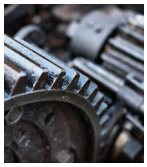


CABLE ATTRIBUTES

OIL RESISTANCE

FLAME RESISTANCE

MOTION TYPE



MECHANICAL PROTECTION

Over 50 years ago, company founder Oskar Lapp designed and manufactured the world's first flexible multi-conductor control cable. Ever since the Lapp Group has been known as the worldwide leader in flexible cable technology.

Through continual R&D and the extensive knowledge of our engineers, the Lapp Group has developed criteria which will aid the cable user in deciding which cable is best suited to their application.

As you will find on the following pages, the Lapp Group has reached a new level for specifying the following cable attributes: Oil Resistance, Flame Resistance, Motion Type, and Mechanical Protection. By setting the criteria for such important attributes, our engineers have given the cable buyer a more precise and definitive way to choose the cable that's right for their specific application or environment.

The symbols located at the top of the page can be found on the cable product pages within this catalog. To help you choose the Lapp cable that best suits your requirements, we suggest you review the criteria and definitions on the following pages and familiarize yourself with the different levels.

The Lapp Group continually strives to provide creative solutions and the highest quality products that you have come to expect.

These criteria are to be used as guidelines, and not definitive test results. Please contact your Lapp sales representative for specific testing results.

OIL RESISTANCE

Level	USA	CSA*	Europe*
OR-00	Minimum oil resistance characteristics	–	–
OR-01	UL 758 In oil for 7 days @ 60°C 75% Unaged Tensile Strength 75% Unaged Elongation	C22.2 No. 49 In oil for 7 days @ 60°C 75% Unaged Tensile Strength 75% Unaged Elongation	VDE 0281 Part 1 In oil for 7 days @ 60°C ± 30% Unaged Tensile Strength ± 30% Unaged Elongation
OR-02	UL Oil Res. I In oil for 4 days @ 100°C 50% Unaged Tensile Strength 50% Unaged Elongation	C22.2 No. 230 In oil for 4 days @ 100°C 50% Unaged Tensile Strength 50% Unaged Elongation	VDE 0472 Sect. 803A In oil for 1 day @ 100°C ± 25% Unaged Tensile Strength ± 25% Unaged Elongation
OR-03	UL Oil Res. II In oil for 60 days @ 75°C 65% Unaged Tensile Strength 65% Unaged Elongation	C22.2 No. 210.2 In oil for 4 days @ 100°C 65% Unaged Tensile Strength 65% Unaged Elongation	SEV TP 20 B In oil for 30 days @ 70°C No cracking after bending
OR-04	UL AWM 21098 In oil for 60 days @ 80°C 65% Unaged Tensile Strength 65% Unaged Elongation	C22.2 No 0.3 In oil for 60 days @ 80°C 65% Unaged Tensile Strength 65% Unaged Elongation	VDE 0472 Sect. 803B In oil for 7 days @ 90°C ± 25% Unaged Tensile Strength ± 25% Unaged Elongation
OR-05	In oil for 4 weeks @ 100°C 40% Unaged Tensile Strength 40% Unaged Elongation	–	–
OR-06	In oil for 7 days @ 180°C 80% Unaged Tensile Strength 60% Unaged Elongation	–	–

The type of industrial environment and other factors such as the duration of oil exposure and quantity of the liquid all attribute to the specific level of oil protection needed. Other parameters, such as the surrounding ambient temperature of the oil and the cable itself, will also play a role in determining the cables ability to withstand this type of chemical exposure. In general, the greater the ability of the cable jacket to resist the possible devastating effects of oil, the longer it will perform uninterrupted in the application. Certain industries (grinding, machine tools, etc.) will require the highest degree of oil resistance available, while other applications (office buildings, residential dwellings, etc.) will only need a minimal amount of this type of protection. The Lapp Group provides a large product offering of cables in a wide array of different constructions that will meet the varying degrees of oil resistance required for your application.

*Note: These oil immersion standards are mentioned for purposes of reference only. Some Canadian and European test standards are not necessarily represented here as complete equivalents to the US Standards but have been referenced due to similarities in requirements. Refer to the individual standards for detailed test procedures and any comparable evaluations.

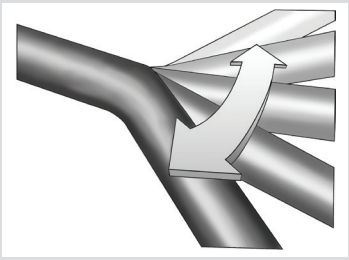
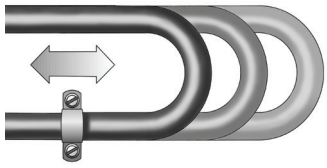
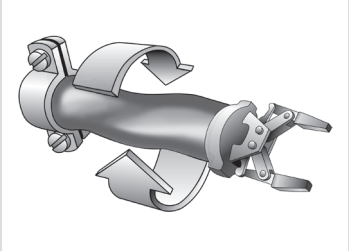
FIRE RESISTANCE

Level	USA	CSA*	Europe*
FR-00	Minimum flame retardancy: cable ignites and burns easily, and will not extinguish itself.	–	–
FR-01	UL 62: Horizontal Flame Test One 30-second flame application. Cable must not emit flame or glowing particles.	FT2: One 30-second flame application. Cable must not emit flame or glowing particles.	VDE 0472 Part 804 One 1-minute flame application. Cable must not ignite or emit flames.
FR-02	UL VW-1 (UL 1581): Vertical Flame Test Five 15-second flame applications. Cable must not emit flame or glowing particles.	FT1: Vertical Flame Test Five 15-second flame applications. Cable must not emit flame or glowing particles.	IEC 60332-1 Flame application time varies by cable diameter. Cable must self-extinguish.
FR-03	UL 1581: Vertical Tray Test Exposed to flame (70,000 BTU) for 20 min. Damage cannot exceed 8 feet.	FT4: Vertical Tray Test Exposed to flame for 20 min. Damage cannot exceed 5 feet.	IEC 60332-3-24 Exposed to flame for 20 min. Damage cannot exceed 8.2 feet.
FR-04	UL Vertical Flame and Smoke Test Exposed to flame for 20 min. Damage cannot exceed 8 feet. Smoke release not to exceed 95 m^2 and peak smoke release rate does exceed 0.25 m^2.	FT4-ST1: Vertical Flame and Smoke Test Exposed to flame for 20 min. Damage cannot exceed 5 feet. Smoke release not to exceed 150 m^2 and peak smoke release rate does exceed 0.40 m^2.	IEC 60332-3-25 Exposed to flame for 20 min. Damage cannot exceed 8.2 feet.
FR-05	UL Flame Test for Riser Cables (UL 1666: 527,500 BTU) Flame spread cannot exceed 12 feet. Measured temperature at any point cannot be greater than 850°F.	–	–
FR-06	UL Flame Test for Plenum Cables (UL 910: 300,000 BTU) Exposed to flame for 20 min. Damage cannot exceed 5 feet, peak smoke optical density not to exceed .50.	FT6 Exposed to flame for 20 min. Damage cannot exceed 5 feet, peak smoke optical density not to exceed .50.	IEC 61034-2 Exposed to flame for a maximum of 40 min. Minimum value of 60% light transmittance.

Lapp cables are manufactured to comply with varying degrees of flame resistance requirements. Depending upon your application, certain levels of flame resistance are necessary in order to meet specific end-use requirements. Flammability ratings generally determine the end-use application, which is generally dictated by local or national electrical codes. Certain applications require a minimal amount of flame resistance, such as UL 62 or CSA FT2 for flexible cordage. In this instance, the end use of these products does not deem the necessity of imposing a high flammability requirement. Other applications, such as cables that will be installed permanently within an industrial building, commercial dwelling, or family residence, will most likely require a higher degree of flammability resistance like UL Vertical Tray or CSA FT4. Whatever the end-use application, the Lapp Group meets your requirements with a wide variety of cable products meeting different levels of flame resistance.

*Note: These flame standards are mentioned for purposes of reference only. Some Canadian and European test standards are not necessarily represented here as complete equivalents to the US Standards but have been referenced due to some similarities in requirements. Refer to the individual standards for detailed test procedures and any comparable evaluations.

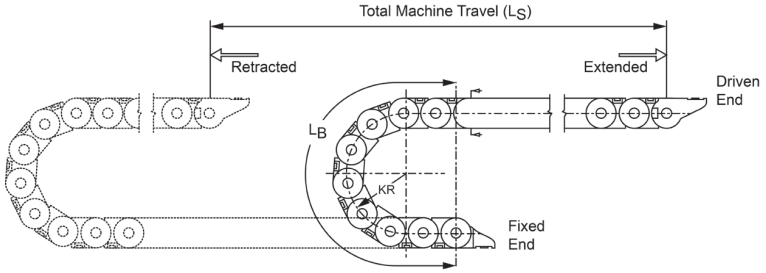
MOTION TYPE

Lapp Terminology	Lapp Definition	Recommended Applications
Stationary	Cables are installed and left in their original position. They are only moved for purposed of maintenance, repair, or retrofitting.	Cable trays, conduits, wire ways installed in buildings, machines, manufacturing facilities, etc.
Flexible 	Cables are moved randomly in a non-automated application. They are susceptible to occasional uncontrolled conditions of movement.	Flexible cable tray routings, machine tools, residential electronics, portable power equipment, etc.
Continuous Flexing 	Cables are in constant linear motion in automated applications. They are subjected to continuous forces applied during bending motions.	Horizontal and vertical c-tracks, power chains, automated assemblies, etc.
Torsion 	Cables are bending and twisting in a x-y-z motion in automated applications. They are subjected to continuous forces applied during torsion motions.	Robot, robot cells, pick-n-place machinery, automotive assembly, etc.

MOTION TYPE

Level	Description	Definition	Cycle Life Range
FL-00	Very Stiff (Static)	Low strand count and difficult to work with, used in static applications	—
FL-01	Flexible	Can be easily installed in machines, conduit, and cable tray when applicable	—
FL-02	Highly Flexible	High flexibility with continuous flexing design attributes	—
WT-01	Wind Turbine Torsion -20°C	Designed for basic wind torsion to an angle of ± 150°/m Application temperature: -20°C	up to 2,000 cycles
WT-02	Wind Turbine Torsion -40°C	Designed for basic wind torsion to an angle of ± 150°/m Application temperature: -40°C	up to 2,000 cycles
WT-03	Wind Turbine Torsion -50°C	Designed for basic wind torsion to an angle of ± 150°/m Application temperature: -50°C	up to 2,000 cycles
CF-01*	Continuous Flexing: Basic	Designed for basic continuous flexing and cable track applications Distance - chain length up to 15 feet	1 - 2 million cycles
CF-02*	Continuous Flexing: Moderate	Designed for continuous flexing and cable track applications Distance - chain length up to 30 feet	2 - 8 million cycles
CF-03*	Continuous Flexing: High	Designed for high cycle continuous flexing and cable track applications Distance - chain length up to 30 feet	8 - 20 million cycles
CF-04*	Continuous Flexing: High-Extended	Designed for high cycle continuous flexing and long cable track applications Distance - chain length up to 300 feet	8 - 20 million cycles
CF-04A*	Continuous Flexing: High-Extended High-Acceleration	Designed for high-cycle continuous flexing and long cable track applications; Distance: chain length up to 300 feet Acceleration: up to 50 m/s^2 for chain length up to 15 feet	8 - 20 million cycles
T-01	Torsion	Designed to withstand torsion applications	2 million cycles
TCF-01	Torsion & Continuous Flex	Designed for high cycle continuous flexing and torsion applications	10 million cycles

* When comparing cycle life data between cables, the following critical variables must be evaluated: bend radius, distance, acceleration, speed & weight



L_S = Total Travel Length
L_B = Loop Length
KR = Bend Radius

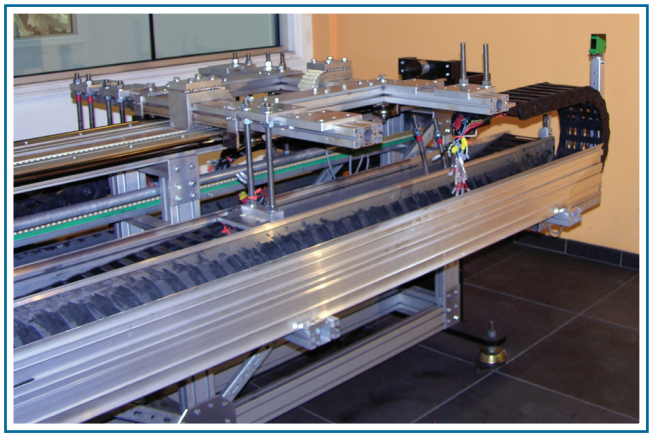
It is important to note that the test variables must be identical, otherwise the comparison is invalid.

The Lapp Group's cable designs are evaluated under the most extreme test conditions. The cycle life testing ranges in the above table do not indicate cable flex cycle failure, but are only indicators of suggested ranges for the intended application. When Lapp continuous flex cables are installed correctly in the application, a longer service life will result. For over half a century, Lapp products have been expertly designed, processed, manufactured, and tested with state-of-the-art equipment, guaranteeing the finest flexible cable products available. Our credibility and expertise have classified Lapp as the "innovator" in the industrial flexible cable and robotic industry.

MOTION TYPE

Test Conditions for Continuous Flex Cables

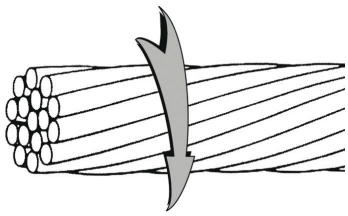
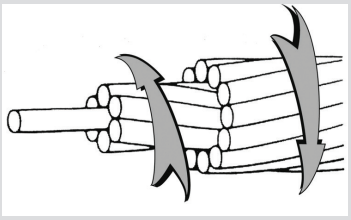
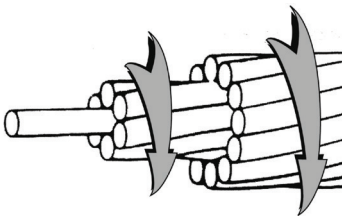
Minimum bend radius range factor	5 - 15 x cable diameter
Bending radius range factor during testing	4 - 12 x cable diameter
Travel distance under test conditions	Varies, 15 - 300 ft
Acceleration under test conditions	Varies, up to 164 ft/s^2
Temperature range during test	-10°C to +22°C
Speed of travel during test	Varies, 6.5 - 16 ft/s

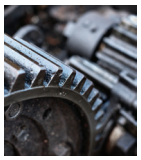


Test Conditions for Torsion Cables

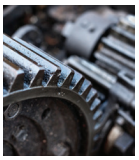
Standard torsion test	± 450°/m
Severe torsion test	± 720°/m
Rotational speed	Varies, up to 5 rpm
Tensile load	Varies, up to 150 lbs

MOTION TYPE

Lapp Design	Lapp Definition	Use
Unilay or Bunch 	Conductors of any number are twisted together with the same lay direction and cable lay length. Bunch construction will not have a well-defined geometric configuration and may have a variable cross-section. A unilay construction will have a well-defined geometric configuration and a defined cross-section.	This type of cabling technique is usually used on stationary designs.
Concentric Contra-Helical 	Conductors are surrounded by well-defined layers of helically laid conductors. Each layer has a reversed lay direction and an increasing lay length in each succeeding layer.	This type of cabling technique is usually used on continuous flex designs.
Concentric Unilay 	Conductors are surrounded by one or more layers of helically-laid conductors with the same direction of lay and increasing lay length in each succeeding layer.	This type of cabling technique is usually used on torsional and continuous flex designs.



MECHANICAL PROTECTION

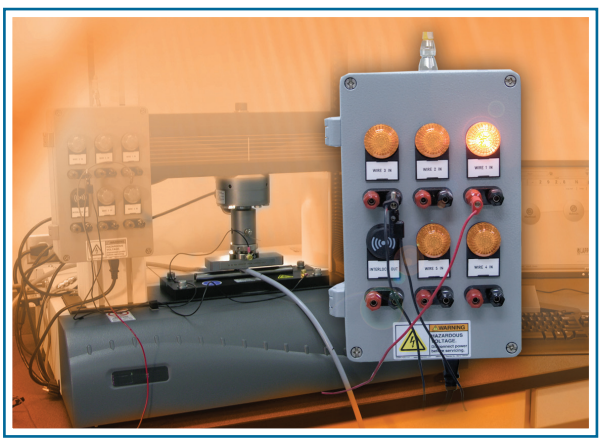


Level	Description	Impact	Crush	Cold Impact	Cold Bend	Tensile	Elongation	Standard
MP-00	Minimum mechanical resistance protection	–	–	–	–	–	–	–
MP-01	Average	–	*	*	–	1,500 psi	100%	ASTM D-412
MP-02	Good: Independent lab-tested for crush & impact	10/50 lb	1,000/ 2,000 lbf	–	-25°C	1,700 psi	175%	UL 1277 ASTM D-412
MP-03	Very Good: Rated for Exposed Run use (-ER)	10/50 lb	2,500/ 4,200 lbf	-25°C (CSA-TC)	-40°C (UL 62)	2,300 psi	275%	UL 1277 ASTM D-412
MP-04	Very Good: Rated for Exposed Run use (-ER)	10/50 lb	2,500/ 4,200 lbf	-40°C	-55°C***	2,300 psi	275%	UL 1277 ASTM D-412
MP-05	Excellent	**	**	–	–	3,400 psi	325%	ASTM D-1457
MP-06	Superior	**	**	–	–	4,200 psi	500%	ASTM D-412

* Impact and crush tests not applicable for intended end use of product.
** Testing is not required. If tested, these groups would meet or exceed UL 1277 impact and crush requirements by virtue of their superior mechanical properties.
*** Lapp standard.

Note: Lapp mechanical protection test values for each level meet or exceed the requirements of the standards referenced.

Depending upon the specific application, a cable may be exposed to external factors and various types of abuse. The explicit type of industrial manufacturing or processing environment will determine the actual degree of mechanical protection that a cable requires. Such environments include: CNC machine centers, mining, food and beverage plants, automotive assembly lines, machine tools, data processing, and automation applications. The unintentional mishaps that occur every day during routine manufacturing can range from a cable being struck by a falling object, to it being accidentally run over; there are many types of potential mechanical abuse in industrial environments. With all the hazards that your cable may be exposed to, you will need the protection and reliability that is provided in the many design configurations offered by the Lapp Group.



Installation Instructions for Lapp Cables in Cable Track

1. Only Lapp continuous flexing cables should be used in a moving cable track application.

2. When selecting cable for cable track, the following criteria must be taken into consideration: environmental conditions such as temperature, chemical influences, indoor or outdoor operation, traveling speed, and frequency of operation.

3. The recommended minimum bend radius of the cable should not be exceeded. Refer to the product pages of this catalog for minimum bend radius for flexing.

4. The cables must be prepared for installation into the cable track without twists, bends, or kinks in the cable. Therefore, the cable should always be unwound from the outside layer of the reel or spool. The cable should never be pulled from a coil. Before insertion into the track, it is important that the cable be laid out or hung at least 24 hours prior to installation into the cable track to relax any stresses resulting from transit or storage. If the cable cannot be relaxed, it should be shook out by grasping the cable length at its mid-point and shaking the cable as you move to each end. Then, wrap each end of the cable with masking tape and mark the top of each cable end. **Maintain this alignment throughout installation and clamping.**

5. When placing the cable into the cable track, the track should be laid out flat with the bending direction facing upward, then fitted with the cables in working position. The cables should be laid into the cable track and not weaved between or around other cables. The cables should lay loosely side by side in the track. A minimum clearance of five percent of the cable diameter should be allowed on each side of the cable. When cable is installed in track where spacers are provided, they should be separated from each other.

6. The cables should not be fixed to the track or tied together in the track.

7. The weight of the cables must be evenly distributed. Heavier cables should be placed towards the outside of the cable track, while lighter ones should occupy the center of the cable track. When the cable track is side-mounted, always place the larger cable towards the outside and the smaller cables toward the inside of the cable track. Cables must not be pulled tight against the inner track curve. Cables must not be pushed tight against the outer track curve.

8. After the cable track is installed, the cables should be cycled through several flexes and observed for freedom of movement. It is important to ensure the cables can move with complete freedom within the bend radius, so that movement of the cables among themselves and with the track is possible.

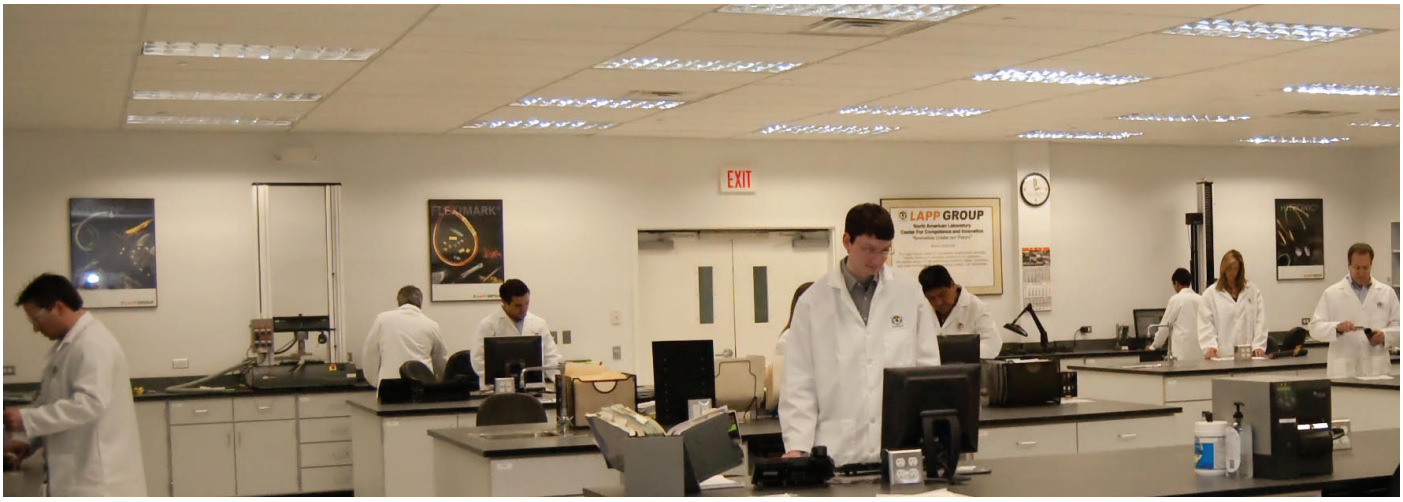
9. The cables should be clamped into position at both ends of the cable track. Prior to clamping, the alignment marks on the taped ends should be correctly positioned. Do not crush the cables when clamping. The clamping points must be located at a distance of 15 x cable diameter from the end point of the flexing movement.

NOTE: When calculating 15 x cable diameter, it is important to use the diameter of the largest cable in the track.

North America Laboratory

For over half a century, the Lapp Group's products have been expertly designed, processed, manufactured, and tested with state-of-the-art equipment, guaranteeing the finest flexible cable products available. Our credibility and expertise have classified Lapp as the innovator in the industrial flexible cable market.

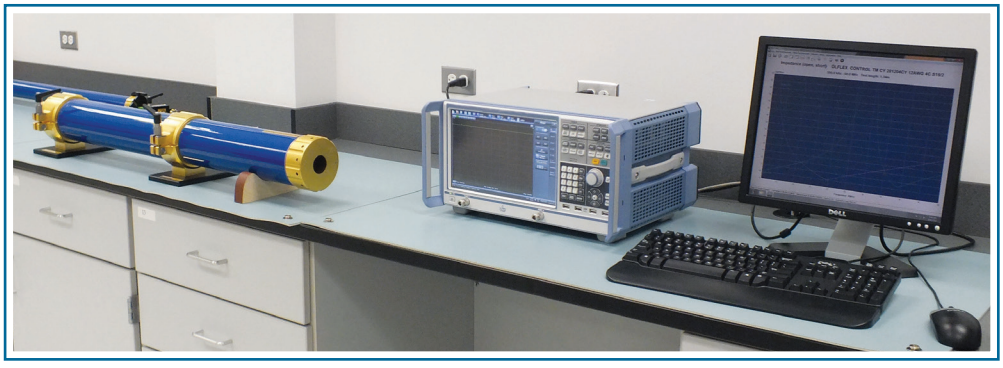
In 2008, the Lapp Group launched a state-of-the-art laboratory at our North American headquarters in Florham Park, New Jersey. This facility is the key to Lapp's leadership in new product development, testing, and product performance validation. This laboratory can simulate specific applications, environments, and test conditions to confirm our products' performance.



To further illustrate our commitment and dedication, Lapp customers are welcome to visit and tour our laboratory and witness product testing. Another Lapp milestone was achieved in July of 2008 when Underwriters Laboratories (UL) completed their initial assessment of this facility. Since 2008, Lapp successfully maintains status in the Data Acceptance Program (DAP) as a Client Test Data Program (CTDP) laboratory through intense annual UL audit assessments.

As a CTDP member, the Lapp North American Laboratory has the equipment, test methods, and procedures that are identical or superior to those used at the Underwriters Laboratories test facility. This laboratory provides Lapp with the ability and confidence to predetermine compliance to UL and other safety standards. This in turn leads to significant time and cost savings.

The North American Laboratory helps provide the Lapp Group with invaluable resources to maintain its edge in research and innovative leadership. This advantage is not only limited to North America but is also available globally through the Lapp Group network of laboratories. Providing a vital asset internationally, the combined effort of the Lapp Group Laboratories offer a wide variety of testing to global requirements, standards, and specifications.



State-of-the-art "Network Analyzer" for electrical properties validation

North America Laboratory (NAL) Services

The Lapp Group North America Laboratory now offers a unique and exclusive service to our existing and prospective customers. This service enables the customer to validate available products in the market, authenticate test methods and procedures in accordance to UL standards, and simulate product performance in field applications.

The North American Laboratory staff members' combined experience of over 50 years in the wire and cable industry provides immediate assurance of our credibility. Lapp is fully capable to simulate test conditions similar to real world mechanical, electrical, environmental and motion applications.

Using the test services offered by Lapp NAL will pay off with huge dividends by saving time and money. Customers can now rest assured with the knowledge that a product's test performance is no longer in question. This commitment is clearly reflected in Lapp's current product portfolio and offerings.

The Lapp Group North America Laboratory has the capability to perform a wide variety of mechanical, electrical, environmental, and motion testing:

Conditions	Types of Test	Test Method
High Temperature	Oil Resistance I	Unaged sample is submerged in oils or chemicals in a controlled environment to be tested for physical properties retention
	Oil Resistance II	
	Air Oven Aging	Unaged sample in a controlled environment to be tested for physical properties retention
Low Temperature	Cold Impact	Sample prepared at required low temperature to be tested for impact
	Cold Bend	Sample prepared at required low temperature and wrapped around a mandrel
Mechanical	Tensile & Elongation	Tubular or dumbbell samples to be tested for tensile strength & elongation
	Exposed Run Crush	Crushes made on a sample with a gradual compression force
	Exposed Run Impact	Impacts on sample with a free-fall force
	Direct Burial	Crushes on a sample with constant compression force for 60 seconds
Electrical	Direct Current Resistance	Maximum DC resistance is measured across a conductor sample
	Short Term Insulation Resistance	Sample is submerged in water for a short period in a controlled environment to be tested for insulation resistance
Flame	Vertical Flame	Flame application for applicable duration, sample must self-extinguish
	Horizontal Flame	
Motion	Continuous Flexing	Sample is tested for flexibility based on bend radius and speed
	Torsion	Sample is tested for torsion based on twist angle

Terms and Conditions

1) A complete detailed test report will be provided.
2) Test data is intended for reference purposes only.
3) For prices and details, please contact nalg@lappusa.com.

Properties of Insulation Materials

Properties	ASTM Method	PVC	Semi-Rigid PVC	Polyethylene	Foamed Polyethylene	Polypropylene	Foamed Polypropylene	Polyurethane
Specific Gravity	D-792	1.15 - 1.68	1.37	0.90 - 1.27	0.55 - 0.61	0.895 - 0.910	0.55 - 0.60	1.00 - 1.20
Tensile Strength, psi	D-638	1500 - 4400	3900	1500 - 2150	540	2800 - 4400	250	>4800
Elongation %	D-412	38 - 395	240	175 - 590	165	650	100	530 - 750
Volume Resistivity, Ω-cm	D-257	1013 - 1016	1014	>1014	1015	1.5 x 1014 2.8 x 1014	1014	2 x 1012 11 x 1012
Dielectric Strength, Volts/mil	D-149	240 - 490	390	220 - 1400	290	440 - 830	290	320 - 620
Dielectric Constant @ 1 kHz	D-150	3.7 - 8.1	2.9	2.28 - 2.55	1.7	2.2	1.7	5.7 - 7.7
Power Factor Dissipation @ 1 kHz	D-150	0.008 - 0.17	0.0038	0.00049	0.00035	0.0043	0.0034	0.043 - 0.060
Abrasion Resistance		Good	Excellent	Good	Poor	Poor	Poor	Excellent
Heat Resistance		Good	Good	Good	Poor	Good	Poor	Good
Weatherability		Good	Good	Excellent	Poor	Excellent	Poor	Good
Flame Retardancy		Excellent	Good	Poor	Poor	Poor	Poor	Fair
Water Resistance		Good	Good	Excellent	Poor	Excellent	Poor	Good
Acid Resistance		Good	Good	Good	Fair	Excellent	Fair	Fair
Alkali Resistance		Excellent	Excellent	Good	Fair	Excellent	Fair	Fair
Aliphatic Hydrocarbon Resistance		Good	Good	Poor	Fair	Fair	Poor	Fair
Aromatic Hydrocarbon Resistance		Poor	Poor	Poor	Fair	Fair	Poor	Poor

Properties of Insulation Materials

Properties	HYTREL®	Nylon	TPE	Thermoset Neoprene	SBR	KYNAR®	PFA	TEFLON® FEP	TPE
Specific Gravity	1.24	1.08	0.90 - 1.29	1.21 - 1.60	0.92	1.74 - 1.77	2.13 - 2.16	2.13 - 2.16	2.13 - 2.20
Tensile Strength, psi	6000	6000	1250 - 2200	1175 - 2600	>2800	5000 - 7400	4000 - 4200	2600 - 3000	1100 - 3300
Elongation %	490	500	490 - 730	290 - 680	>430	500	300	260 - 320	265
Volume Resistivity, Ω-cm	1010	1012	2 x 1016	1010 - 1012	3 x 1015	2 x 1012	>1014	2 x 1016	>1016
Dielectric Strength, Volts/mil	450	460	700	590	400 - 500	250	480	480 - 550	500
Dielectric Constant @ 1 kHz	3.8	4.6	2.8	4.9 - 7.1	3	7.6	2.2	2.2	2.2
Power Factor Dissipation @ 1 kHz	0.018	0.045	0.0018	3.6	0.0035	0.019	0.00003	0.0006	0.0002
Abrasion Resistance	Excellent	Excellent	Good	Excellent	Good	Good	Fair	Good	Fair
Heat Resistance	Good	Good	Good	Good	Fair	Excellent	Excellent	Excellent	Excellent
Weatherability	Excellent	Good	Good	Good	Fair	Good	Good	Good	Excellent
Flame Retardancy	Poor	Poor	Good	Good	Poor	Excellent	Excellent	Excellent	Excellent
Water Resistance	Good	Fair	Good	Excellent	Good	Good	Excellent	Good	Excellent
Acid Resistance	Good	Good	Good	Good	Fair	Excellent	Excellent	Excellent	Excellent
Alkali Resistance	Good	Good	Good	Good	Fair	Excellent	Excellent	Excellent	Excellent
Aliphatic Hydrocarbon Resistance	Good	Good	Good	Good	Poor	Excellent	Excellent	Excellent	Excellent
Aromatic Hydrocarbon Resistance	Good	Good	Good	Fair	Poor	Excellent	Excellent	Excellent	Excellent

Cable Recommendations for Common Coolants Used in Harsh Environments

Fluid Manufacturer	Product	ÖLFLEX® 90, 150, 190, 890, 891	ÖLFLEX® VFD, VFD with Signal VFD SLIM, TRAY II	UNITRONIC® 190, UNITRONIC® 300	ÖLFLEX® 855 P, 796 CP, 440 P, 540 P	ÖLFLEX® 491 P, 891 P, 900 P	ÖLFLEX® 490 P, 590 P	ÖLFLEX® CRF	ÖLFLEX® HEAT 180 EWKF	ÖLFLEX® HEAT 180 SiHF	HAR Hook-up Wire	SKINTOP® Clamps
		PVC	PVC	PVC	PUR	PUR	PUR	TPE	Silicone	Silicone	Neo	PA
Argent	H-114-LS	G	E	*	E	–	G	–	–	–	–	–
Argent	H-114-M	E	G	*	G	F	G	E	G	*	E	–
Argent	MS-5710-CG	G	E	G	E	–	–	–	–	–	–	–
Argent	MS5710F	E	E	G	G	G	F	E	E	E	E	–
Armour	Lard	E	G	*	G	E	E	–	E	E	*	E
Blaser Swiss	Vasco 1000/Art.2800	E	E	F	E	–	E	–	–	–	–	–
Blaser Swiss	Grindex Univ./Art.882	E	E	G	E	–	E	–	–	–	–	–
Blaser Swiss	Grindex Univ./Art892	F	F	G	G	*	*	E	E	E	E	–
Buckeye	Safe-T-Fluid #4	E	E	*	E	–	E	–	–	–	–	–
Buckeye	Safe-T-Oil #4	E	E	*	G	E	E	E	G	E	E	–
Buckeye	CT9612	E	G	*	E	–	G	–	–	–	–	–
Castrol	WY1-938A	E	G	G	E	–	–	–	–	–	–	–
Castrol	WY3-010C	E	E	*	E	*	G	–	G	F	E	E
Castrol	Syntillo 1023	G	E	G	E	–	–	–	–	–	–	–
Castrol	WS3-020A	G	G	F	E	–	–	–	–	–	–	–
Castrol	Clearedge 6519	E	E	G	G	–	–	–	–	–	–	–
Castrol	Clearedge 6550	G	E	F	G	–	–	–	–	–	–	–
Castrol	Superedge 6768	E	E	*	F	–	–	–	–	–	–	–
Castrol	GTX-SW30- Oil	E	G	*	G	–	–	–	–	–	–	–
Castrol	Type F Transmission	E	E	E	E	–	–	–	–	–	–	–
Castrol	DEXRON III Mercon	E	E	*	E	–	–	–	–	–	–	–
Castrol	Cooledge 8600	E	G	*	*	*	E	G	G	E	E	–
Castrol	Ilogrind FGO Series	E	G	*	F	G	E	E	E	E	E	–
Chem Tech	CT9612 (2)	E	G	F	E	–	E	–	–	–	–	–
Chem Tech	Tech Cool 3404MG	E	G	*	G	E	E	–	E	E	E	E
Chlorox	Sodium Hypochlorite	E	G	G	F	F	F	–	E	E	*	F
Cin. Millicron	Milpro 6000	E	E	*	E	E	E	E	E	E	E	–
Cin. Millicron	Quantalube 270	E	E	*	E	G	G	E	E	E	E	–
CITGO	Citcool 22 Conc.	E	E	*	F	G	G	–	–	E	E	E
CITGO	Citcool 33 Conc.	E	E	E	F	G	G	–	–	E	E	E
CITGO	Sentry 19	E	E	*	G	E	E	–	–	E	G	E
CITGO	Cutting Oil NC 205	E	E	*	*	F	G	–	–	*	*	E
CITGO	Cutting Oil NC 215	E	E	*	F	F	E	–	–	*	*	E
CLC Lubr.	CLC Finish HX-65	E	G	F	E	E	E	–	E	E	E	E
D.A. Stuart	Excelene 420	E	E	*	G	–	–	–	–	–	–	–

E = Excellent (no measurable changes)
G = Good (slight change)
F = Noticeable change
* = Consult sales rep for design assistance
– = Not tested

Note: lubricating oils/coolants, water soluble oils & emulsions and commercial products are tested at 60°C for 5 days. Paint solvents are tested at 23°C for 5 days. Not all products tested are listed above. If the cable series you need is not listed above, call your Lapp sales representative for assistance.

Cable Recommendations for Common Coolants Used in Harsh Environments

Fluid Manufacturer	Product	ÖLFLEX® 90, 150, 190, 890, 891	ÖLFLEX® VFD, VFD with Signal VFD SLIM, TRAY II	UNITRONIC® 190, UNITRONIC® 300	ÖLFLEX® 855 P, 796 CP, 440 P, 540 P	ÖLFLEX® 491 P, 891 P, 900 P	ÖLFLEX® 490 P, 590 P	ÖLFLEX® CRF	ÖLFLEX® HEAT 180 EWKF	ÖLFLEX® HEAT 180 SiHF	HAR Hook-up Wire	SKINTOP® Clamps
		PVC	PVC	PVC	PUR	PUR	PUR	TPE	Silicone	Silicone	Neo	PA
D.A. Stuart	Dascool Nobalt KM	E	G	G	G	E	E	E	E	E	E	–
EPP Tech	400 Klear Kool	G	G	F	G	–	–	–	–	–	–	–
Fuchs Lubr.	GK225	E	G	*	G	F	G	G	G	*	G	–
Fuchs Lubr.	Renogrind FG16	G	G	*	F	G	E	–	–	G	F	E
Fuchs Lubr.	CPD 7003	E	E	*	G	E	E	–	–	F	G	E
Fuchs Lubr.	ECOSYN 975 (4%)	E	E	E	E	E	G	E	E	E	E	–
Fuchs Lubr.	ECOSYN 2205 CO	E	E	E	G	G	E	–	–	G	E	E
Fuchs Lubr.	Melsol Supersol	E	G	*	E	G	G	–	F	F	E	E
Fuchs Lubr.	Tuf Draw 2806-M-100	E	E	E	E	E	E	E	E	E	E	–
G-C Lubr.	Kool Grind 900N	E	G	*	F	G	E	–	–	F	F	E
G-C Lubr.	Kool Grind 960	E	E	*	F	E	E	G	E	F	F	E
G-C Lubr.	Aqua Kool PTC	E	G	*	F	F	G	–	–	G	*	E
G-C Lubr.	Aqua Syn 55	E	F	E	G	G	G	–	–	G	E	E
G-C Lubr.	SintoGrind TT	E	E	*	E	E	E	G	E	E	E	–
Hangsterfers	Missie Lube #1XL	G	G	*	G	E	E	–	–	F	G	E
Hangsterfers	Missie Lube #1XXL	G	G	*	G	F	E	–	–	F	E	–
Hangsterfers	Crystal Cut #322	E	G	E	F	F	F	–	–	G	F	–
Hangsterfers	Crystal Cut #322 @5%	E	G	E	E	E	G	–	–	G	G	–
Hangsterfers	R-100	E	E	E	E	E	E	–	E	E	G	E
Hangsterfers	R-100 @ 5%	E	G	E	E	G	E	–	–	E	G	–
Hangsterfers	S500CF	E	E	*	F	G	F	–	G	*	G	E
Hangsterfers	S500CF@10%	E	G	E	G	F	E	–	–	E	G	–
Hangsterfers	Hard Cut 5418	E	E	*	F	G	E	E	E	G	E	–
Hangsterfers	Way Oil #2	G	F	*	G	E	E	–	–	*	E	–
Hangsterfers	Antiwear 32	G	E	G	G	E	E	–	–	*	E	–
Hangsterfers	Antiwear 66	G	E	G	G	E	E	–	–	*	E	–
Hanilo	171	E	E	*	F	E	E	E	*	*	E	–
Humoco	Iodine	G	G	E	*	E	G	E	E	G	E	–
Itech	CT9612 (3)	E	G	*	E	–	E	–	–	–	–	–
J & J	Mineral Oil	E	G	*	E	E	E	–	F	E	G	E
Lubrisystems	Lubra-Cut UMC	E	E	E	F	G	E	–	–	E	G	–
Master Chem.	Trim O D250	E	G	F	G	F	E	G	G	E	E	–
Master Chem.	Trim VHP E210	E	E	G	*	G	G	E	E	E	E	–
Master Chem.	Trim WB 9303 12 2	E	E	*	E	*	G	G	F	F	E	–
Mobile	Mobile Met Upsilon	G	G	*	G	–	E	–	–	–	–	–

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Note: lubricating oils/coolants, water soluble oils & emulsions and commercial products are tested at 60°C for 5 days. Paint solvents are tested at 23°C for 5 days. Not all products tested are listed above. If the cable series you need is not listed above, call your Lapp sales representative for assistance.

Cable Recommendations for Common Coolants Used in Harsh Environments

Fluid Manufacturer	Product	ÖLFLEX® 90, 150, 190, 890, 891	ÖLFLEX® VFD, VFD with Signal VFD SLIM, TRAY II	UNITRONIC® 190, UNITRONIC® 300	ÖLFLEX® 855 P, 796 CP, 440 P, 540 P	ÖLFLEX® 491 P, 891 P, 900 P	ÖLFLEX® 490 P, 590 P	ÖLFLEX® CRF	ÖLFLEX® HEAT 180 EWKF	ÖLFLEX® HEAT 180 SiHF	HAR Hook-up Wire	SKINTOP® Clamps
		PVC	PVC	PVC	PUR	PUR	PUR	TPE	Silicone	Silicone	Neo	PA
Mobile	DTE 11M	E	E	*	G	G	E	G	E	E	E	–
Mobile	DTE FM 32	E	E	*	E	G	E	G	E	F	E	–
Monsanto	Glacier Motor	E	E	G	G	G	E	E	E	G	E	–
Motorex	SwissCool 7300 CF	E	G	F	F	E	G	–	E	G	E	E
Mullen	1270-4	E	G	*	E	–	E	–	–	–	–	–
NASCO	Acetone	*	*	*	E	F	*	E	E	E	G	–
National Oil	Nocco Grind (11) Conc.	G	E	*	F	G	E	–	–	G	F	E
National Oil	Nocco Grind (11) 10%	E	F	E	G	G	G	–	–	E	E	E
National Oil	Nocco Grind 11	E	E	*	E	E	E	G	E	G	E	–
National Oil	Nocco Grind Modl	E	E	*	E	E	E	G	E	G	E	–
Novamax	Circlene #FG 20AMO	G	E	F	E	–	G	–	–	–	–	–
Novamax	Circlene #FG 67	G	G	*	G	–	G	–	–	–	–	–
Quaker	13413	E	E	*	E	–	E	–	–	–	–	–
Rustick	WS-500A	E	E	*	F	F	G	–	–	F	*	E
Solutia	MCS-2638	E	G	*	G	F	G	E	E	E	E	–
Spartan	Carbide Grinder	G	G	F	E	–	E	–	–	*	–	–
Spartan	Synspar GP	G	G	G	G	–	–	–	–	*	–	–
Spartan	Cutter EXP	E	E	G	F	–	–	–	–	*	–	–
STP	Dot 3 Brake Fluid	G	G	F	*	*	*	E	E	E	E	–
STP	Dot 4 Brake Fluid	G	G	G	*	–	–	–	–	–	–	–
Texaco	Rando Oil HD 26	E	E	*	E	G	E	–	–	*	E	–
Texaco	Cleartex D	E	E	*	G	G	E	–	–	E	F	E
Texaco	Oil Coolant Reno 488	E	G	*	F	F	E	–	–	F	*	E
Uni-Pro	Pro Cool 3000	E	G	F	G	*	G	–	E	G	F	E
WD-40	WD-40	E	E	*	G	G	E	E	E	F	E	–
Wesson	Vegetable Oil	E	G	*	F	E	E	–	E	G	G	E
Westmont	Bio-Cool 55	E	G	G	G	E	G	–	E	G	E	E
Yushiro Chem.	Yushiron Oil #2	E	E	*	F	G	E	–	–	*	E	–
Zip Strip	Denaturated Alcohol	E	G	*	G	G	E	E	G	E	E	–
Zip Strip	MEK	*	*	*	*	*	*	E	E	E	G	–
Zip Strip	Naphtha	E	E	E	E	E	E	G	E	E	E	–
Zip Strip	Toulene	*	*	*	G	G	G	G	E	E	G	–
Zip Strip	Xylene	F	*	*	G	G	G	G	F	G	G	–
Zip Strip	Turpentine	E	E	*	E	E	E	G	E	E	E	–

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Note: lubricating oils/coolants, water soluble oils & emulsions and commercial products are tested at 60°C for 5 days. Paint solvents are tested at 23°C for 5 days. Not all products tested are listed above. If the cable series you need is not listed above, call your Lapp sales representative for assistance.

Cable Chemical Resistance

– **Not tested**

⛒ **Good resistance**
no to slight reaction

✖ **Moderate resistance**
slight to moderate reaction

✖ **Low/no resistance**
moderate to strong reaction

All tests were performed at a temperature of +20°C.

Chemical	ÖLFLEX® SMART 108, CLASSIC 100/110, SERVO 2YSLCY/9YSLCY	ÖLFLEX® FD 90/90 CY, 150 QUATTRO, 190, 890, 191/191 CY, FD, TRAY II, VFD cables, SERVO 709 CY, SERVO TC, AUTO-I, CONTROL TM/TM CY, FORTIS, SERVO cables per SEW® & SIEMENS® 6FX 5008, UNITRONIC® 300	ÖLFLEX® CLASSIC 110 SY/110 CY, 100 CY	PUR-jacketed cables; ÖLFLEX® CLASSIC 400 P/CP, 490 P, 540 P/CP, 590 P, SERVO 795 P, SERVO 796 CP, 855 P/CP, FD 891 P, ROBOT 900, F1, PUR S, CRANE PUR, SERVO cables per SIEMENS® FX 8 Plus, UNITRONIC® FD P, LiYD 11Y, FD CP/CP (TP), FD Plus, PUR; HITRONIC® POF (PUR)	ÖLFLEX® CRANE, round & flat	ÖLFLEX® CRANE 2S, LIFT F, POWER IX, H07RN-F, LiFY single core	ÖLFLEX® HEAT 180
Inorganic Chemicals							
Alums, cold-saturated concentration	⛒	⛒	⛒	–	⛒	⛒	⛒
Aluminum salts, any concentration	⛒	⛒	⛒	–	⛒	⛒	⛒
Ammonia, aqueous, 10% concentration	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Ammonium acetate, aqueous, any concentration	⛒	⛒	⛒	–	–	⛒	⛒
Ammonium carbonate, aqueous, any concentration	⛒	⛒	⛒	✖	⛒	⛒	–
Ammonium chloride, aqueous, any concentration	⛒	⛒	⛒	⛒	⛒	⛒	–
Barium salts, any concentration	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Boric acid, aqueous	⛒	⛒	⛒	✖	⛒	⛒	⛒
Calcium chloride, aqueous, cold-saturated concentration	⛒	⛒	⛒	✖	⛒	⛒	⛒
Calcium nitrate, aqueous, cold-saturated concentration	⛒	⛒	⛒	–	⛒	⛒	✖
Chromium salts, aqueous, cold-saturated concentration	⛒	⛒	⛒	⛒	⛒	⛒	–
Potassium carbonate, aqueous (potash)	⛒	⛒	⛒	–	✖	⛒	⛒
Potassium chlorate, aqueous, cold-saturated concentration	⛒	⛒	⛒	–	⛒	⛒	–
Potassium chloride, aqueous, cold-saturated concentration	⛒	⛒	⛒	✖	⛒	⛒	⛒
Potassium dichromate, aqueous	⛒	⛒	⛒	✖	⛒	⛒	⛒
Potassium iodide, aqueous	⛒	⛒	⛒	–	⛒	⛒	⛒
Potassium nitrate, aqueous, cold-saturated concentration	⛒	⛒	⛒	–	–	–	–
Potassium permanganate, aqueous	✖	✖	✖	✖	⛒	✖	⛒
Potassium sulfate, aqueous	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Copper salts, aqueous, cold-saturated concentration	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Magnesium salts, aqueous, cold-saturated concentration	⛒	⛒	⛒	✖	⛒	⛒	⛒
Sodium bicarbonate, aqueous (natron)	⛒	⛒	⛒	✖	⛒	⛒	⛒
Sodium bisulfate, aqueous	⛒	⛒	⛒	⛒	✖	⛒	⛒
Sodium chloride, aqueous (table salt)	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Sodium thiosulfate, aqueous (fixing salt)	⛒	⛒	⛒	✖	⛒	⛒	⛒
Nickel salts, aqueous, cold-saturated concentration	⛒	⛒	⛒	–	⛒	⛒	⛒
Phosphoric acid, 50% concentration	⛒	⛒	⛒	✖	⛒	⛒	✖
Mercury, 100% concentration	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Mercury salts, aqueous, cold-saturated concentration	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Nitric acid, 30% concentration	✖	✖	✖	✖	✖	✖	✖
Hydrochloric acid, concentrated	✖	✖	✖	✖	✖	✖	✖
Sulfur, 100% concentration	⛒	⛒	⛒	⛒	⛒	⛒	✖
Sulfur dioxide, gaseous	⛒	⛒	⛒	–	⛒	⛒	✖
Carbon disulfide	✖	✖	✖	✖	✖	✖	✖
Hydrogen sulfide	⛒	⛒	⛒	⛒	⛒	⛒	✖
Sea water	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Silver salts, aqueous	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Hydrogen peroxide, 3% concentration	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Zinc salts, aqueous	⛒	⛒	⛒	✖	⛒	⛒	✖
Tin(II) chloride	⛒	⛒	⛒	–	⛒	⛒	⛒
Organic Chemicals							
Ethanol, 100% concentration	✖	✖	✖	✖	⛒	✖	⛒
Formic acid, 30% concentration	✖	✖	✖	✖	⛒	✖	–
Petrol	✖	✖	✖	⛒	✖	✖	✖
Succinic acid, aqueous, cold-saturated concentration	⛒	⛒	⛒	⛒	⛒	⛒	–
Acetic acid, 20% concentration	✖	✖	✖	✖	⛒	✖	⛒
Hydraulic oil	✖	✖	✖	✖	✖	✖	–
Isopropanol, 100% concentration	✖	✖	✖	✖	⛒	✖	✖
Machinery oil	✖	⛒	✖	⛒	✖	✖	✖
Methanol, 100% concentration	✖	✖	✖	✖	⛒	✖	⛒
Oxalic acid, aqueous, cold-saturated concentration	⛒	⛒	⛒	–	✖	⛒	✖
Cutting oil	✖	⛒	✖	⛒	✖	✖	–
Plant-based oils & fats	✖	⛒	✖	⛒	✖	✖	✖
Tartaric acids, aqueous	⛒	⛒	⛒	–	⛒	⛒	⛒
Citric acids	⛒	⛒	⛒	✖	⛒	⛒	⛒

The information presented in this table is accurate to the best of our knowledge and experience.
However, it must be treated as a non-binding guideline only; in many cases, tests must be carried out under working conditions to reach a definitive conclusion.

Cable Chemical Resistance

– **Not tested**

⛒ **Good resistance**
no to slight reaction

✖ **Moderate resistance**
slight to moderate reaction

✖ **Low/no resistance**
moderate to strong reaction

All tests were performed at a temperature of +20°C.

Chemical	TPE-jacketed cables; ÖLFLEX® HEAT 205/260, CRF, HF Tray Plus, SDP, AUTO-X, CONTROL M	Halogen-free cables; UNITRONIC® H-(ST)H, NHXMH, HF TRAY	HITRONIC® fiber optic cables	ÖLFLEX® TC 600, POWER QUAD II, C304, D304, I304, UNITRONIC® 190, 100 CY, LiYY, LiYCY, Li2YCY(TP), Li2YCY PiMF, FD/FD CY, FD 890, computer cables; HITRONIC® FD/FD CY, POF (PVC)	ÖLFLEX® CRANE NSHTÖU, NSGAFÖU, CRANE 2S, H01N2-D, H05RN-F, H07RN-F, H07RN8-F	LiY single cores, H05V-K, H07V-K, LiFY, Multi-standard SC 1/SC 2.1	ÖLFLEX® ROBUST 200, 210, 215 C
Inorganic Chemicals							
Alums, cold-saturated concentration	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Aluminum salts, any concentration	⛒	✖	⛒	⛒	⛒	⛒	⛒
Ammonia, aqueous, 10% concentration	⛒	✖	⛒	⛒	–	⛒	⛒
Ammonium acetate, aqueous, any concentration	⛒	–	⛒	⛒	✖	⛒	⛒
Ammonium carbonate, aqueous, any concentration	⛒	–	⛒	⛒	⛒	⛒	⛒
Ammonium chloride, aqueous, any concentration	⛒	–	⛒	⛒	⛒	⛒	⛒
Barium salts, any concentration	⛒	✖	⛒	⛒	⛒	⛒	⛒
Boric acid, aqueous	⛒	✖	⛒	⛒	⛒	⛒	⛒
Calcium chloride, aqueous, cold-saturated concentration	⛒	✖	⛒	⛒	⛒	⛒	⛒
Calcium nitrate, aqueous, cold-saturated concentration	⛒	✖	⛒	⛒	⛒	⛒	⛒
Chromium salts, aqueous, cold-saturated concentration	⛒	–	⛒	⛒	⛒	⛒	✖
Potassium carbonate, aqueous (potash)	⛒	–	⛒	⛒	⛒	⛒	⛒
Potassium chlorate, aqueous, cold-saturated concentration	⛒	–	⛒	⛒	✖	⛒	⛒
Potassium chloride, aqueous, cold-saturated concentration	⛒	✖	⛒	⛒	⛒	⛒	⛒
Potassium dichromate, aqueous	⛒	–	⛒	⛒	⛒	⛒	⛒
Potassium iodide, aqueous	⛒	✖	⛒	⛒	⛒	⛒	–
Potassium nitrate, aqueous, cold-saturated concentration	–	✖	⛒	⛒	⛒	⛒	⛒
Potassium permanganate, aqueous	⛒	–	✖	✖	⛒	✖	⛒
Potassium sulfate, aqueous	⛒	✖	⛒	⛒	⛒	⛒	⛒
Copper salts, aqueous, cold-saturated concentration	⛒	✖	⛒	⛒	⛒	⛒	⛒
Magnesium salts, aqueous, cold-saturated concentration	⛒	✖	⛒	⛒	⛒	⛒	⛒
Sodium bicarbonate, aqueous (natron)	⛒	–	⛒	⛒	⛒	⛒	⛒
Sodium bisulfate, aqueous	⛒	–	⛒	⛒	⛒	⛒	⛒
Sodium chloride, aqueous (table salt)	⛒	✖	⛒	⛒	⛒	⛒	⛒
Sodium thiosulfate, aqueous (fixing salt)	⛒	–	⛒	⛒	⛒	⛒	⛒
Nickel salts, aqueous, cold-saturated concentration	⛒	✖	⛒	⛒	⛒	⛒	⛒
Phosphoric acid, 50% concentration	⛒	–	⛒	⛒	⛒	⛒	⛒
Mercury, 100% concentration	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Mercury salts, aqueous, cold-saturated concentration	⛒	✖	⛒	⛒	⛒	⛒	⛒
Nitric acid, 30% concentration	⛒	✖	✖	✖	✖	✖	✖
Hydrochloric acid, concentrated	⛒	✖	✖	✖	✖	✖	✖
Sulfur, 100% concentration	⛒	⛒	⛒	⛒	⛒	⛒	✖
Sulfur dioxide, gaseous	⛒	–	⛒	⛒	⛒	⛒	⛒
Carbon disulfide	⛒	✖	✖	✖	✖	✖	✖
Hydrogen sulfide	⛒	–	⛒	⛒	⛒	⛒	✖
Sea water	⛒	✖	⛒	⛒	⛒	⛒	⛒
Silver salts, aqueous	⛒	✖	⛒	⛒	⛒	⛒	⛒
Hydrogen peroxide, 3% concentration	⛒	⛒	⛒	⛒	⛒	⛒	✖
Zinc salts, aqueous	⛒	✖	⛒	⛒	⛒	⛒	⛒
Tin(II) chloride	⛒	✖	⛒	⛒	⛒	⛒	⛒
Organic Chemicals							
Ethanol, 100% concentration	⛒	✖	✖	✖	⛒	✖	⛒
Formic acid, 30% concentration	⛒	✖	✖	✖	⛒	✖	–
Petrol	⛒	✖	✖	✖	✖	✖	✖
Succinic acid, aqueous, cold-saturated concentration	⛒	⛒	⛒	⛒	⛒	⛒	⛒
Acetic acid, 20% concentration	⛒	✖	✖	✖	⛒	✖	⛒
Hydraulic oil	⛒	✖	✖	✖	✖	✖	✖
Isopropanol, 100% concentration	⛒	⛒	✖	✖	⛒	✖	⛒
Machinery oil	⛒	⛒	✖	✖	✖	✖	✖
Methanol, 100% concentration	⛒	✖	✖	✖	⛒	✖	⛒
Oxalic acid, aqueous, cold-saturated concentration	⛒	✖	⛒	⛒	✖	⛒	⛒
Cutting oil	⛒	✖	✖	✖	✖	✖	✖
Plant-based oils & fats	⛒	✖	✖	✖	✖	✖	✖
Tartaric acids, aqueous	⛒	✖	⛒	⛒	⛒	⛒	⛒
Citric acids	⛒	✖	⛒	⛒	⛒	⛒	⛒

The information presented in this table is accurate to the best of our knowledge and experience.
However, it must be treated as a non-binding guideline only; in many cases, tests must be carried out under working conditions to reach a definitive conclusion.

NFPA 79: The Electrical Standard for Industrial Machinery

Save Time & Money by Meeting the Requirements

NFPA 79 is the section of the National Electric Code (NEC®) that focuses on the electrical wiring standards used with industrial machinery. NFPA 79 applies to the electrical equipment used within a wide variety of machines, as well as groups of machines working together in a coordinated manner. Examples of industrial machinery include, among others: machine tools, injection molding machines, woodworking equipment, assembling machinery, material handling machinery, and inspection and testing machines. The scope of NFPA 79 includes all electrical and electronic elements of machinery operating at 600V or less.

In 2007, the NFPA 79 code underwent significant revisions in order to harmonize it with IEC-60204, its European counterpart. This involved reorganizing the NFPA 79 chapter structure to follow IEC-60204 and to agree with less restrictive, more progressive requirements without sacrificing equipment safety. One of the major changes in the 2007 update involved cable selection options required under section 12.2.7.3, which indicated that single conductor or multi-conductor AWM shall not be permitted, unless completed assembly was listed prior for such use. Many industry participants considered this change an unrealistic requirement, and it was soon realized that further clarification was necessary.

With the release of NFPA 79 2012, the use of AWM is now permitted as long as certain requirements are met as specified in the NFPA 79 electrical standard. That said, the acceptability of AWM requires a thorough review of the standard because the allowance is not automatic. If the new requirements are not followed, or are deemed noncompliant by the inspection authority, serious repercussions could occur.

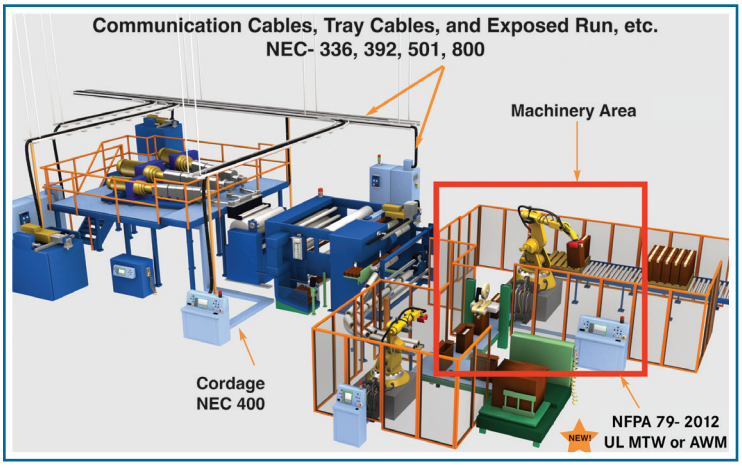
Historically, little attention has been given to cable selection; often it was an afterthought. Today, however, with ever increasing concerns of liability issues, more time is devoted to machine components such as wire and cable to ensure performance reliability. Regardless of the product, the strength of quality is only as good as its weakest component.

With present day global supply access, it is more important than ever to meet regulatory requirements and proper cable selection for industrial machinery.

In keeping with the principles of the Lapp Group, customer education is at the top of the list. We strive to keep our customers aware of breaking industry changes. For a more detailed technical explanation, please visit the White Papers section in the Lapp USA website at www.lappusa.com.

The cost of improper cable selection and non-compliance is too expensive in today's highly competitive marketplace. Save time and money now. Lapp USA can assist in the selection of the proper cable for your installation. Please contact one of our technical representatives today.

Lapp USA offers a variety of product solutions that are UL listed and conform to the NFPA 79 2012 Edition. The diagram below illustrates key NEC and NFPA regulatory codes for an industrial plant manufacturing floor. Each code calls out permissible cables.



* NEC is a registered trademark of the National Fire Protection Association.

National Electrical Code

Allowable Conductor Ampacity

Table 310.15(B)(16)

Allowable Ampacities of Insulated Conductors Rated 0 - 2000 Volts, 60° to 90°C (140° to 194°F) Not More Than Three Conductors in Raceway or Cable or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

Size	Temperature Rating						
	60°C (140°F) Types		75°C (167°F) Types		90°C (194°F) Types		
	TW*	UF*	FEPW* RHW* THW* XHHW* ZW*	RH* THHW* THWN* USE*	TA SIS MI THHN* THWN-2 XHHW*	TBS FEP* RHH* THHW* USE-2 XHHW-2	SA FEPB* RHW-2 THW-2 XHH ZW-2
18 AWG	–	–			14		
16 AWG	–	–			18		
14 AWG	20*	20*			25*		
12 AWG	25*	25*			30*		
10 AWG	30	35*			40*		
8 AWG	40	50			55		
6 AWG	55	65			75		
4 AWG	70	85			95		
3 AWG	85	100			110		
2 AWG	95	115			130		
1 AWG	110	130			150		
1/0 AWG	125	150			170		
2/0 AWG	145	175			195		
3/0 AWG	165	200			225		
4/0 AWG	195	230			260		
250 KCMIL	215	255			290		
300 KCMIL	240	285			320		
350 KCMIL	260	310			350		
400 KCMIL	280	335			380		
500 KCMIL	320	380			430		
600 KCMIL	355	420			475		
700 KCMIL	385	460			520		
750 KCMIL	400	475			535		
800 KCMIL	410	490			555		
900 KCMIL	435	520			585		
1000 KCMIL	455	545			615		
1250 KCMIL	495	590			665		
1500 KCMIL	520	625			705		
1750 KCMIL	545	650			735		
2000 KCMIL	560	665			750		

Table 310.15(B)(17)

Allowable Ampacities of Single Insulated Conductors Rated 0 - 2000 Volts, In Free Air, Based on Ambient Air Temperature of 30°C (86°F)

Size	Temperature Rating						
	60°C (140°F) Types		75°C (167°F) Types		90°C (194°F) Types		
	TW*	UF*	FEPW* RHW* THW* XHHW*	RH* THHW* THWN* ZW*	TA SIS MI THHN* THWN-2 XHHWT	TBS FEP* RHH* THHW* USE-2 XHHW-2	SA FEPB* RHW-2 THW-2 XHH ZW-2
18 AWG	–	–			18		
16 AWG	–	–			24		
14 AWG	25*	30*			35*		
12 AWG	30*	35*			40*		
10 AWG	40*	50*			55*		
8 AWG	60	70			80		
6 AWG	80	95			105		
4 AWG	105	125			140		
3 AWG	120	145			165		
2 AWG	140	170			190		
1 AWG	165	195			220		
1/0 AWG	195	230			260		
2/0 AWG	225	265			300		
3/0 AWG	260	310			350		
4/0 AWG	300	360			405		
250 KCMIL	340	405			455		
300 KCMIL	375	445			505		
350 KCMIL	420	505			570		
400 KCMIL	455	545			615		
500 KCMIL	515	620			700		
600 KCMIL	575	690			780		
700 KCMIL	630	755			855		
750 KCMIL	655	785			885		
800 KCMIL	680	815			920		
900 KCMIL	730	870			985		
1000 KCMIL	780	935			1055		
1250 KCMIL	890	1065			1200		
1500 KCMIL	980	1175			1325		
1750 KCMIL	1070	1280			1445		
2000 KCMIL	1155	1385			1560		

* Unless otherwise specifically permitted elsewhere in this Code, the overcurrent protection for conductor types marked with an asterisk shall not exceed 15 amperes for No. 14 copper, 20 amperes for No. 12 copper, and 30 amperes for No. 10 copper, after any correction factors for ambient temperature and number of conductors have been applied.

Table 310.15(B)(3)(a)

Adjustment Factors for More than Three Current-Carrying Conductors in a Raceway or Cable.

Where the number of current-carrying conductors in a raceway or cable exceeds three, the allowable ampacities shall be reduced as shown:

Number of Current-Carrying Conductors*	Percent of Values in Tables as Adjusted for Ambient Temperature (if necessary)
4 - 6	80
7 - 9	70
10 - 20	50
21 - 30	45
31 - 40	40
more than 40	35

* Does not include ground

Table 310.15(B)(2)(a)

Temperature Correction Factors

For ambient temperatures other than 30°C (86°F), multiply the allowable ampacities shown above by the appropriate factor shown below.

Ambient Temperature	60°C	75°C	90°C
30°C	1.00	1.00	1.00
40°C	0.82	0.88	0.91
50°C	0.58	0.75	0.82
60°C	–	0.58	0.71
70°C	–	0.33	0.58
80°C	–	–	–

Example:

- Using Lapp P/N 221007 (**10 AWG**, **6c** + ground, **90°C THHN**):

40 Amps (ampacity @ 30°C) × **0.80** (Table 310.15(B)(3)(a)) = **32 Amps**

- Using the same P/N at **40°C**:

40 Amps (ampacity @ 30°C) × **0.80** (Table 310.15(B)(3)(a)) × **0.91** (Table 310.15(B)(2)(a)) = **28 Amps**

VFD Cable Selection Guide

Motor Properties: AWG Size Selection Chart per NEC

Drive HP	230V 3ø AWG	460V 3ø AWG	575V 3ø AWG	Drive HP	230V 3ø AWG	460V 3ø AWG	575V 3ø AWG
½ - 3	14	14	14	60	4/0	1	2
5	14	14	14	75	300 KCMIL	1/0	1
7 ½	10	14	14	100	500 KCMIL	3/0	1/0
10	8	14	14	125	–	4/0	3/0
15	6	10	12	150	–	300 KCMIL	4/0
20	4	8	10	200	–	500 KCMIL	300 KCMIL
25	2	6	8	250	–	–	500 KCMIL
30	1	6	8	300	–	–	–
40	2/0	4	6	350	–	–	–
50	3/0	2	4	400 - 500	–	–	–

Note: The above table references the suggested wire AWG to use based on horse power (HP) and the full load current (FLC) × 125% per NEC Art. 430-122 (A).
Amperes (FLC) were determined from NEC Art. 430-250:

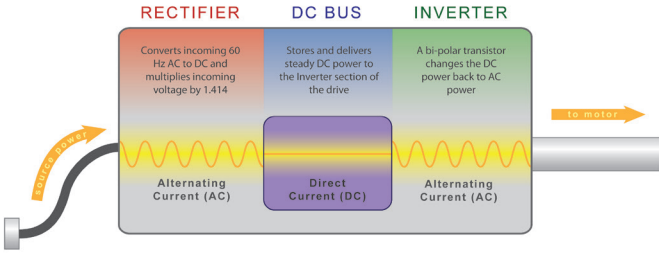
Example:
To calculate AWG size, three factors must be known: motor HP, motor voltage, and full load current (FLC).

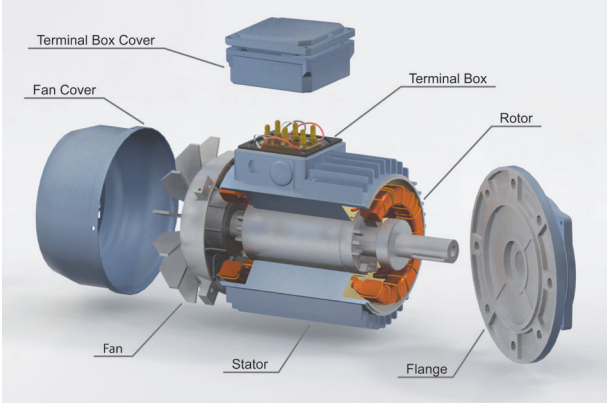
For a 30 HP and 460V motor, the FLC is 40A. Per NEC, FLC x 125% is required to calculate AWG size.

40A x 125% = 50 A, therefore the right AWG wire is 6 AWG per NEC Article 310.15.

See NEC table 310.15(B)(16) on previous page. 60°C column ampacities are referenced to avoid safety hazards that can occur when the maximum allowable temperature ratings of equipment and other non-cable components have been exceeded.

ADJUSTABLE SPEED DRIVE			
REG No. LAPP MOTOR EXAMPLE			
Power Input	Volts 460V	Power Output	Power 30 HP
	Amps 40A		Volts 500V
	Hertz 60 Hz		Amps 50A
Model No. LAPP MOTOR		LAPP GROUP	
Serial No. LAPP 12345			
ML No. 4DFJKJ48DK			





Voltage Drop Factors, Volts at FLC @ 20°C

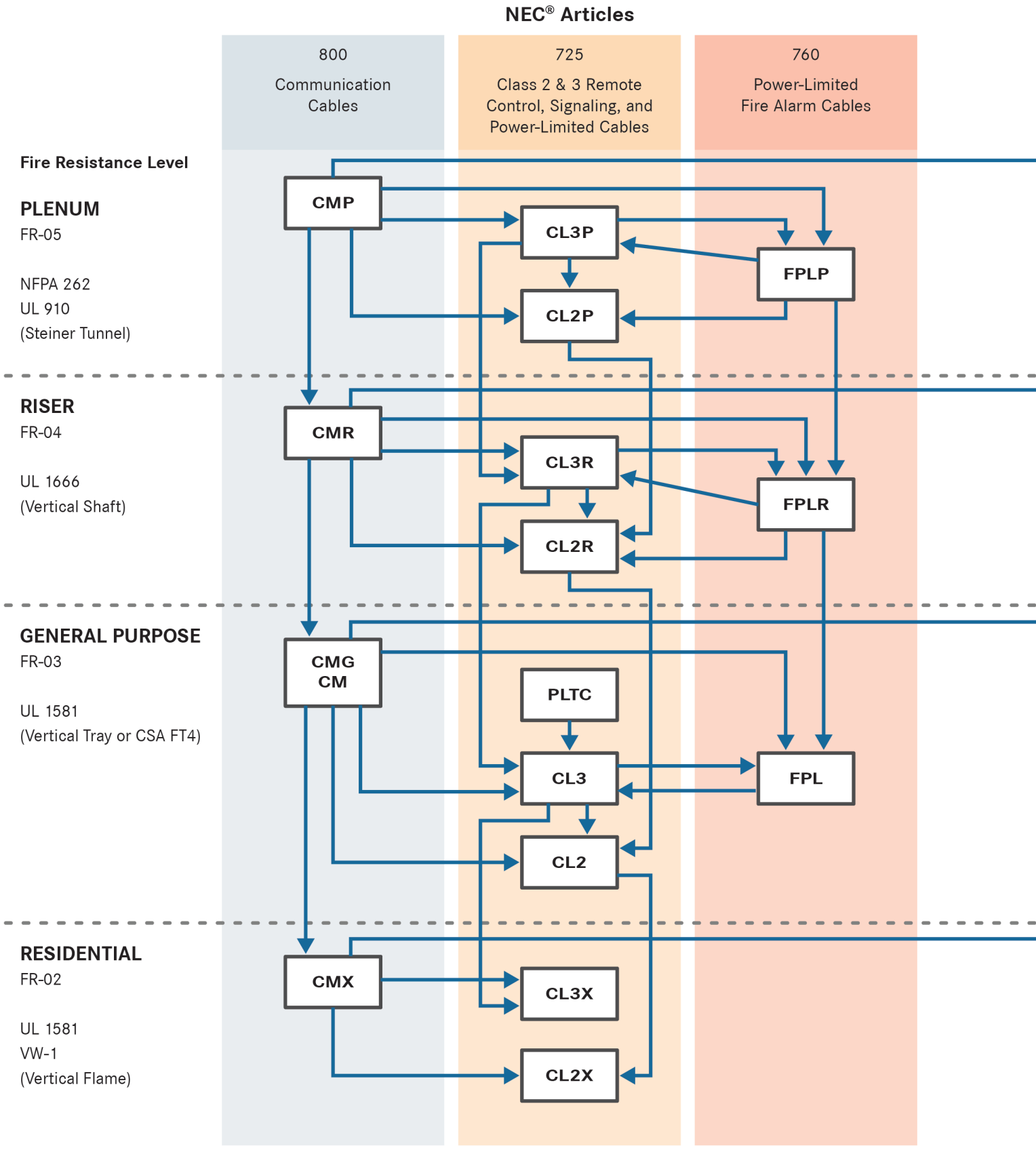
Drive HP	Voltage Drop Factor (Vdf)			Drive HP	Voltage Drop Factor (Vdf)		
	230V 3ø	460V 3ø	575V 3ø		230V 3ø	460V 3ø	575V 3ø
½	0.00696	0.00348	0.00285	25	0.01575	0.01627	0.02030
¾	0.01013	0.00506	0.00411	30	0.01732	0.01914	0.02406
1	0.01329	0.00665	0.00538	40	0.01203	0.01843	0.01962
1½	0.01899	0.00949	0.00759	50	0.01185	0.01506	0.01843
2	0.02152	0.01076	0.00854	60	0.01125	0.01667	0.01436
3	0.03038	0.01519	0.01234	75	0.00872	0.01385	0.01667
5	0.04809	0.02405	0.01930	100	0.00676	0.01130	0.01429
7 ½	0.02868	0.03481	0.02848	125	–	0.01139	0.01139
10	0.02105	0.04430	0.03481	150	–	0.00818	0.01052
15	0.02009	0.02738	0.03335	200	–	0.00655	0.00872
20	0.01914	0.02030	0.02868	250	–	–	0.00660

The above table references the voltage drop over distances. It was determined by using selection criteria of the Motor Properties Table.
In order to determine the voltage drop, multiply the length by the data above.

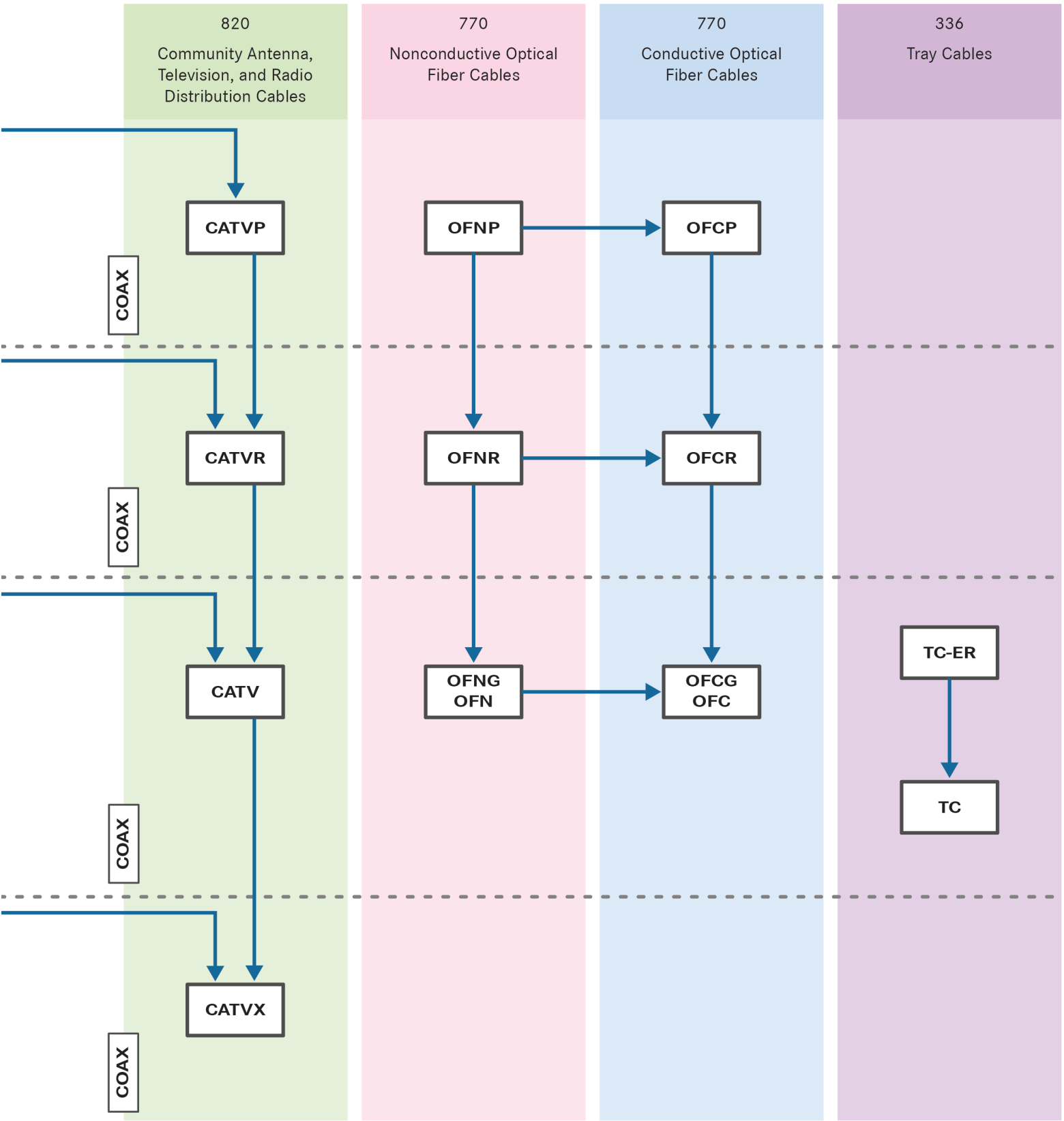
Example:
To calculate voltage drop over a specified distance, two factors must be known: the distance to the motor and the voltage drop factor.
For a 30 HP and 460V motor, the voltage drop for a distance of 200 feet would be **200 x 0.01914 = 3.83 volts**

In keeping with the principles of the Lapp Group, customer education is at the top of the list.
We strive to keep our customers aware of breaking industry changes. For a more detailed technical explanation, please visit Lapp USA's website.

NEC® Cable Substitution Hierarchy



NEC® Articles



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NEC® Doppler for Use in Cable Tray Applications

LAPP GROUP Lapp Products			–	ÖLFLEX® Power Multi ÖLFLEX® Power IX	–	–	–	
UL Cable Types		Plenum					FPLP	
		Riser					FPLR	
		General	CT	STOOW, SOOW	PLTC	MC, MI, ITC-HL	FPL	
Article	Type of Article	Voltage	Hook-up	Cordage	Thermocouple	Armored	Fire Alarm	
330	Metal Clad: Type MC	600V 2000V				✔		
332	Mineral Insulated Metal Sheathed Cable	300V 600V				✔		
336	Power and Control Tray Cable	600V 2000V				✔		
392	Cable Trays*	150V 2000V	✔ ≥ 1/0 AWG	✔ TC/STOOW**	✔ *	✔ *	✔ *	
400	Flexible Cords & Cables	300V 600V		✔ SOOW, STOOW				
500	Hazardous Locations & Class 1 Locations	150V		✔ Portable SOOW, STOOW Class 1, Division 1	✔ Class 1, Division 2	✔ Class 1, Division 1		
501		2000V						
545	Data Processing	300V 600V	✔ (GND) ≥ 4 AWG		✔	✔	✔	
725	Power Limited Tray Cable	300V			✔			
727	Instrumentation Tray Cables	150V						
760	Fire Alarm Systems	300V					✔	
770	Optical Fiber Cables & Raceways	N/A						
800	Communications Circuits	300V						
820	Community Antenna Television and Radio	60V						

* Different voltage rated cables may be installed in the same tray provided that cables ≤ 600V are separated by a divider from cable > 600V.

** UL Dual Rated

ER: Exposed Run, support every 6 feet

	–	UNITRONIC® 190 UNITRONIC® 300 UNITRONIC® BUS DeviceNet™ UNITRONIC® BUS PB UNITRONIC® BUS CC-Link UNITRONIC® BUS ASi UNITRONIC® BUS FOUNDATION Fieldbus ETHERLINE® CAT.5/CAT.5e	UNITRONIC® 300 UNITRONIC® BUS DeviceNet™ UNITRONIC® BUS PB UNITRONIC® BUS CC-Link UNITRONIC® BUS ASi UNITRONIC® BUS FOUNDATION Fieldbus ETHERLINE® CAT.5/CAT.5e	ÖLFLEX® TRAY II ÖLFLEX® TC 600 ÖLFLEX® CONTROL TM ÖLFLEX® CONTROL M ÖLFLEX® AUTO X ÖLFLEX® AUTO I ÖLFLEX® VFD	–
	CATVP	CMP	CL3P, CL2P		OFCP
	CATVR	CMR	CL2R, CL2R		OFCR
	CATV	CMG, CM, DP-1	ITC, PLTC, CL3/2	TC, TC-ER	OFCG, OFC
	Coaxial	Data Cables	Control Cables	Power Cables	Fiber Optic
				✔ ER*	
	✔*	✔*	✔*	✔ *	✔ *
				✔ * Class 1, Division 2	
			✔ Class 1, Division 2	✔ * Class 1, Division 2	
	✔	✔	✔	✔	✔
		✔	✔ ER 300V PLTC		
			✔ 150V ITC		
		✔			
					✔
		✔	✔ No PLTC		
	✔	✔			

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North America Regulatory & Safety Standard Agencies

Underwriters Laboratories, Inc., (UL) is chartered to establish, maintain, and operate laboratories for the examination and testing of devices, systems, and materials. UL determines hazards to life and property, and defines standards, classifications, and specifications for materials, devices, products, equipment, constructions, methods, and systems affecting such hazards.

UL Listed Wire and Cable Products

Wire and cable covered by this category are intended for use as fixed wiring for the three general building types: residential, commercial, and industrial. Listed wire and cable must not only comply with the applicable individual UL standards but also with requirements indicated under specific Articles of the National Electrical Code. The National Electrical Code defines specific end use application and where a particular listed wire or cable is installed.

Example of Listed wire and cable use: A UL Listed wire or cable can be used inside a building where a connection is required from a circuit breaker box to a wall outlet or externally as a coaxial cable when a connection is required from a satellite dish to a television wall receptacle. UL Listed cable can also be used to supply power to a UL Listed piece of equipment, such as the flexible cord used in the cord set of your computer or appliance.

cUL Listing Mark

This marking is represented by a lower case “c” appearing adjacent to the applicable UL symbol and indicate that a wire or cable has been tested by Underwriters Laboratories for conformance to standards from the Canadian Standards Association. These Marks are applied to products that are intended for use in the Canadian marketplace.

UL Listed Component Mark for Canada and the United States

This Listing Mark was introduced by UL in early 1998. This Mark indicates compliance with both US and Canadian requirements. The use of the combined Canada/US UL Mark is optional. UL encourages manufacturers with products certified for both countries to use this Mark, but they may continue using separate UL Marks for Canada and the United States.

UL AWM Recognized Components

Appliance Wiring Material (AWM) covers wire and cable intended for use as factory installed components of complete equipment. Appliance Wiring Material is not intended for use in direct separate installation in the field. Wire or cable indicating a UL AWM style marking is intended for applications that are unique to each individual style sheet. The usage statement of an individual style sheet will dictate specific end use limitations of the AWM wire or cable.

The NEC does not recognize AWM as an approved wiring method.

Example of AWM use: If a manufacturer desires to obtain UL Listing for their new piece of equipment they must submit their design to Underwriters Laboratories. The entire UL Listing process will move much more quickly and easily if all internal components used within the equipment design are UL Recognized. If the internal components are not UL Recognized then the UL Listing process will take much longer and cost more as the individual components now must be tested for compliance. AWM can also be used externally to interconnect two UL Listed components such as the data cable assembly that connects a computer to a printer.

North America Regulatory & Safety Standard Agencies

UL AWM Recognized Components

This Mark also covers Appliance Wiring Material and is applied to products that are intended for use in the Canadian market. Products that contain this Mark have been evaluated by UL for compliance to the applicable CSA standard for either internal or external use as designated by Class number and group type.

Recognized Component Mark for Canada and the United States

This new UL Recognized Component Mark, which became effective April 1, 1998, may be used on components certified by UL to both Canadian and US requirements. Although UL had not originally planned to introduce a combined Recognized Component Mark, the popularity of the Canada/US Listing and classification marks among clients with UL certifications for both Canada and the United States has led to the new Mark.

General Information

The local or state office of the electrical inspector dictates regulations governing cables that are installed in conduit. These regulations can vary or fluctuate depending upon interpretation of the National Electrical Code in different states and local municipalities.

Canadian Standards Association (CSA)

CSA is one of five accredited standards writing organizations in Canada. Unlike other foreign countries, Canada does not have separate standards and national testing agencies. The CSA Mark indicates that a product has been tested and approved for use in Canada. Lapp USA offers the following type of wire and cable certified by the Canadian Standards Association on a wide variety of different products.

Appliance Wiring Material (AWM) refers to wire and cable that is manufactured per the requirements specified in CSA Standard C22.2 No.210. AWM wire and cable is intended to be used internally within electrical and electronic equipment and can also be used for external interconnection between equipment. C22.2 No.210 defines AWM categories as follows:

Class I Internal

Group (A) – Where not subjected to mechanical abuse
Group (B) – Where may be subjected to mechanical abuse
(1) Wet Location
(2) Oil Resistant

Class II External

Group (A) – Where not subjected to mechanical abuse
Group (B) – Where may be subjected to mechanical abuse
(1) Wet Location
(2) Oil Resistant

International Regulatory Standard Agencies

International Safety Standards Agencies

Most countries have their own standards writing agencies. However, the basis for the majority of international standards are adaptations from, or exact duplication of, publications from the following safety standard agencies. These standards agencies are commissioned to create and publicize international safety standards. They are standards-setting agencies only. The enforcement of and testing to these standards is undertaken at the national level, but the final interpretation of design and approval of the product always lies with the national test agencies.

IEC (International Electrotechnical Commission)

The IEC is composed of representatives from manufacturers, users, and national testing labs from many of the European industrialized nations. Their primary directive is to publicize recommendations for safety standards. Although IEC publications do not have the force of law, in most cases new standards published by the National Testing Agencies in Europe and Australia have only minor deviations from IEC publications.

CEE (International Commission for Rules for the Approval of Electrical Equipment)

CEE was composed of representatives from European National Testing Labs.
The CEE's work has been taken over by CENELEC.

CENELEC (European Committee for Electrotechnical Standardization)

The primary responsibility of CENELEC is to develop electrotechnical standards that represent a consensus among its European member countries. While IEC publications are generally the basis for European National Standards, CENELEC will cover matters that are not completely addressed by IEC documents.

International Testing & Approval Agencies

Although a product may have been designed to comply with individual standard agencies, or with IEC, CEE, or CENELEC, each product must be tested, approved, and marked by the National Testing Agency for each country the cords are to be sold in (such as VDE, SEMKO, DEMKO, etc.) In most cases it is illegal to sell non-approved products.

Australia: ETSA (Electricity Trust of South Australia)

There are six electrical testing agencies in Australia. Generally, an approval by one of the agencies is accepted by the others. The Standards Association of Australia (SAA) is the recognized association for the preparation of Australian standards. SAA's policy is to use IEC standards as its guidelines. The SAA mark molded into a plug or connector indicates that a product has been tested and approved by one of the Australian testing agencies and SAA. Australian agencies require that an approval number be molded into the plug and connector. The cordage itself is the same used in Europe.

Austria: ÖVE (Austrian Association for Electrical Technology)

ÖVE is the standards association and the National Testing Agency in Austria. IEC standards are the basis for ÖVE standards. The ÖVE mark molded into a plug or connector indicates that a product has been tested and approved for use in Austria.

Belgium: CEBEC (Belgium Electrotechnical Committee)

The recognized association for Belgian standards is the Belgium Electrotechnical Committee (CEB). The range of CEB standards is similar to that of the IEC. The CEBEC mark molded into a plug or connector indicates that a product has been tested and approved by CEBEC for use in Belgium. CEBEC approval in Belgium is voluntary.

Denmark: DEMKO (Danish Electrical Testing Station)

The recognized association for Danish standards is the Danish Electrotechnical Committee (DEK). DEK adopts CENELEC and IEC standards as their basis for standards. The DEMKO mark molded into a plug or connector indicates that a product has been tested and approved by DEMKO. Goods not bearing this mark cannot be sold in Denmark.

International Testing & Approval Agencies

Finland: SETI (Electrical Inspectorate)

The recognized association for Finnish standards is the Finnish Electrotechnical Standards Association (SESKO). Most of the standards set by SESKO are in accordance with IEC and CENELEC publications. The SETI mark molded into a plug or connector indicates that a product has been tested and approved by SESKO and SETI for use in Finland. Use of this mark is mandatory only on equipment used in homes, offices, shops, and other premises where the public is admitted.

Germany: VDE (Association of German Electrical Engineers)

The recognized association for German standards is the German Electrotechnical Commission of DIN & VDE (DKE). The DKE standards are identical to IEC standards. The VDE mark indicates that a product has been tested and approved by DKE and VDE.

Italy: IMQ (Italian Institute of the Mark of Quality)

The recognized association for the preparation of Italian standards is the Italian Electrotechnical Committee (CEI). The basis of CEI standards is the IEC and CENELEC standards. The IMQ mark on the plug or connector indicates that a product has been manufactured according to CEI standards. There is no legal authority for the mandatory application of standards in Italy.

Netherlands: KEMA

The recognized association for standards in the Netherlands is the Netherlands Electrotechnical Committee (NEC). The NEC adopts IEC standards with few deviations. The KEMA mark on the plug or connector indicates that a product has been tested and approved by NEC and KEMA. The use of electrotechnical standards is voluntary in the Netherlands.

Norway: NEMKO (Norwegian Board for Testing and Approval of Electrical Equipment)

The recognized association for Norwegian standards is the Norwegian Electrotechnical Committee (NEK). NEK standards are identical to IEC and CENELEC. The NEMKO mark molded into a plug or connector indicates that a product has been tested and approved by NEMKO.

Sweden: SEMKO (Swedish Institute for Testing and Approval of Electrical Equipment)

The recognized association for Swedish standards is the Swedish Electrical Commission (SEK). There are more than 800 Swedish electrical standards. Most of them are identical to IEC standards. Most of the standards are voluntary. However, domestic electrical equipment is subject to approval and cannot be sold unless approved by SEMKO. The SEMKO mark molded into a plug or connector indicates that a product has been tested and approved by SEMKO.

Switzerland: SEV (Swiss Electrotechnical Association)

The recognized association for Swiss standards is the Swiss Standards Association (SEV). The SEV has adopted IEC standards almost without exception. The SEV mark molded into a plug or connector indicates that a product has been tested and approved for use in Switzerland. All products to be sold in Switzerland must bear this mark.

Alternative Markings

European agencies require the agency marking to be molded into the plugs and connectors. There are two alternatives for marking cordage and wires. The manufacturer's name and the National Test Agency symbol are printed on the blue primary conductor. In addition to the primary conductor marking, "HAR", the symbol for CENELEC, can be printed on the outer jacket. According to CENELEC and the national approval agencies, the "HAR" symbol is not mandatory as long as a National Test Agency symbol is on the cordset. The product is fully approved for use in any continental European country as long as it is manufactured to CENELEC and foreign agency standards and carries one of the above markings.

TÜV SÜD Group is a global, independent testing laboratory. The range of services TÜV provides includes consulting, inspections, tests, and expert opinions, as well as certification and training on global norms.

Products with Russian Certification: Gost-R

Product	Product	Product
ÖLFLEX® CLASSIC 100/100 CY	SERVO cable acc. to LENZE® Standard	UNITRONIC® LiYCY (TP)
ÖLFLEX® CLASSIC 100 SY	SERVO cable acc. to SEW® Standard	UNITRONIC® 300/300 CY
ÖLFLEX® CLASSIC 110/110 CY	ÖLFLEX® FD CLASSIC 810/810 CY	UNITRONIC® PUR CP
ÖLFLEX® CLASSIC 110 SY	ÖLFLEX® FD 820 H/820 CH	UNITRONIC® PUR CP TP
ÖLFLEX® CLASSIC 110 BLACK	ÖLFLEX® FD CLASSIC 810 P/810 CP	UNITRONIC® LiHH/LiHCH
ÖLFLEX® CLASSIC 110 CY BLACK	ÖLFLEX® FD 855 P/855 CP	UNITRONIC® LiHCH (TP)
ÖLFLEX® CLASSIC 115 CW	ÖLFLEX® FD ROBUST	UNITRONIC® FD/FD CY
ÖLFLEX® EB/EB CY	ÖLFLEX® FD ROBUST C	UNITRONIC® FD P PROFIBUS HYBRID
ÖLFLEX® 150 QUATTRO/150 CY QUATTRO	ÖLFLEX® FD 90/90 CY	UNITRONIC® FD P plus A
ÖLFLEX® 191/191 CY	ÖLFLEX® FD 891/891 CY	UNITRONIC® FD CP plus A
ÖLFLEX® CONTROL TM/TM CY	ÖLFLEX® FD 891 P/891 CP	UNITRONIC® FD CP (TP) plus A
ÖLFLEX® TRAY II	ÖLFLEX® ROBOT 900 P	UNITRONIC® Li2YCY (TP)
ÖLFLEX® CLASSIC 100 H	ÖLFLEX® ROBOT 900 DP	UNITRONIC® Li2YCYv (TP)
ÖLFLEX® CLASSIC 110 H	ÖLFLEX® ROBOT F1	UNITRONIC® Li2YCY PIMF
ÖLFLEX® CLASSIC 110 CH	ÖLFLEX® SOLAR XL multi	UNITRONIC® LAN TYPE 1A 600 MHz
ÖLFLEX® 120 H/120 CH	ÖLFLEX® SOLAR XLS	UNITRONIC® LAN Twinax
ÖLFLEX® CLASSIC 130 H	ÖLFLEX® SOLAR XLV	UNITRONIC® BUS IBS
ÖLFLEX® CLASSIC 135 CH	ÖLFLEX® SOLAR V4A	UNITRONIC® BUS P COMBI IBS
ÖLFLEX® CLASSIC 130 H BLACK	ÖLFLEX® SOLAR plus	UNITRONIC® BUS FD P IBS
ÖLFLEX® CLASSIC 135 CH BLACK	ÖLFLEX® SOLAR XL	UNITRONIC® BUS FD P COMBI IBS
ÖLFLEX® ROBUST 200	ÖLFLEX® SOLAR XLR ST	UNITRONIC® BUS YV IBS
ÖLFLEX® ROBUST 210	ÖLFLEX® SOLAR SR	UNITRONIC® BUS YV COMBI IBS
ÖLFLEX® ROBUST 215 C	ÖLFLEX® SOLAR plus V4A	UNITRONIC® BUS PB A
ÖLFLEX® CLASSIC 400 P/400 CP	ÖLFLEX® CRANE NSHTÖU	UNITRONIC® BUS FD P L2/FIP
ÖLFLEX® 491 P/491 CP	ÖLFLEX® CRANE VS NSHTÖU	UNITRONIC® BUS PB FD P FC A
ÖLFLEX® CONTROL M	ÖLFLEX® CRANE PUR	UNITRONIC® BUS PB FD P COMBI
ÖLFLEX® 540 P/540 CP	ÖLFLEX® CRANE	UNITRONIC® BUS PB YV
H07RN8-F	ÖLFLEX® CRANE 2S	UNITRONIC® BUS DN THICK FRNC
H07BN4-F Wind	ÖLFLEX® LIFT	UNITRONIC® BUS DEVICENET THICK CABLE FRNC, UL/CSA (CMG) (halogen-free)
OLFLEX® SERVO 700/700 CY	ÖLFLEX® LIFT T	
ÖLFLEX® SERVO 720 CY	ÖLFLEX® LIFT S	UNITRONIC® BUS DN THIN FRNC
ÖLFLEX® SERVO 730/730 CY	ÖLFLEX® CRANE F	UNITRONIC® BUS DEVICENET THIN CABLE FRNC, UL/CSA (CMG) (halogen-free)
ÖLFLEX® SERVO 2YSLCY-JB	ÖLFLEX® LIFT F	
ÖLFLEX® 709 CY	ÖLFLEX® HEAT 105 SC/105 MC	UNITRONIC® BUS CAN
ÖLFLEX® SERVO 9YSLCY-JB	ÖLFLEX® HEAT 145 SC/145 MC	UNITRONIC® BUS CAN FD
SERVO cable acc. to SIEMENS® Standard 6FX 5008	ÖLFLEX® HEAT 180 SiHF	H05RR-F
	ÖLFLEX® HEAT 180 SiF/GL	H05RN-F
ÖLFLEX® SERVO FD 750 P	ÖLFLEX® HEAT 180 SiD	H07RN-F
ÖLFLEX® SERVO FD 755 P/755 CP	ÖLFLEX® HEAT 180 SiZ	NSSHÖU
ÖLFLEX® SERVO FD 755 CP DESINA®	ÖLFLEX® HEAT 180 FZLSi	H07ZZ-F
ÖLFLEX® SERVO FD 760 CP	ÖLFLEX® HEAT 180 H05SS-F EWKF	H01N2-D
ÖLFLEX® SERVO FD 770 CP	ÖLFLEX® HEAT 180 MC	LiFY measurement cores
ÖLFLEX® SERVO FD 770 CP DESINA®	ÖLFLEX® HEAT 180 GLS	LiFY highly flexible measurement cores
ÖLFLEX® SERVO FD 781 CY	ÖLFLEX® HEAT 205 SC/205 MC	ESUY copper earthing cable
ÖLFLEX® SERVO FD 781 P/781 CP	ÖLFLEX® HEAT 205 PTFE/FEP	H00V3-D copper earthing cable
ÖLFLEX® SERVO FD 785 P/785 CP	ÖLFLEX® HEAT 260 SC/260 MC	NSGAFÖU
ÖLFLEX® SERVO FD 790 CP	ÖLFLEX® HEAT 260 C MC	NSHXAFÖ
ÖLFLEX® SERVO FD 795 P/795 CP	ÖLFLEX® HEAT 260 GLS	NiCr/Ni PVC/PVC compensating cable
SERVO cable acc. to SIEMENS® Standard 6FX 7008	ÖLFLEX® HEAT 350 SC (Zero Flame 350 SC)	LiY stranded hook-up wire
	ÖLFLEX® HEAT 350 MC (Zero Flame 350 SC)	H05V-K single core
SERVO cable acc. to SIEMENS® Standard 6FX 8008	ÖLFLEX® HEAT 1565 SC (Zero Flame SC 1565)	H07V-K single core
	UNITRONIC® LiYY/LiYCY	H05Z-K single core
SERVO cable acc. to INDRAMAT® Standard INX	UNITRONIC® LiYCY-CY	H07Z-K single core
	UNITRONIC® LiYY (TP)	

Environmental Standards: REACH & RoHS

The use of hazardous substances in products is subject to ever stricter international laws and restrictions. All products in this catalogue meet the following legal requirements (among others):

- **REACH directive 1907/2006/EC**
- **RoHS directive 2011/65/EU, or 2002/95/EC**

REACH:

Directive 1907/2006/EC represents the EU's standard system for the Registration, Evaluation, Authorization and Restriction of Chemicals, or REACH for short. The purpose of the directive is to ensure a high level of protection for human health and the environment.

REACH came into force on June 1, 2007 and replaced a number of former specifications relating to the material composition of products as previously governed, for example, by directive 76/769/EEC on the approximation of the laws, regulations, and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations. All Lapp Group products fall within the meaning of REACH. The following requirements of the REACH directive are therefore particularly significant:

1. Information requirement for manufacturers and importers of products containing a material on the Candidate List at a concentration in excess of 0.1% of the mass of the product.
2. Observance of substances requiring authorization in accordance with REACH Annex XIV.
3. Observance of the manufacturing, marketing, and use restrictions specified in REACH Annex XVII.

No duty of substance registration applies to the Lapp Group. The duty of registration is linked to specific conditions, such as the manufacture of substances or preparations, or the release of substances from products. The Lapp Group does not meet any of these conditions.

The Lapp Group has attributed great importance to the subject of safety and the environment from a very early stage. Our aim is to implement the REACH directive by keeping our products free from substances of very high concern (SVHC) or to replace such substances with non-hazardous materials. We therefore keep a very close eye on the Candidate List, in which the European Chemicals Agency lists these dangerous substances, continuously evaluate our products and implement any necessary substitution measures.

We observe all registration requirements for materials in accordance with REACH Annex XIV as well as the manufacturing, marketing, and use restrictions specified in REACH Annex XVII.

For further information on the subject of REACH, visit our website at www.lappusa.com or contact our competent REACH experts regarding specific substances.

RoHS:

The full title of the RoHS directive is as follows: "DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment". The new RoHS directive 2011/65/EC was published on July 1, 2011 and replaces the previous RoHS directive 2002/95/EC. Different transitional periods apply for the amendments introduced by the new RoHS directive.

In addition to the extended scope of the directive, which now also comprises other electrical and electronic equipment (EEE), one significant new feature is the obligation to assure compliance with the requirements of the RoHS directive by means of a conformity assessment procedure. Lapp certifies the RoHS conformity of EEE covered by the directive with a product-specific EC declaration of conformity and the application of the CE Mark.

Irrespective of the scope of the RoHS directive, all products in this catalogue meet the substance-specific requirements of RoHS. The exceptions detailed in the RoHS directive notwithstanding, our products do not contain any of the restricted substances specified in the RoHS directive or exceed the maximum concentrations stipulated therein.

Note:

All information is provided to the best of our knowledge and belief. This information provided is representative of current environmental standards. This is supported through continuous random testing of our products.

Given the vast number of our products, complete verification without exception is not possible. Therefore, the specifications above do not constitute a generally applicable guarantee in a legal or warranty sense.

WEEE Directive

The WEEE directive governs the disposal and recycling of electrical and electronic goods. A list of products from our range falling under the category of electrical and electronic tools and equipment is provided below, along with the relevant registration numbers:

Article Number	Registration Number
61806430	54158606
21700002, 21700012	39257114

The stated article/registration numbers are subject to change as a result of any modifications to the scope of the WEEE directive after printing of this catalogue.

Lapp Global Stranding

AWG	Lapp	mm²	Class K	mm²	Class 5	mm²	DCR	Class 6	Class M	mm²
26	–	–	–	–	–	0.14	42.0	18 / 0.10	7/34	0.14
24	–	–	–	–	14 / 0.15	0.25	24.0	32 / 0.10	10/34	0.20
22	–	–	7/30	0.35	19 / 0.15	0.34	17.3	42 / 0.10	19/34	0.38
20	–	–	10/30	0.51	16 / 0.21	0.50	11.88	28 / 0.15	26/34	0.52
	–	–	–	–	24 / 0.21	0.75	7.92	42 / 0.15	41/34	0.83
18	19/30*	–	16/30	1.00	32 / 0.21	1.0	5.94	56 / 0.15	–	–
16	28 / 30	1.5	26/30	1.32	30 / 0.26	1.5	4.05	84 / 0.15	65/34	1.31
14	46 / 30	2.5	41/30	2.08	50 / 0.26	2.5	2.43	140 / 0.15	105/34	2.11
12	56 / 0.0117	4	65/30	3.30	56 / 0.31	4	1.50	224 / 0.15	168/34	3.38
10	82/ 0.0117	6	105/30	5.32	84 / 0.31	6	1.00	192 / 0.20	259/34	5.21
8	74/ 0.0159	10	168/30	8.52	80 / 0.41	10	0.582	320 / 0.20	413/34	8.31
6	119 / 0.0159	16	266/30	13.5	128 / 0.41	16	0.368	512 / 0.20	665/34	13.40
4	–	–	413/30	21.0	200 / 0.41	25	0.237	800 / 0.20	1064/34	21.40
2	–	–	665/30	33.7	280 / 0.41	35	0.168	1120 / 0.20	1666/34	33.50
1	–	–	836/30	43.0	400 / 0.41	50	0.117	705 / 0.30	2109/34	42.0
2/0	–	–	1330/30	67.0	356 / 0.50	70	0.082	990 / 0.30	–	–
3/0	–	–	–	–	485 / 0.50	95	0.062	1340 / 0.30	–	–
4/0	–	–	2107/30	106	614 / 0.50	120	0.049	1690 / 0.30	–	–
300 KCMIL	–	–	–	–	765 / 0.50	150	0.039	2123 / 0.30	–	–
350 KCMIL	–	–	–	–	944 / 0.50	185	0.032	1470 / 0.40	–	–
500 KCMIL	–	–	–	–	1225 / 0.50	240	0.024	1905 / 0.40	–	–
600 KCMIL	–	–	–	–	1530 / 0.50	300	0.019	2385 / 0.40	–	–
750 KCMIL	–	–	–	–	2035 / 0.50	400	0.014	–	–	–
1000 KCMIL	–	–	–	–	1768 / 0.60	500	0.011	–	–	–

* Meets only the Class 5 Cross section and DC Resistance

European Cable Stranding

Cross-Section (mm²)	Strands VDE 0295 BS 6360 Class 2 (1)	Multi-Wire Strands (2)	Fine-Wire Strands VDE 0295 BS 6360 Class 6 (3)	Fine-Wire Strands VDE 0295 BS 6360 Class 5 (4)	Super Fine Wire Strands (5)	Super Fine Wire Strands (6)	Super Fine Wire Strands (7)
0.05	–	–	–	–	–	36 x 0.07	24 x 0.05
0.08	–	–	–	–	–	65 x 0.07	41 x 0.05
0.14	–	–	–	18 x 0.10	18 x 0.10	88 x 0.07	72 x 0.05
0.25	–	–	14 x 0.16	32 x 0.10	32 x 0.10	100 x 0.07	128 x 0.05
0.34	–	7 x 0.25	19 x 0.16	42 x 0.10	42 x 0.10	131 x 0.07	174 x 0.05
0.38	–	7 x 0.27	12 x 0.21	21 x 0.15	48 x 0.10	195 x 0.07	194 x 0.05
0.50	7 x 0.30	7 x 0.30	16 x 0.21	28 x 0.15	64 x 0.10	260 x 0.07	256 x 0.05
0.75	7 x 0.37	7 x 0.37	24 x 0.21	42 x 0.15	96 x 0.10	392 x 0.07	384 x 0.05
1.00	7 x 0.43	7 x 0.43	32 x 0.21	56 x 0.15	128 x 0.10	651 x 0.07	512 x 0.05
1.50	7 x 0.52	7 x 0.52	30 x 0.26	84 x 0.15	192 x 0.10	1040 x 0.07	768 x 0.05
2.50	7 x 0.67	19 x 0.41	50 x 0.26	140 x 0.15	320 x 0.10	1560 x 0.07	1280 x 0.05
4	7 x 0.85	19 x 0.52	56 x 0.31	224 x 0.15	512 x 0.10	2600 x 0.07	–
6	7 x 1.05	19 x 0.64	84 x 0.31	192 x 0.20	768 x 0.10	–	–
10	7 x 1.35	49 x 0.51	80 x 0.41	320 x 0.20	1280 x 0.10	–	–
16	7 x 1.70	49 x 0.65	128 x 0.41	512 x 0.20	2048 x 0.10	–	–
25	7 x 2.13	84 x 0.62	200 x 0.41	800 x 0.20	3200 x 0.10	–	–
35	7 x 2.52	133 x 0.58	280 x 0.41	1120 x 0.20	–	–	–
50	19 x 1.83	133 x 0.69	400 x 0.41	705 x 0.30	–	–	–
70	19 x 2.17	189 x 0.69	356 x 0.51	990 x 0.30	–	–	–
95	19 x 2.52	259 x 0.69	485 x 0.51	1340 x 0.30	–	–	–
120	37 x 2.03	336 x 0.67	614 x 0.51	1690 x 0.30	–	–	–
150	37 x 2.27	392 x 0.69	765 x 0.51	2123 x 0.30	–	–	–
185	37 x 2.52	494 x 0.69	944 x 0.51	1470 x 0.40	–	–	–
240	61 x 2.24	627 x 0.70	1225 x 0.51	1905 x 0.40	–	–	–
300	61 x 2.50	790 x 0.70	1530 x 0.51	2385 x 0.40	–	–	–
400	61 x 2.89	–	2035 x 0.51	–	–	–	–
500	61 x 3.23	–	1768 x 0.51	–	–	–	–

Note: The number of wires in columns (3) - (7) is optional.
VDE 0295 specifies only the maximum diameter of the individual wires and the maximum resistance assigned to the cross-section.

Stranded Conductors: AWG

AWG	Stranding	Diameter (inches)	Diameter (mm^2)	Cross-Sectional Area (CMA*)	Cross-Sectional Area (mm^2)	Weight (lbs/mft)	DCR @ 20°C (Ω/mft) Bare Cu	DCR @ 20°C (Ω/mft) Tinned Cu
30	7/38	0.012	0.3048	112.00	0.0567	0.34	100.3	107.700
30	19/42	0.013	0.3302	118.75	0.0589	0.36	101.9	109.400
28	7/36	0.015	0.3810	175.00	0.0889	0.55	63.55	68.220
28	19/40	0.016	0.4064	182.59	0.0931	0.59	63.06	67.690
27	7/35	0.017	0.4318	219.52	0.1113	0.63	50.44	54.150
27	65/44	0.018	0.4572	260.00	0.1235	0.70	49.41	53.050
26	7/34	0.019	0.4826	277.83	0.1407	0.87	39.70	42.610
26	10/36	0.020	0.5080	250.00	0.1270	0.77	44.92	48.210
26	19/38	0.020	0.5080	304.00	0.1539	0.93	37.33	40.070
24	7/32	0.024	0.6096	448.00	0.2268	1.38	24.46	26.250
24	10/34	0.023	0.5842	396.90	0.2010	1.22	28.06	31.120
24	19/36	0.025	0.6350	475.00	0.2413	1.47	23.64	25.380
24	41/40	0.024	0.6096	384.40	0.2009	1.25	29.78	31.970
22	7/30	0.030	0.7620	700.00	0.3542	2.19	15.57	16.720
22	19/34	0.032	0.8128	754.11	0.3819	2.32	14.77	16.100
22	26/36	0.029	0.7366	650.00	0.3302	1.97	17.44	18.720
20	7/28	0.038	0.9652	1111.00	0.5628	3.49	9.81	10.420
20	10/30	0.036	0.9144	1000.00	0.5060	3.14	11.00	11.810
20	19/32	0.038	0.9652	1216.00	0.6156	3.75	9.10	9.770
20	26/34	0.040	1.0160	1031.94	0.5226	3.21	10.90	11.700
20	41/36	0 038	0.9652	1025.00	0.5207	3.17	11.17	11.990
18	7/26	0 046	1.1684	1769.60	0.8960	5.04	6.165	6.550
18	16/30	0.046	1.6840	1600.00	0.8096	5.00	6.877	7.384
18	19/30	0.048	1.2192	1900.00	0.9614	5.90	5.791	6.218
18	41/34	0.046	1.6840	1627.29	0.8241	5.06	6.975	7.487
18	65/36	0.048	1.2192	1625.00	0.8255	5.00	7.043	7.560
16	7/24	0.060	1.5240	2828.00	1.4322	8.56	3.855	4.002
16	19/29	0.054	1.3716	2426.30	1.2293	7.50	4.538	4.817
16	26/30	0.058	1.4732	2600.00	1.3156	8.06	4.273	4.588
16	65/34	0.059	1.4986	2579.85	1.3065	8.03	4.400	4.723
16	105/36	0.059	1.4986	2625.00	1.3335	8.09	4.360	4.680
14	7/22	0.073	1.8542	4480.04	2.2694	12.76	2.428	2.531
14	19/27	0.068	1.7272	3830.40	1.9399	12.50	2.874	3.054
14	41/30	0.070	1.7780	4100.00	2.0746	12.88	2.735	2.937
14	105/34	0.086	2.1844	4167.50	2.1105	13.00	2.724	2.924
12	7/20	0.096	2.4384	7168.00	3.6302	21.69	1.516	1.574
12	19/25	0.090	2.2860	6087.60	3.0837	19.70	1.806	1.916
12	65/30	0.102	2.5908	6500.00	3.2890	20.76	1.725	1.853
12	165/34	0.095	2.4130	6548.90	3.3165	19.82	1.750	1.878
10	37/26	0.110	2.7940	9353.60	4.7360	29.00	1.189	1.263
10	49/27	0.116	2.9464	9878.40	5.0029	29.89	1.136	1.207
10	105/30	0.120	3.0480	105300.00	5.3130	33.10	1.068	1.147
8	49/25	0.147	3.7338	15699.60	7.9527	47.53	0.714	0.757
8	133/29	0.166	4.2164	16984.11	8.6051	52.87	0.661	0.701
8	655/36	0.147	3.7338	16625.01	8.3185	51.30	0.706	0.757
6	133/27	0.206	5.2324	26812.80	13.5793	81.14	0.418	0.445
6	266/30	0.210	5.3340	25900.01	13.4596	86.01	0.426	0.457
6	1050/36	0.184	4.6736	26250.01	13.3350	79.47	0.440	0.472
4	7x19/25	0.257	6.5278	42613.00	21.5859	133.00	0.263	0.279
4	259/27	0.232	5.8928	52214.40	26.4439	158.02	0.217	0.231
4	1666/36	0.232	5.8928	41650.00	21.1582	126.10	0.277	0.298
2	133/32	0.292	7.4168	67936.40	34.4071	205.62	0.164	0.171
2	259/26	0.292	7.4168	65475.20	33.1520	198.14	0.173	0.184
2	665/30	0.328	8.3112	66500.00	33.1430	213.00	0.170	0.183
2	2109/34	0.292	7.4168	66150.00	33.6042	200.28	0.175	0.187
1	19/0.0664	0.328	8.3312	82983.60	42.4700	251.20	0.134	0.137
1	19x44/30	0.377	9.5758	81700.00	43.3016	267.79	0.135	0.171
1	2109/34	0.328	8.3312	83706.20	42.3909	253.29	0.137	0.147
1/0	133/21	0.368	9.3472	108035.90	54.7162	327.05	0.104	0.108
1/0	259/24	0.368	9.3472	104636.00	52.9914	316.76	0.108	0.112
2/0	133/20	0.414	10.5156	136192.00	68.9738	400.41	0.0821	0.085
2/0	259/23	0.414	10.5156	132297.20	67.0033	430.00	0.0855	0.089
2/0	1330/30	0.406	10.3124	133300.00	67.2980	501.70	0.0851	0.091
3/0	259/22	0.464	11.7856	163195.00	83.9678	522.20	0.0682	0.071
3/0	427/24	0.464	11.7856	172508.00	87.3642	638.88	0.0657	0.068
4/0	259/21	0.597	15.1638	210385.70	106.5526	660.01	0.0537	0.056
4/0	427/23	0.598	15.1892	218111.60	110.4649	653.00	0.0519	0.054
4/0	2107/30	0.608	15.4332	211468.00	106.6142	676.00	0.0537	0.058

* CMA: Circular Mil Area

Solid Conductors: AWG

AWG	Diameter		Cross-Sectional Area		DCR @ 20°C (Ω/mft)		Weight	Break Strength
	(inches)	(mm^2)	(CMA*)	(mm^2)	Bare Cu	Tinned Cu	(lbs/mft)	(lbs/Max)
40	0.0031	0.07874	9.6	0.0049	1552	1236.60	0.0291	0.3106
39	0.0035	0.08890	12.3	0.0062	897.10	963.00	0.0371	0.3917
38	0.0040	0.10160	16.0	0.0081	681.90	732.00	0.0484	0.4939
37	0.0045	0.11430	20.3	0.0103	535.70	575.10	0.0613	0.6228
36	0.0050	0.12700	25.0	0.0127	431.90	463.60	0.0757	0.7854
35	0.0056	0.14224	31.4	0.0159	342.80	368.00	0.0949	0.9904
34	0.0063	0.16002	39.7	0.0201	269.80	289.60	0.120	1.249
33	0.0071	0.18034	50.4	0.0255	211.70	227.30	0.153	1.575
32	0.0080	0.20320	64.0	0.0324	166.20	178.40	0.194	1.986
31	0.0089	0.22606	79.2	0.0401	133.90	143.70	0.240	2.504
30	0.0100	0.25400	100	0.0506	105.80	113.60	0.304	3.157
29	0.0113	0.28702	128	0.0647	82.90	88.00	0.387	3.981
28	0.0126	0.32004	159	0.0804	66.70	70.80	0.481	5.020
27	0.0142	0.36068	202	0.1021	52.50	55.80	0.610	6.331
26	0.0159	0.40386	253	0.1280	41.90	44.50	0.765	7.983
25	0.0179	0.45466	320	0.1623	33.00	35.00	0.970	10.070
24	0.0201	0.51054	404	0.2046	26.20	27.20	1.22	12.690
23	0.0226	0.57404	511	0.2587	20.70	21.50	1.55	15.410
22	0.0253	0.64262	640	0.3242	16.50	17.20	1.94	19.430
21	0.0285	0.72390	812	0.4114	13.00	13.50	2.46	24.500
20	0.0320	0.81280	1020	0.5186	10.30	10.70	3.10	30.890
19	0.0359	0.91186	1290	0.6527	8.21	8.54	3.90	38.950
18	0.0403	1.02362	1620	0.8225	6.52	6.78	4.92	49.120
17	0.0453	1.15062	2050	1.0393	5.16	5.37	6.21	61.930
16	0.0508	1.29032	2580	1.3070	4.10	4.26	7.81	78.100
15	0.0571	1.45034	3260	1.6512	3.25	3.38	9.87	98.480
14	0.0641	1.62814	4110	2.0809	2.58	2.68	12.40	124.20
13	0.0720	1.82880	5180	2.6254	2.04	2.12	15.70	156.60
12	0.0808	2.05232	6530	3.3064	1.62	1.68	19.80	197.50
11	0.0907	2.30378	8230	4.1663	1.29	1.34	24.90	249.00
10	0.1019	2.58826	10380	5.2588	1.02	1.06	31.40	314.00
9	0.1144	2.90576	13090	6.6281	0.809	0.833	39.60	380.50
8	0.1285	3.26390	16510	8.3626	0.641	0.660	50.00	479.80
7	0.1443	3.66522	20820	10.5456	0.508	0.523	63.00	605.00
6	0.1620	4.11480	26240	13.2913	0.403	0.415	79.40	762.90
5	0.1819	4.62026	33090	16.7572	0.320	0.329	100	961.90
4	0.2043	5.18922	41740	21.1385	0.254	0.261	126	1213
3	0.2294	5.82676	52620	26.6516	0.201	0.206	159	1530
2	0.2593	6.58622	66360	34.0520	0.157	0.161	201	1929
1	0.2893	7.34822	83690	42.3871	0.126	0.129	253	2432
1/0	0.3249	8.25246	105600	53.4609	0.100	0.102	319	2984
2/0	0.3648	9.26592	133100	67.3980	0.0795	0.0814	403	3763
3/0	0.4096	10.43084	167800	84.9683	0.0631	0.0616	508	4745
4/0	0.4600	11.68400	211600	107.1649	0.0500	0.0512	641	5983

* CMA: Circular Mil Area

Size Conversion Charts

American Wire Gauge (AWG) to mm^2

AWG	mm^2	AWG	mm^2	AWG	mm^2
30	0.05	12	4	4/0	120
28	0.08	10	6	250	120
26	0.14	8	10	300	150
24	0.25	6	16	350	185
22	0.34	4	25	400	185
20	0.50	2	35	450	240
19	0.75	1	50	500	240
18	1.0	1/0	50	600	300
16	1.5	2/0	70	750	400
14	2.5	3/0	95		

mm^2 to American Wire Gauge (AWG)

mm^2	AWG	mm^2	AWG	mm^2	AWG
0.14	26	4	12	95	4/0
0.25	24	6	10	120	250
0.34	22	10	8	150	300
0.50	20	16	6	185	350, 400
0.75	19	25	4	240	450, 500
1.0	18	35	2, 1	300	600
1.5	16	50	1/0	400	750, 800
2.5	14	70	2/0, 3/0		

Frequently Asked Questions

1. What is U0/U?

The nominal voltage in European applications is expressed by the combination of two values expressed by the designations U0/U, where:
U0: The voltage between any insulated conductor and shield or ground.
U: The voltage between any two conductors of a multi-conductor cable.

Example:

P/N 0026157: the nominal voltage is expressed as 300/500 V.
U0: 300V, the voltage between any insulated conductor and shield ground.
U: 500V, the voltage between any two conductors of a multi-conductor cable.

2. Are voltage ratings in the catalog AC or DC?

Voltages are expressed in terms of Alternating Current (AC). A conservative estimate of the amount of Direct Current (DC) voltage is 1.5 times the AC value.

Example:

P/N 0026157: based on the voltage listed above, the estimated DC voltage would be as follows:
U0: 300 VAC x 1.5 = 450 VDC
U: 500 VAC x 1.5 = 750 VDC

3. Do wire and cable require MSDS sheets?

No. Any products that meets the definition of an “article” are exempt from the OSHA Communication Standard and do not require an MSDS. An article is a manufactured item:

a. which is formed to a specific shape or design during manufacture.
b. which has end use functions dependent in whole or part upon its shape or design during end use.
c. which does not release, or otherwise result in exposure to a hazardous chemical under normal conditions of use.

4. What are the requirements for green/yellow stripe width of Lapp conductors?

For the conductor identified by the combination of the colors green and yellow, the distribution of those colors shall comply with the following condition: for every 15 mm length of core, one of those colors shall cover at least 30% and not more than 70% of the surface of the core, the other color covering the remainder.

5. Why symmetrical grounds in a VFD cable?

The three symmetrical bare ground wires provide a balanced ground system. This combination reduces AC motor shaft voltage, thereby reducing the likelihood of premature motor bearing or motor insulation failure.

6. Why are conductor diameters not specified for European stranding?

VDE only specifies maximum DC resistance requirements; VDE does not specify a conductor tolerance to the number of strands or diameters. These can vary so that maximum DC resistance requirements are not exceeded.

7. My cable order has been shipped; can I get a test report?

Relevant Test reports can only be provided when requested at the time of order.

8. Can a flexible cable be used in a continuous flexing application?

No. Flexible cables are intended to move randomly in a non-automated application. They are susceptible to occasional uncontrolled conditions of movement.

9. Can a continuous flexing cable be used in a festoon trolley application?

No. Continuous flexing cables are intended for constant linear motion in automated non-festoon applications.

10. Can a continuous flexing cable be used in a robotic application?

No. Robotic applications requires x-y-z motion which will incur continuous bending and torsional (twisting) movements.

Frequently Asked Questions

11. For wire and cable, can temperature and/or voltage ratings be exceeded?

No. It is never recommended to exceed either temperature and/or voltage ratings due to the potential safety issues.

12. Are UL 94 flammability tests (V-0, V-1, or V-2) required for wire and cable?

No. The standard “Tests for Flammability of Plastic Materials for Parts in Devices and Appliances” is only applicable to plastic materials.

13. AWG versus mm²?

North American agency standards recognize conductors based on diameter tolerances (AWG). European agency standards recognize conductors based on cross-section (mm²) and compliance with maximum DC resistance requirements.

14. Halogen versus Non-Halogen?

Halogens are the elements of the seventeenth group of the periodic table: chlorine, fluorine, bromine, iodine, and astatine. Halogenated compounds include chlorides, fluorides, bromides, and iodides, which are present in many wire and cable compounds. Non-halogen wire and cable compound formulations include non-antimony based systems to replace traditional halogenated elements. Non-halogenated cable compounds do not contain any of these elements and will not release high levels of smoke or corrosive gases during a fire.

15. How do I determine ampacity of cables with conductors smaller than 18 AWG?

See the following table from the latest edition of NFPA 79. To calculate based on adjustment factors (conductors and ambient temperature), refer to the tables and examples on Lapp catalog page 678.

Conductor Size (AWG)	Ampacity (A)		
	60°C (140°F)	75°C (167°F)	90°C (194°F)
30	–	0.5	0.5
28	–	0.8	0.8
26	–	1.0	1.0
24	2.0	2.0	2.0
22	3.0	3.0	3.0
20	5.0	5.0	5.0

Color Code Charts

Chart 1

ÖLFLEX® 590 P/CP, C304/C304 S, D304 OS

Conductor	Color	Conductor	Color	Conductor	Color
1 black		5 brown		9 violet	
2 white		6 blue		10 gray	
3 red		7 orange		11 pink	
4 green*		8 yellow		12 tan	

* Cables with CE approval have green/yellow conductor for #4

Numbers are spaced 20 - 55 mm apart and are inverted with underline

Chart 2

C304/304 S, UNITRONIC® 190/190 CY

Conductor	Color	Conductor	Color	Conductor	Color	Conductor	Color
1	black	17	white/red	33	blue/white/orange	49	blue/orange/red
2	white	18	orange/red	34	black/white/orange	50	black/orange/red
3	red	19	blue/red	35	white/red/orange	51	white/black/orange
4	green	20	red/green	36	orange/white/blue	52	red/orange/black
5	orange	21	orange/green	37	white/red/blue	53	green/red/blue
6	blue	22	black/white/red	38	black/white/green	54	orange/black/blue
7	white/black	23	white/black/red	39	white/black/green	55	blue/black/orange
8	red/black	24	red/black/white	40	red/white/green	56	black/orange/green
9	green/black	25	green/black/white	41	green/white/blue	57	white/orange/green
10	orange/black	26	orange/black/white	42	orange/red/green	58	red/orange/green
11	blue/black	27	blue/black/white	43	blue/red/green	59	green/black/blue
12	black/white	28	black/red/green	44	black/white/blue	60	orange/green/blue
13	red/white	29	white/red/green	45	white/black/blue	61	black/orange/blue
14	green/white	30	red/black/green	46	red/white/blue		
15	blue/white	31	green/black/orange	47	green/orange/red		
16	black/red	32	orange/black/green	48	orange/red/blue		

Chart 3

D304 IS/OS, UNITRONIC® CY TP

Pair	Color	Pair	Color	Pair	Color
1	black + red	14	green + white	27	brown + orange
2	black + white	15	green + blue	28	orange + yellow
3	black + green	16	green + yellow	29	violet + orange
4	black + blue	17	green + brown	30	violet + red
5	black + yellow	18	green + orange	31	violet + white
6	black + brown	19	white + blue	32	violet + dark green
7	black + orange	20	white + yellow	33	violet + light blue
8	red + white	21	white + brown	34	violet + yellow
9	red + green	22	white + orange	35	violet + brown
10	red + blue	23	blue + yellow	36	violet + black
11	red + yellow	24	blue + brown	37	gray + white
12	red + brown	25	blue + orange		
13	red + orange	26	brown + yellow		

Color Code Charts

Chart 4

UNITRONIC® 300/300 CY (24 - 22 AWG)

Conductor	Color	Conductor	Color	Conductor	Color	Conductor	Color
1	black	14	white/orange	27	white/black/gray	40	white/red/gray
2	brown	15	white/yellow	28	white/brown/red	41	white/orange/yellow
3	red	16	white/green	29	white/brown/orange	42	white/orange/green
4	orange	17	white/blue	30	white/brown/yellow	43	white/orange/blue
5	yellow	18	white/violet	31	white/brown/green	44	white/orange/violet
6	green	19	white/gray	32	white/brown/blue	45	white/orange/gray
7	blue	20	white/black/brown	33	white/brown/violet	46	white/yellow/green
8	violet	21	white/black/red	34	white/brown/gray	47	white/yellow/blue
9	gray	22	white/black/orange	35	white/red/orange	48	white/yellow/violet
10	white	23	white/black/yellow	36	white/red/yellow	49	white/yellow/gray
11	white/black	24	white/black/green	37	white/red/green	50	white/green/blue
12	white/brown	25	white/black/blue	38	white/red/blue		
13	white/red	26	white/black/violet	39	white/red/violet		

Chart 5

UNITRONIC® 300/300 CY (20 - 16 AWG)

Conductor	Color	Conductor	Color	Conductor	Color	Conductor	Color
1	black	14	red/yellow	27	white/black/yellow	40	white/green/black
2	red	15	red/black	28	white/black/blue	41	white/green/red
3	white	16	white/black	29	white/black/brown	42	white/green/green
4	green	17	white/red	30	white/black/orange	43	white/green/blue
5	orange	18	white/green	31	white/black/gray	44	white/green/brown
6	blue	19	white/yellow	32	white/black/violet	45	white/green/violet
7	brown	20	white/blue	33	white/black/black	46	white/blue/black
8	yellow	21	white/brown	34	white/red/black	47	white/blue/red
9	violet	22	white/orange	35	white/red/red	48	white/blue/green
10	gray	23	white/gray	36	white/red/green	49	white/blue/blue
11	pink	24	white/violet	37	white/red/blue	50	white/blue/brown
12	tan	25	white/black/red	38	white/red/brown		
13	red/green	26	white/black/green	39	white/red/violet		

Chart 6: VDE 0293-308

# of Conductors	Cables with green/yellow ground	Cables without green/yellow ground
2	–	blue + brown
3	green/yellow ground + brown + blue	brown + black + gray
4	green/yellow ground + brown + black + gray	blue + brown + black + gray
5	green/yellow ground + blue + brown + black + gray	blue + brown + black + gray + black
6 and above	green/yellow ground with printed numbers	black with printed numbers

Flexible Cables built to DIN VDE 0293:

ÖLFLEX® CLASSIC 100
ÖLFLEX® CLASSIC 100 CY
ÖLFLEX® CLASSIC 100 SY
ÖLFLEX® 540 P
ÖLFLEX® CRANE
ÖLFLEX® CRANE F
ÖLFLEX® CRANE NSHTOU
ÖLFLEX® CRANE PUR
ÖLFLEX® CRANE VS (N) NSHTOU
ÖLFLEX® HEAT 180 MS
ÖLFLEX® HEAT 180 SiHF
ÖLFLEX® HEAT 180 GLS
ÖLFLEX® HEAT 180 H05SS-F EWKF
ÖLFLEX® HEAT 145 MC
ÖLFLEX® H05VV-F
ÖLFLEX® H07RN-F
ÖLFLEX® LIFT F
ÖLFLEX® POWER IX
ÖLFLEX® POWER QUAD II
ÖLFLEX® SERVO 9YSLCY-JB
ÖLFLEX® SERVO 2YSLCY-JB
ÖLFLEX® SPIRAL H07BQ-F

Color Code Charts

Chart 7: DIN 47100 for Paired Cables (for telephone & electronic use only)

UNITRONIC® CY PiDY (TP), UNITRONIC® FD CP (TP), UNITRONIC® LiHCH (TP), UNITRONIC® LiYCY (TP)

UNITRONIC® FD CP (TP)
UNITRONIC® CY PIDY (TP)
UNITRONIC® LiFYCY (TP)
UNITRONIC® LiYCY (TP)
INTERBUS bus cables
PROFIBUS bus cables
MITSUBISHI CCL BUS

The color code for paired cables is in accordance with DIN 47100. At 23 pairs, the identification repeats itself for the first time and from 45 pairs for the second time.

Pair	Color	Pair	Color
1	white + brown	13	white/black + brown/black
2	green + yellow	14	gray/green + yellow/gray
3	gray + pink	15	pink/green + yellow/pink
4	blue + red	16	green/blue + yellow/blue
5	black + violet	17	green/red + yellow/red
6	gray/pink + red/blue	18	green/black + yellow/black
7	white/green + brown/green	19	gray/blue + pink/blue
8	white/yellow + yellow/brown	20	gray/red + pink/red
9	white/gray + gray/brown	21	gray/ black + pink/black
10	white/pink + pink/brown	22	blue/black + red/black
11	white/blue + brown/blue	23-44	repeat 1-22
12	white/red + brown/red	45-66	repeat 1-22

Chart 8: DIN 47100 without color repetition (for telephone & electronic use only)

ÖLFLEX® ROBOT 900 P/DP, ÖLFLEX® ROBOT F1/F1 C, UNITRONIC® BUS CAN/CAN FD, UNITRONIC® BUS INTERBUS, UNITRONIC® FD 890, UNITRONIC® FD/FD CY/FD P plus/FD CP plus, UNITRONIC® LD/LD FD P, UNITRONIC® LiHH/LiHCH, UNITRONIC® LiYY/LiYCY, UNITRONIC® SPIRAL

Conductor	Color	Conductor	Color	Conductor	Color	Conductor	Color
1	white	17	white/gray	33	green/red	49	white/green/black
2	brown	18	gray/brown	34	yellow/red	50	brown/green/black
3	green	19	white/pink	35	green/black	51	white/yellow/black
4	yellow	20	pink/brown	36	yellow/black	52	yellow/brown/black
5	gray	21	white/blue	37	gray/blue	53	white/gray/black
6	pink	22	brown/blue	38	pink/blue	54	gray/brown/black
7	blue	23	white/red	39	gray/red	55	white/pink/black
8	red	24	brown/red	40	pink/red	56	pink/brown/black
9	black	25	white/black	41	gray/black	57	white/blue/black
10	violet	26	brown/black	42	pink/black	58	brown/blue/black
11	gray/pink	27	gray/green	43	blue/black	59	white/red/black
12	red/blue	28	yellow/gray	44	red/black	60	brown/red/black
13	white/green	29	pink/green	45	white/brown/black	61	black/white
14	brown/green	30	yellow/pink	46	yellow/green/black		
15	white/yellow	31	green/blue	47	gray/pink/black		
16	yellow/brown	32	yellow/blue	48	red/blue/black		

Color Code Charts

Chart 9: Six or More Conductors

ÖLFLEX® PUR S

Conductor	Color	Conductor	Color	Conductor	Color	Conductor	Color
0	green/yellow	26	violet/black	52	transparent/red	78	tan/white/blue
1	white	27	pink/black	53	tan/red	79	gray/white/brown
2	black	28	orange/black	54	pink/violet	80	red/white/brown
3	blue	29	transparent/black	55	orange/violet	81	violet/white/brown
4	brown	30	tan/black	56	transparent/violet	82	pink/white/brown
5	gray	31	brown/blue	57	tan/violet	83	orange/white/brown
6	red	32	gray/blue	58	transparent/pink	84	transparent/white/brown
7	violet	33	red/blue	59	tan/pink	85	tan/white/brown
8	pink	34	pink/blue	60	transparent/orange	86	red/white/gray
9	orange	35	orange/blue	61	tan/orange	87	violet/white/gray
10	transparent	36	transparent/blue	62	blue/white/black	88	pink/white/gray
11	tan	37	tan/blue	63	brown/white/black	89	orange/white/gray
12	black/white	38	gray/brown	64	gray/white/black	90	transparent/white/gray
13	blue/white	39	red/brown	65	red/white/black	91	tan/white/gray
14	brown/white	40	violet/brown	66	violet/white/black	92	blue/white/red
15	gray/white	41	pink/brown	67	pink/white/black	93	brown/white/red
16	red/white	42	orange/brown	68	orange/white/black	94	violet/white/red
17	violet/white	43	transparent/brown	69	transparent/white/black	95	pink/white/red
18	pink/white	44	tan/brown	70	tan/white/black	96	orange/white/red
19	orange/white	45	red/gray	71	brown/white/blue	97	brown/white/violet
20	transparent/white	46	violet/gray	72	gray/white/blue	98	orange/white/violet
21	tan/white	47	pink/gray	73	red/white/blue	99	brown/black/blue
22	blue/black	48	orange/gray	74	violet/white/blue	100	gray/black/blue
23	brown/black	49	transparent/gray	75	pink/white/blue	101	red/black/blue
24	gray/black	50	tan/gray	76	orange/white/blue		
25	red/black	51	orange/red	77	transparent/white/blue		

Chart 10: ICEA-NEMA (K-2)

ÖLFLEX® TC 600

Conductor	Color	Conductor	Color	Conductor	Color	Conductor	Color
1	black	7	red/black	13	blue/red	19	orange/blue
2	red	8	blue/black	14	orange/red	20	yellow/blue
3	blue	9	orange/black	15	yellow/red	21	brown/blue
4	orange	10	yellow/black	16	brown/red	22	black/orange
5	yellow	11	brown/black	17	black/blue	23	red/orange
6	brown	12	black/red	18	red/blue	24	blue/orange

The last conductor of the cable is always green/yellow (30% stripe width) with no printing.

Example:
Lapp USA P/N 2118152 is a 12 conductor cable. The base color for this cable is black and printed with white ink as follows:
1: black, 2: red, 3: blue, 4: orange, 5: yellow, 6: brown, 7: red/black, 8: blue/black, 9: orange/black, 10: yellow/black, 11: brown/black, 12: green/yellow

Connector Housings

The most important considerations for a heavy duty connector are its electrical characteristics, its mechanical characteristics and the materials from which it is manufactured. The heavy duty connector provides safe connection and disconnection of electrical power or signals with robust housings suitable for hostile environments (connectors should never be mated or unmated under load due to the possibility of arc flash.)

The construction of a rectangular connector can be selected specifically for a customer's requirement. EPIC® industrial connectors from Lapp are made up of various components (housings, inserts, contacts, strain relief.)

The various components of the heavy duty rectangular connector are purchased individually and assembled together. A wide range of housing sizes and many options of inserts and contacts make it possible to design the ideal connector for each application.

Housing Types

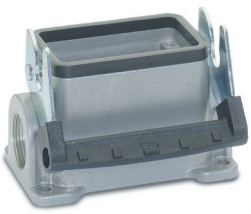
For 3D or 2D CAD drawings refer to www.lappusa.com

Hood:

A hood may have a top or an angle (side) entry of different PG, metric, or NPT sizes to accommodate a wide range of cable diameters. The hood can be mated with either a surface or panel mounting base, or a cable coupler hood (for cable to cable connection.)

Panel Mount Base Housings:

The panel base is wired from below through a hole cut in a panel. The panel base is attached to the surface of a control panel for connection of control or power cables.

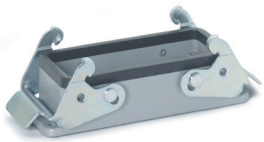


Surface Mount Base Housings:

The surface base is a complete enclosure only offering cable entry through a cable gland mounted either on one or both sides of the base.

Cable Coupler Hood:

The cable connector mates with a top entry hood to offer cable to cable connection. This is frequently used to extend cables.

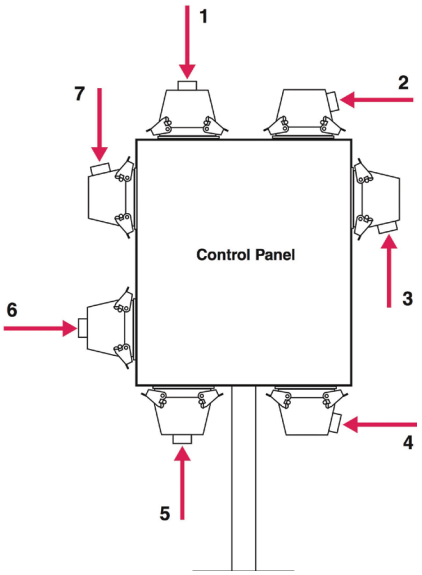


Fixed Locking Lever (Latches) Types:

There are two types of locking levers:

- Single locking lever which bolts on the longer side of the connector
- Double locking lever which bolts two levers on the shorter sides of the connector
- Hoods or Bases can feature single or double levers

Choosing the Correct Connector Housing



There is no right or wrong. The goal is to match the hood entry to the installation requirement as closely as possible.

Choose your housing by answering these two questions:

1. Where are you mounting the connector?

2. Where is the cable coming from?

This will allow you to make a reasonable selection.

Example	Hood Entry Location	Panel Surface where connector is mounted	Cable Entry Direction
1	Top	Top	Vertical down from above
2	Side	Top	Horizontal from side
3	Side	Side	Vertical up from below
4	Side	Bottom	Horizontal from side
5	Top	Bottom	Vertical up from below
6	Top	Side	Horizontal from side
7	Side	Side	Vertical down from above

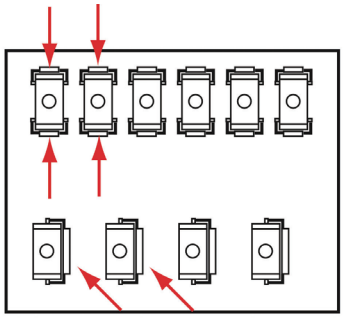
Single vs. Double Bolt Hoods

Although either bolt location can be used, the key is to use a bolt location that allows the connectors to be mounted as close together as possible while providing the maximum access possible to the locking levers on the base.

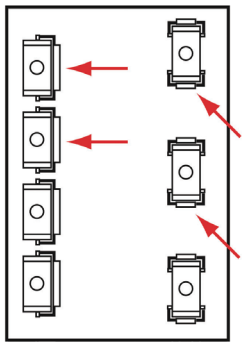
For connectors mounted horizontally side by side, the double bolt location is preferred.

For connectors mounted vertically top-to-bottom, the single bolt location is preferred.

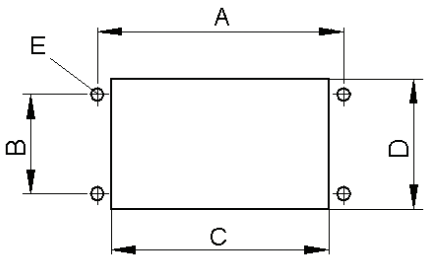
Connectors mounted horizontally side-to-side



Connectors mounted vertically top-to-bottom



Panel Cut-out Sizes

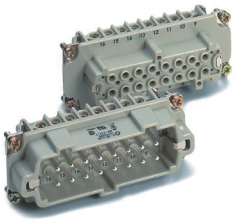


Panel cut out for panel mount base (mm):

	A	B	C	D	E
HA 3	30	–	21	21	3.3
HA 10	70	17.5	57.5	24	3.6
HA 16	86	17.5	73.7	24	3.6
HA 32	92	42	74.2	48.4	4.3
HA 48	110	65	85.5	71	5.5
HA 64	148	70	117	82	7
HB 6	70	32	52.2	35	4.3
HB 10	83	32	65.2	35	4.3
HB 16	103	32	85.5	35	4.3
HB 24	130	32	112.2	35	4.3
HB 32	110	65	85.5	71	5.5
HB 48	148	70	117	82	7

Plugs & Receptacles Overview

The male and female inserts house male (pins) and female (sockets) contacts respectively, and are the interface for the electrical connection. Cable is terminated to the contacts. Inserts provide the electrical insulation.



Screw-Terminated Plugs & Receptacles

This simple type of termination is distinguished by its ease of maintenance. No special tool is required, just a screwdriver to undo and tighten up the terminal screws.
Screw connection technology (as per DIN EN 60999):

Conductor section (mm²)	1	1.5	2.5	4	5	10
Screw Thread	M 2.6	M 3	M 3	M 3.5	M 4	M 4
Recommended Ncm	40.7	50	50	80	120	120

Crimp-Terminated Plugs & Receptacles

The purpose of crimping is to produce a good mechanical, electrical, and gas-tight connection. This should remain unchanged with regard to quality in the long-term, and should thus be reliable. Crimping also reduces termination time and allows the designer to achieve more connections than screw termination would permit in the same space.

Hand operated tools or crimping machines can be used to assemble crimp contacts. The following points must be followed in order to obtain the ideal crimping result:

- Cross section dimension/gauge size and structure of the cable
- Contact type and size
- Tool and tool setting

There are two different crimp contact types: machined and stamped and formed. These two types of contacts have differing characteristics in terms of quality and how the termination is made.

Stamped & Formed Contacts:

The crimping sleeve allows a wider range of wire gauges to be crimped. This guarantees reliable crimping quality. Furthermore, the insertion and extraction force is usually lower with stamped pin and socket contacts, achieved by the large contact area and the spring characteristics of the stamped contacts' material. Stamped contacts can be supplied reeled for use with automatic feed crimping tools.

Machined Contacts:

With this popular type of contact, the suitable contact size is matched to the wire gauge of the cable. The correct crimping tool or dies must be used.

Screwless Spring Cage Clamp Inserts

This type of termination is noted for its ease and speed of fitting without an additional tool. The compensating effect of the cage clamp enables good contact to be maintained in the long term.

Modular Series

The modular series inserts provide flexibility. A combination of 2 or up to 14 modules can be combined into one connector housing. The available modules include coax, high voltage, cage clamp and crimp terminated.

# of contacts: 2 up to 280

General Design Specifications

General Design:
EPIC® connectors consist of mating male and female inserts of various sizes and electrical characteristics, which utilize either screw-clamp, crimp contacts, or cage clamp terminations. The inserts are fully enclosed in hoods and housings of either plastic or metal.

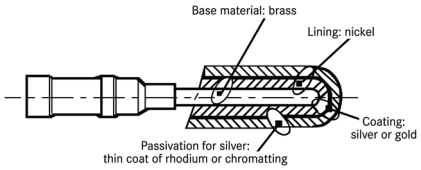
Termination:
Screw-Clamp: Screw-clamp insert contacts are made of copper alloy and plated with silver to inhibit corrosion. Clamping and fixing screw are made of galvanized steel with a silver chromate plating.

Cage Clamp:
Cage clamp insert contacts are made of copper alloy. The cage clamp screwless spring termination requires no special tools for termination. The connection is vibration-proof and never requires re-tightening.

Crimp Contact:
Crimp-contact inserts shall accept either stamped and formed or machined crimp contacts. Crimp contacts feature a base crimp contact and a stainless steel locking spring. Crimp contacts are made of a copper zinc alloy, plated with an appropriate material (tin/lead, gold or silver) to provide corrosion resistance.

Hoods and Bases:
Hoods and bases are made of either metal or plastic depending on the application requirement. Metal hoods are made of an anodized aluminum or zinc cast material for corrosion resistance. Additionally, metal hoods and bases feature a powder-paint or nickel-plated surface for wear resistance. Thermoplastic housings are heat resistant for high temperature applications.

Conductor Specifications



Contact Material Details:
The coating of the base material with a precious metal is necessary to guarantee a good, long lasting connection. The contacts are normally plated through galvanic processes. For a long-lasting plating, there are some requirements for the contact and the plating material:

Requirements on contact material:
- Good dimensional stability
- High corrosion resistance
- Good electrical conductivity

Brass (copper zinc alloy) is used for its good mechanical properties and electrical conductivity. Because it is also relatively economical, it has become one of the most preferred contact materials.

Requirements on contact coatings:
- High abrasion resistance
- Low contact resistance
- High corrosion resistance
- Low porosity
- Good coat formation
- Solderability

Silver or gold are the normal choice for surface coating.

Silver possesses the highest electrical conductivity of any metal and is the most cost-effective precious metal. With sulfur or sulfurous products in the ambient air, a brownish to black oxide coating made up of silver sulfide (Ag_2S) will rapidly be formed. However, this coating will break up in the process of mating and will be broken down by high currents, so that the necessary electrical conductivity is maintained. Passivation of the silver surface will delay the formation of the oxide coating and will reduce the mating and unmating forces.

Gold is the most tarnish-resistant precious metal. Formation of oxides and sulfides can be discounted. Gold contacts are distinguished by their low mating and unmating forces. They are mainly used for transmission of signals with low current and voltage values.

Alternative materials for surface coating:
Nickel is normally applied as a corrosion protection and blocking layer. Furthermore, the relatively high hardness of the Ni coating has a positive effect on wear characteristics.

Tin or tin/lead is one of the most frequently employed metals for contacts, especially in the automotive field. As an aid to soldering, virtually all partially coated strips in the connection are coated with tin or tin/lead. Due to the low hardness of tin, the mating forces are very high and this makes it unsuitable for connectors that are designed for a high number of mating cycles.

General Approvals

Pollution:
The numerical value which states the anticipated pollution in the micro-environment:

Pollution level 1:
No pollution or only dry, non-conductive pollution occurs. This pollution has no influence. For example: open, unprotected insulations in air-conditioned or clean, dry rooms.

Pollution level 2:
Only non-conductive pollution occurs. Occasionally, however, transient conductivity may arise due to condensation. For example: open unprotected insulations in residential, commercial, or business premises (fine mechanical engineering workshops, laboratories, test areas, rooms used for medical purposes). Pollution level 2 is typical for households.

Pollution level 3:
Conductive pollution occurs, or condensation causes dry, non-conductive pollution to become conductive. For example: open unprotected insulations in rooms of industrial, commercial, and agricultural companies, unheated storage rooms, boiler houses, and workshops. Pollution level 3 is typical for industrial environments.

Pollution level 4:
Contamination leads to continuous conductivity caused by condensation or other environmental contaminants. For example: external exposed installation subject to all environmental changes.

Insulation materials:
Insulation materials are categorized into 4 groups according to the CTI values (Comparative Tracking Index)

Insulation material group I	600 ≤ CTI
Insulation material group II	400 ≤ CTI < 600
Insulation material group IIIa	175 ≤ CTI < 400
Insulation material group IIIb	100 ≤ CTI ≤ 175

Comparative Tracking Index:
The test for determination of the comparative index of tracking (CTI or comparative tracking index) as per IEC 112 provides a comparison of the characteristics of various insulating materials under test conditions. By dripping an aqueous solution onto a horizontal surface the electrolytic condition can be measured. This produces a qualitative result. When the insulating material is introduced to the tracking, a quantitative comparison can be measured, ex. the comparative tracking index.

Switch contact:
If the construction of the circuit requires that, for safety reasons, the circuit power should remain off until one or more contacts are engaged, or that the circuit power should be turned off prior to one or more contacts being disengaged, then a connector with switch contacts (EPIC® HBVE series) should be used.

EMC (electromagnetic compatibility):
EMC is the capacity of an electrical installation to function properly in an electromagnetic environment without adversely influencing the environment, including other installations (DIN/VDE 0870, Section 1).

Coding:
Coding is a system by which it is possible to prevent interfacing confusion between adjacent connectors that are similarly configured. This is useful if two or more connectors of the same type are mounted on the same unit.

Polarization:
Polarization of connectors prevents incorrect mating of male and female inserts, e.g., pin1 to pin1.

As of December 31, 1999, the safety standard VDE 0619 and the therein referenced standards DIN 46319 for metric dimensions and DIN 46320 for PG dimensions were withdrawn.

The new standard DIN EN 50262 became valid as of January 1, 2000.

A 1 to 1 conversion is not possible.

Lapp North America will continue to support PG and metric components.

PG to Metric Conversion

PG	Metric
7	12
9	16
11	20
13	–
16	25
21	–
29	32
36	40
42	50
48	63

Materials

PA (Polyamides)

Polyamides are high-impact, very tough thermoplastics that exhibit very good electrical insulation characteristics, favorable tracking characteristics, and resistance to flashover. The greater the proportion of filling agents, the lower the water absorption rate and the better the dimensional stability. Their specific surface resistance, due to humidity absorption, is somewhat less than that of other plastics. However, this reduces the likelihood of a build up of electrostatic charge and consequently avoids attracting dust. These characteristics mean that polyamides are suitable for production of casings for electrical plants.

(Typical application: high voltage modules, plastic frame grips)

PC (Polycarbonate)

Polycarbonate is an amorphous thermoplastic. It is distinguished by high strength, viscosity, hardness, rigidity, a good resistance to heat and cold in relation to its form, and good electrical characteristics. PC is a glass-clear, easily dyed plastic with very low water absorption, and exhibits high dimensional precision, low waste, and good processability.

(Typical applications: inserts/ insulators, frames, and individual modules for modular systems)

PBT (Polybutylenterephthalate)

Polybutylenterephthalate is a thermoplastic polyester and is distinguished by its high rigidity, high stability of form under heat, low creep, low water absorption of < 0.2%, high dimensional stability, and good to very good electrical characteristics. It is a tough, viscous plastic with high abrasion resistance, high dimensional stability, and long-term strength combined with good slip and wear characteristics.

(Typical application: insert/insulators)

Chemical Resistance of Plastics

Diluted acid	PA 6 GF	PA 66 GF	PC GF	PBT GF
Acetone	+	+	+	+
Aqueous ammoniac	+	+	-	+
Benzene	+	+	+	+
Benzol	+	+	+	+
Diesel oil	+	+	-	+
Concentrated acetic acid	+	+	+	+
Alkaline potassium	-	-	-	•
Methanol	-	-	-	+
Engine oil	•	•	-	+
Diluted alkalis	+	+	+	+
Chlorohydrocarbons	+	+	-	+
Outdoor exposure	+	+	-	•
Cold water/seawater	+	+	•	+

+ = resistant
• = conditionally resistant
- = non-resistant

Electrical, Thermal & Mechanical Values

	Unit	PA 6 GF	PA 66 GF	PC GF	PBT GF
Electrical Values					
Flash over resistance (DIN 53481; VDE 0303)	Ed * KV/mm	80/40	> 80/40	35	100
Tracking current resistance (DIN 53480; VDE 0303)	CTI	> 500	> 500	> 125 to 250	> 500
Thermal values					
Temperature limit for short-term application	°C	180	200	165	190
Temperature limit for long-term application	°C	105	120	130	140
Mechanical values					
Density (DIN 53479)	g/cm3	1.35	1.35	1.34	1.53
Modulus of elasticity in the flexional and tensile test (DIN 53457)	EZ * MPa	8500/6000	9700/7500	6000	10000
Absorption of humidity in NK until occurrence of saturation (DIN 5714)	%	2.1	1.5	0.13	0.13

* Numerical information relates to both dry and atmospherically humid conditions

Sealing Materials

NBR (e.g.: Perbunan®)

This is a synthetic rubber used for parts with high resistance to fuels, oils, fats, and aliphatic solvents at high temperatures. The durability of the material can be used to protect against ozone or the prevailing environmental conditions.

O-rings are used in various applications: electrical and automotive industry, hydraulics, mechanical engineering, oil industry for membranes, fuel hoses, seals, formed items, plate gaskets, etc.

Typical applications: Seals and gaskets for rectangular connectors and glands.

Perbunan® is a registered trademark of BAYER AG.

FPM (e.g.: Viton®)

This fluoroelastomer is commonly used for rubber parts and withstands fuels, oils, lubricants, and many acids and chemicals during extreme thermal stress. Viton also has good mechanical qualities, flame resistance, and high durability against ozone and environmental impacts of every kind.

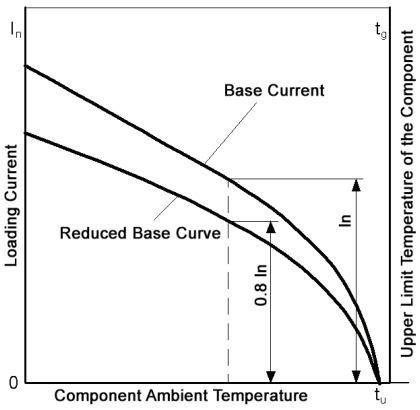
Typical application: Seal in circular connector type A and glands.

Viton® is a registered trademark of DuPont de Nemour.

Chemical, Thermal & Mechanical Values

Abbreviation	NBR	FPM
Commercial Name	Perbunan N Hycar	Viton/Fluorel
Shore A hardness range at standard solid quality tolerance ± 5° Shore (approx.)	25 - 40	60 - 90
Tear strength N/mm² @ +20°C	Approx. 20	Approx. 17
General weather-resistance	Good	Excellent
Ozone resistance	Satisfactory	Excellent
Resistance to oil	Excellent	Excellent
Resistance to fuel	Good	Excellent
Resistance to solvent	Partially good	Very good
General resistance to acids	Satisfactory	Very good
Temperature resistance: a) Short-term: b) Long-term:	 -40°C to +150°C -30°C to +120°C	 -30°C to +280°C -20°C to +230° C
Vapor resistance	Good	Satisfactory to good
Can be supplied in food packaging products	Yes	No

Derating Curves



The derating curve indicates the maximum current that can permanently and simultaneously flow through all connections if the component is exposed to ambient temperatures below its upper limit temperature.

The upper limit temperature of a component is determined by its material(s). The maximum temperature is calculated from the ambient temperature and from heating due to current loading. It must not exceed the upper limit temperature of the component. The derating of a component is not a constant value, but decreases hand-in-hand with the increase in component ambient temperature. Furthermore, current loading capacity is dependent upon geometry, the materials employed, the number of poles, and the conductor.

Since it is not advisable to use heavy duty connectors at their loading limits, the base curve is reduced. If the loading currents are reduced to 80%, then this produces the reduced base curve in relation to the various connectors and measurement uncertainties at which temperature measurements are taken into account. Experience shows that use of the reduced base curve data will provide operation over the widest range of connector applications.

Note: only the reduced base curve is reproduced on the following derating curves for inserts.

Recommended Torque for EPIC® Assembly Screws

Screw Size	EPIC® Connector Assembly Part Example	Recommended Torque Metric	US
M3	EPIC® HBE & HA screw terminals, EPIC® insert mounting screws, EPIC® guide pin & bushing	0.80 Nm	0.59 lb/ft (7.08 lb)
M4	EPIC® HD, HDD, HBE & HA ground screw, EPIC® HBS screw terminal	1.50 Nm	1.11 lb/ft (13.32 lb)
M5	EPIC® HBS grounding screw	2.50 Nm	1.84 lb/ft (22.13 lb)
M6	MP 80A screw terminal Modular MC2 screw terminal	3.00 Nm	2.21 lb/ft (26.52 lb)

Size Conversion Charts

American Wire Gauge (AWG) to mm²

AWG	mm²	AWG	mm²	AWG	mm²
30	0.05	12	4	4/0	120
28	0.08	10	6	250	120
26	0.14	8	10	300	150
24	0.25	6	16	350	185
22	0.34	4	25	400	185
20	0.50	2	35	450	240
19	0.75	1	50	500	240
18	1.0	1/0	50	600	300
16	1.5	2/0	70	750	400
14	2.5	3/0	95		

mm² to American Wire Gauge (AWG)

mm²	AWG	mm²	AWG	mm²	AWG
0.14	26	4	12	95	4/0
0.25	24	6	10	120	250
0.34	22	10	8	150	300
0.50	20	16	6	185	350, 400
0.75	19	25	4	240	450, 500
1.0	18	35	2, 1	300	600
1.5	16	50	1/0	400	750, 800
2.5	14	70	2/0, 3/0		

Cable Outer Diameter for PG Glands

PG Size	Cable Outer Diameter Range (in)	(mm)	PG Size	Cable Outer Diameter Range (in)	(mm)
PG 7	0.157 - 0.236	4.0 - 6.0	PG 21	0.354 - 0.787	9.0 - 20.0
PG 9	0.157 - 0.433	4.0 - 11.0	PG 29	0.669 - 1.102	17.0 - 28.0
PG 11	0.256 - 0.531	6.5 - 13.5	PG 36	0.906 - 1.339	23.0 - 34.0
PG 13	0.256 - 0.531	6.5 - 13.5	PG 42	1.142 - 1.575	29.0 - 40.0
PG 16	0.256 - 0.630	6.5 - 16.0			

For more information, see page 412.

PG Gland Sizes for Multi-Wire Cables

20 AWG (0.5 mm²)

Number of Wires	Cable Diameter (mm)	PG Sizes						
2	5.7 - 8.7	9						
3	6.0 - 9.0	9	11					
4	6.7 - 9.7	9	11	13	16			
5	7.2 - 10.2	9	11	13	16			
6	7.6 - 10.6	9	11	13	16			
7	8.0 - 10.6	9	11	13	16			
8	9.4 - 12.8	9	11	13	16			
10	9.4 - 12.8	9	11	13	16			
12	9.7 - 12.9	9	11	13	16			
14	10.2 - 13.4		11	13	16			
16	10.7 - 13.9		11	13	16			
21	12.3 - 15.1			13	16	21		
24	13.5 - 16.7			13	16	21		
30	14.3 - 17.5				16	21		
35	16.0 - 18.6					21		
40	16.6 - 19.2					21		
52	19.2 - 21.6					21	29	
61	20.3 - 23.1					21	29	
80	22.9 - 25.7						29	36
100	26.4 - 29.6						29	36

18 AWG (1.0 mm²)

Number of Wires	Cable Diameter (mm)	PG Sizes						
2	6.8 - 9.8	9	11					
3	7.2 - 9.7	9	11	13				
4	7.9 - 10.3	9	11	13	16			
5	8.9 - 10.9	9	11	13	16			
6	8.9 - 12.3	9	11	13	16			
7	9.6 - 12.3	9	11	13	16			
8	10.4 - 13.8		11	13	16			
9	10.7 - 13.9		11	13	16			
10	10.4 - 13.8		11	13	16			
12	10.7 - 13.9		11	13	16			
15	12.3 - 13.5			13	16			
18	13.0 - 16.2			13	16			
21	13.6 - 16.8			13	16	21		
25	15.9 - 18.5				16	21		
32	17.1 - 19.7					21	29	
40	19.0 - 21.4					21	29	
50	21.3 - 24.1					21	29	
61	22.6 - 25.4					21	29	36
80	26.1 - 29.3					21	29	36
100	29.4 - 33.0							36

16 - 18 AWG (1.0 mm²)

Number of Wires	Cable Diameter (mm)	PG Sizes						
2	7.1 - 10.1	9	11					
3	7.5 - 10.1	9	11					
4	8.4 - 10.7	9	11	13				
5	9.2 - 11.4	9	11	13	16			
6	9.2 - 12.6	9	11	13	16			
7	9.2 - 12.6	9	11	13	16			
8	11.0 - 14.4		11	13	16	21		
9	11.8 - 15.2		11	13	16	21		
10	11.0 - 14.4		11	13	16	21		
12	11.8 - 14.6		11	13	16	21		
14	12.4 - 15.2			13	16	21		
16	13.0 - 16.2			13	16	21		
18	13.7 - 16.9			13	16	21		
20	14.4 - 17.6				16	21		
24	16.5 - 19.1					21		
25	16.9 - 19.5					21		
34	19.4 - 21.8					21		
48	22.0 - 24.8					21		
56	23.2 - 26.0					21	36	
61	24.5 - 27.2						36	
80	27.7 - 30.9						36	
100	31.8 - 35.2						36	42

16 AWG (1.5 mm²)

Number of Wires	Cable Diameter (mm)	PG Sizes						
2	8.0 - 11.0	9	11	13	16			
3	8.7 - 11.0	9	11	13	16			
4	9.7 - 11.8	9	11	13	16			
5	10.8 - 13.0		11	13	16			
6	10.8 - 14.2		11	13	16			
7	10.8 - 14.2		11	13	16			
8	13.2 - 16.6			13	16	21		
11	13.6 - 16.8			13	16	21		
12	17.6 - 16.8			13	16	21		
14	14.4 - 17.6				16	21		
16	15.8 - 18.4				16	21		
18	16.6 - 19.2					21	29	
20	17.4 - 20.0					21	29	
25	20.2 - 23.0					21	29	
32	23.8 - 24.5						29	36
34	22.6 - 25.4						29	36
42	25.8 - 29.0						29	36
50	27.0 - 30.2						29	36
56	27.8 - 31.0						29	36
61	28.6 - 31.8							36
80	33.0 - 36.4							36	42
90	34.6 - 37.6							36	42
100	37.8 - 41.4								42

12 - 14 AWG (2.5 mm²)

Number of Wires	Cable Diameter (mm)	PG Sizes							
2	9.8 - 12.8	9	11	13	16				
3	10.6 - 13.4		11	13	16				
4	11.7 - 14.4		11	13	16				
5	13.0 - 16.4			13	16	21			
6	13.3 - 16.7			13	16	21			
7	13.3 - 16.7			13	16	21			
8	17.4 - 20.8					21	29		
11	18.0 - 20.6					21	29		
16	20.6 - 23.4					21	29		
18	21.7 - 24.5						29	36	
25	26.4 - 29.6						29	36	
34	31.3 - 33.1							36	42
50	37.0 - 39.4								42
61	39.0 - 41.5								42

10 - 12 AWG (4 mm²)

Number of Wires	Cable Diameter (mm)	PG Sizes						
2	10.7 - 14.1	9	11	13		21		
4	13.0 - 16.4			13		21		
5	14.3 - 17.7					21		
7	16.2 - 19.6					21	29	36
11	ca - 24.5						29	36

These tables are based on a representative construction type of multi-conductor cable. Other products may vary.

IP Ratings

Modes of Protection per DIN VDE 0470-1 (IEC EN 60529)

Ingress Protection (IP) is a measure of protection against water and particles for devices. The level of protection offered by a device is laid down in the manufacturer's specification according to DIN 40050.

The first digit of the code states the level of protection against particle ingression. The second digit states the level of protection against penetration of water.

Degrees of protection against solid foreign objects

First digit of code

Digit	Protection
0	No particular protection
1*	Large solid foreign bodies with diameters ≥ 50 mm, and accidental contact with large surfaces of the body, e.g.: the back of the hand.
2*	Medium-sized solid foreign bodies with diameters ≥ 12 mm, e.g.: fingers.
3*°	Small solid foreign bodies with diameters ≥ 2.5 mm, e.g.: some tools, wires.
4*°	Granular foreign bodies with diameters ≥ 1 mm, e.g.: tools, small wires.
5•	Harmful accumulations of dust (dust protection). Penetration of dust is not entirely preventative, but must not penetrate in such quantities that operation is affected. Complete contact protection.
6	Penetration of dust (dust-proof). Complete contact protection.

* Protection levels 1 - 4: Consistently or inconsistently formed foreign bodies with three perpendicular dimensions (i.e.: cubic) larger than the specified diameter are also prevented from entering.

° Protection levels 3 & 4: This table is appropriate for devices with drain holes or cooling air apertures. It complies with the respective expert committee.

• Protection level 5: This table is appropriate for devices with drain holes. It complies with the respective expert committee.

Degrees of protection against water

Second digit of code

Digit	Protection
0	No particular protection
1	Water falling vertically (water drip).
2	Water sprays up to 15° from vertical (oblique water drip).
3	Water sprays up to 60° from vertical (water spray).
4	Water splashing onto the unit from any direction (water splash). Limited ingress is permitted, but must not affect operation.
5	Jets of water from any direction (water spray). Limited ingress is permitted, but must not affect operation.
6	Strong jets of water from any direction (flooding). Limited ingress is permitted, but must not affect operation, e.g.: ship decks
7	Immersion between 15 cm and 1 m (dipping).
8†	Permanent immersion under conditions defined by the manufacturer (immersion).
9 K	Ingress of water, even high-pressure or steam cleaning, from any direction.

† Protection level 8: This level of protection normally relates to air-tight field-operating devices. For certain devices, however, water may penetrate as long as proper operation is not affected.

Example:

IP65 provides protection against:

1. Penetration of dust (6)
2. Jets of water from any direction (5)

IP68, 5 bar provides protection against:

1. Penetration of dust (6)
2. Water protection up to 5 bar, i.e.: 70 psi

NEMA Ratings

NEMA Type 1:
General Purpose: Indoor Use
Intended to provide protection against contact with the enclosed equipment and against a limited amount of falling dirt.

NEMA Type 2:
Drip-proof: Indoor Use
General purpose indoor use intended to be dust-proof and provide protection against limited amounts of falling dirt and water.

NEMA Type 3:
Dust-tight, Rain-tight, Sleet Resistant: Outdoor Use
Intended to provide protection against wind-blown dust and rain. Should be undamaged by the formation of ice on the enclosure.

NEMA Type 3R:
Rain-proof & Sleet Resistant: Outdoor Use
Intended to provide protection against falling rain. Should be undamaged by the formation of ice on the enclosure.

NEMA Type 3S:
Outdoor Use
Intended to provide protection against wind-blown dust, rain, and sleet. The external mechanisms should remain operable while ice-laden.

NEMA Type 4:
Water-tight & Dust-tight: Indoor/Outdoor Use
Intended to provide protection against dust, falling rain, splashing, and hose-directed water sprays. Should be undamaged by the formation of ice on the enclosure.

NEMA Type 4X:
Water-tight, Dust-tight, Corrosion Resistant: Indoor/Outdoor Use
Intended to provide protection against dust, falling rain, splashing, and hose-directed water sprays. Should be undamaged by the formation of ice on the enclosure. Should be corrosion resistant.

NEMA Type 5:
Dirt-tight, Dust-tight, Liquid-tight: Indoor Use
Intended to provide protection against falling dirt, airborne dust, lint, fibers, and filings. Also provides protection against dripping and light splashing of liquids.

NEMA Type 6:
Indoor/Outdoor Use
Intended to provide protection against the entry of water during temporary and limited submersion. Should remain undamaged by the formation of ice on the enclosure.

NEMA Type 6P:
Indoor/Outdoor Use
Intended to provide protection against the entry of water during prolonged submersion at limited depths. Should remain undamaged by the formation of ice on the enclosure.

NEMA Type 7:
Indoor Use in Hazardous Applications
Used in Class 1, Division 1, Groups A, B, C, or D applications.

NEMA Type 8:
Indoor/Outdoor Use in Hazardous Applications
Used in Class 1, Division 1, Groups A, B, C, or D applications.

NEMA Type 9:
Indoor Use in Hazardous Applications
Used in Class 2, Division 1, Groups E, F, or G applications.

NEMA Type 10:
Mine Use
Meets the requirements of the mine safety and health administration, 30 FR, Part 18.

NEMA Type 11:
Indoor Use
Intended to provide corrosion resistance and protection during oil immersion.

NEMA Type 12:
Indoor Use
Intended to provide protection against entry of dust, dirt, and dripping water. Should provide protection against non-corrosive liquids.

NEMA Type 13:
Indoor Use
Intended to provide protection against entry of dust, dirt, and dripping water. Should provide protection against non-corrosive liquids.

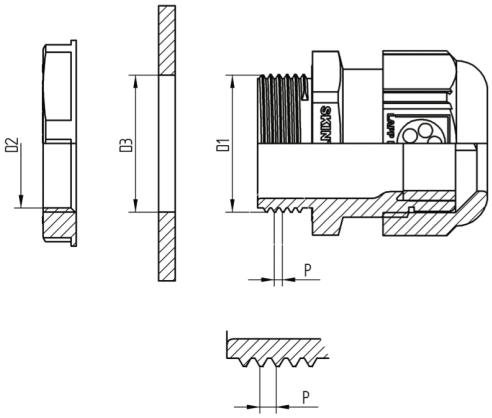
NEMA Ratings Applied to EPIC® Connectors

NEMA 4: Standard gray coating

NEMA 4X: Black coating

Threading Dimensions

For SKINTOP® Cable Glands



NPT Thread Technical Data for Assembly ASA B2.1-1945

Thread Size	D1 Core Diameter (inches)	D1 Core Diameter (mm)	P Pitch (inches)	P Pitch (mm)	D3 Nominal Thread Bore Diameter (inches)	D3 Nominal Thread Bore Diameter (mm)
NPT ¼"	0.539	13.7	0.055	1.41	0.556 - 0.008	14.1 - 0.2
NPT ⅜"	0.673	17.1	0.055	1.41	0.685 - 0.008	17.4 - 0.2
NPT ½"	0.839	21.3	0.071	1.81	0.851 - 0.008	21.6 - 0.2
NPT ¾"	1.051	26.7	0.071	1.81	1.063 - 0.008	27.0 - 0.2
NPT 1"	1.315	33.4	0.087	2.21	1.327 - 0.008	33.7 - 0.2
NPT 1¼"	1.662	42.2	0.087	2.21	1.674 - 0.008	42.5 - 0.2
NPT 1½"	1.903	48.3	0.087	2.21	1.918 - 0.008	48.7 - 0.2
NPT 2"	2.375	60.3	0.087	2.21	2.391 - 0.008	60.7 - 0.2

PG Thread Technical Data for Assembly DIN 40430

Thread Size	D1 Core Diameter (inches)	D1 Core Diameter (mm)	P Pitch (inches)	P Pitch (mm)	D2 Outside Diameter (inches)	D2 Outside Diameter (mm)	D3 Nominal Thread Bore Diameter (inches)	D3 Nominal Thread Bore Diameter (mm)
PG 7	0.492	12.5	0.050	1.27	0.445	11.3	0.504 - 0.008	12.8 - 0.2
PG 9	0.598	15.2	0.055	1.41	0.547	13.9	0.611 - 0.008	15.5 - 0.2
PG 11	0.732	18.6	0.055	1.41	0.681	17.3	0.745 - 0.008	18.9 - 0.2
PG 13	0.803	20.4	0.055	1.41	0.752	19.1	0.816 - 0.008	20.7 - 0.2
PG 16	0.886	22.5	0.055	1.41	0.835	21.2	0.898 - 0.008	22.8 - 0.2
PG 21	1.115	28.3	0.063	1.59	1.055	26.8	1.127 - 0.008	28.6 - 0.2
PG 29	1.457	37.0	0.063	1.59	1.398	35.5	1.474 - 0.012	37.4 - 0.3
PG 36	1.851	47.0	0.063	1.59	1.792	45.5	1.868 - 0.012	47.4 - 0.3
PG 42	2.127	54.0	0.063	1.59	2.068	52.5	2.143 - 0.012	54.4 - 0.3
PG 48	2.336	59.3	0.063	1.59	2.277	57.8	2.352 - 0.012	59.7 - 0.3

Metric Thread Technical Data for Assembly, EN 60423 (for cable glands EN 50 262)

Thread Size	D1 Core Diameter (inches)	D1 Core Diameter (mm)	P Pitch (inches)	P Pitch (mm)	D2 Outside Diameter (inches)	D2 Outside Diameter (mm)	D3 Nominal Thread Bore Diameter (inches)	D3 Nominal Thread Bore Diameter (mm)
M12 x 1.5	0.472	12.0	0.059	1.50	0.417	10.6	0.484 - 0.008	12.3 - 0.2
M16 x 1.5	0.630	16.0	0.059	1.50	0.575	14.6	0.642 - 0.008	16.3 - 0.2
M20 x 1.5	0.788	20.0	0.059	1.50	0.732	18.6	0.799 - 0.008	20.3 - 0.2
M25 x 1.5	0.985	25.0	0.059	1.50	0.929	23.6	0.996 - 0.008	25.3 - 0.2
M32 x 1.5	1.260	32.0	0.059	1.50	1.205	30.6	1.272 - 0.008	32.3 - 0.2
M40 x 1.5	1.576	40.0	0.059	1.50	1.520	38.6	1.591 - 0.012	40.4 - 0.3
M50 x 1.5	1.970	50.0	0.059	1.50	1.914	48.6	1.985 - 0.012	50.4 - 0.3
M63 x 1.5	2.482	63.0	0.059	1.50	2.427	61.6	2.497 - 0.012	63.4 - 0.3
M75 x 1.5	2.955	75.0	0.059	1.50	2.899	73.6	2.969 - 0.012	75.4 - 0.3
M90 x 2.0	3.546	90.0	0.078	2.00	3.498	88.8	3.559 - 0.012	90.4 - 0.3
M110 x 2.0	4.334	110.0	0.078	2.00	4.286	108.8	4.347 - 0.012	110.4 - 0.3

Tightening Values

Tightening Torque for Metric Cable Glands

Metric SKINTOP® recommended tightening torque for attainment of protection category IP68, 5 bar and strain relief category A acc. to EN 50262.

Given values are tightening torques for the intermediary, as well as maximum tightening torques for the cap nuts. To prevent damage to the outer sheath, please note that different cable materials require various torques.

Not for SKINTOP® ATEX glands.

Metric Thread Size	Tightening Torque (Nm)	
	Polymer	Metal
M12 x 1.5	1.5	8.0
M16 x 1.5	3.0	10.0
M20 x 1.5	6.0	12.0
M25 x 1.5	8.0	12.0
M32 x 1.5	10.0	18.0
M40 x 1.5	13.0	18.0
M50 x 1.5	15.0	20.0
M63 x 1.5	16.0	20.0
M63 x 1.5 Plus	–	25.0
M75 x 1.5	–	30.0
M90 x 2	–	45.0
M110 x 2	–	55.0

Tightening Torque for NPT & PG Cable Glands

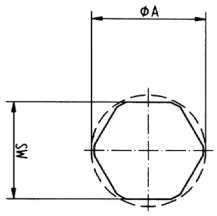
NPT & PG SKINTOP® recommended tightening torque for protection in acc. with DIN/VDE 0619, Point 7.

Given values are tightening torques for the intermediary, as well as maximum tightening torques for the cap nuts. To prevent damage to the outer sheath, please note that different cable materials require various torques.

NPT Thread Size	PG Thread Size	Tightening Torque for Intermediary (Nm)		Tightening Torque for Cap Nut (Nm)	
		Polymer	Metal	Polymer	Metal
–	PG 7	3.0	6.25	1.7	6.25
NPT ⅜"	PG 9	4.0	6.25	2.5	6.25
–	PG 11	4.0	6.25	2.5	6.25
NPT ½"	PG 13	4.0	6.25	2.5	6.25
–	PG 16	6.0	7.50	3.3	7.50
NPT ¾"	PG 21	8.0	10.00	5.0	10.0
NPT 1"	PG 29	13.0	10.00	5.0	10.0
–	PG 36	13.0	10.00	5.0	10.0
–	PG 42	13.0	10.00	5.0	10.0
–	PG 48	13.0	10.00	5.0	10.0

Fitting Dimensions & Widths Across Flats

The diameter SW indicates the wrenching flats. The diameter A indicates the assembly space required for the relevant hexagon. This diameter corresponds to the width across the corner of the hexagon, plus an assembly tolerance.



SW Wrenching Flats (inches)	SW Wrenching Flats (mm)	øA Assembly Space (inches)	øA Assembly Space (mm)	SW Wrenching Flats (inches)	SW Wrenching Flats (mm)	øA Assembly Space (inches)	øA Assembly Space (mm)	SW Wrenching Flats (inches)	SW Wrenching Flats (mm)	øA Assembly Space (inches)	øA Assembly Space (mm)
0.354	9.0	0.409	10.4	1.063	27.0	1.205	30.6	1.812	46.0	2.068	52.5
0.433	11.0	0.492	12.5	1.103	28.0	1.252	31.8	1.851	47.0	2.068	52.5
0.512	13.0	0.587	14.9	1.142	29.0	1.280	32.5	1.970	50.0	2.297	58.3
0.551	14.0	0.630	16.0	1.182	30.0	1.339	34.0	2.088	53.0	2.364	60.0
0.590	15.0	0.673	17.1	1.260	32.0	1.426	36.2	2.127	54.0	2.403	61.0
0.630	16.0	0.717	18.2	1.300	33.0	1.465	37.2	2.167	55.0	2.442	62.0
0.669	17.0	0.764	19.4	1.418	36.0	1.595	40.5	2.245	57.0	2.537	64.4
0.709	18.0	0.803	20.4	1.457	37.0	1.635	41.5	2.364	60.0	2.659	67.5
0.748	19.0	0.866	22.0	1.536	39.0	1.733	44.0	2.521	64.0	2.846	72.3
0.787	20.0	0.894	22.7	1.576	40.0	1.780	45.2	2.561	65.0	2.880	73.1
0.945	24.0	1.075	27.3	1.615	41.0	1.816	46.1	2.600	66.0	2.935	74.5
0.984	25.0	1.118	28.4	1.654	42.0	1.851	47.0	2.639	67.0	2.935	74.5
1.024	26.0	1.162	29.5	1.773	45.0	2.017	51.2				

ATEX

Electric Systems in Areas with Risk of Explosions: Directive 94/9/CE

The ATEX directive 94/9/CE applies to all products for systems designed to be used in explosive atmospheres. ATEX stands for **AT**mosphere **EX**plosive 94/9/CE (year/number/European Community). It defines the requirements for protecting the safety and health of people, pets, and property, and states the various procedures to be followed for demonstrating the conformity of devices to the directive's requirements.

An "explosive environment" means a mixture of air and flammable substances (gas, vapors, mists, or dusts) at ambient temperature and pressure which rapidly combusts when it comes in contact with a source of ignition.

Components conforming to ATEX safety requirements should be used in all hazardous areas with a risk of explosions. The risk is divided into three levels, each of which has a particular construction category:

- **Category 1** covers the level of maximum risk (areas 0 & 20)
- **Category 2** covers the highest risk level (areas 1 & 21)
- **Category 3** covers the "normal" risk level (areas 2 & 22)

All community laws impose the maximum possible levels of protection against the formation of explosive atmospheres, so that only areas 2 and 22 should exist in "normal" conditions. A number of different methods of protection can be employed. The protection method used should be clearly marked on the device. ATEX SKINTOP® glands conform to protection method "e" (increased safety), which consists of taking provisions to prevent the formation of hot-spots.

Protection modes: Ex n

Protection method Ex n is fundamentally based on provisions for prevention and is divided into two main categories.

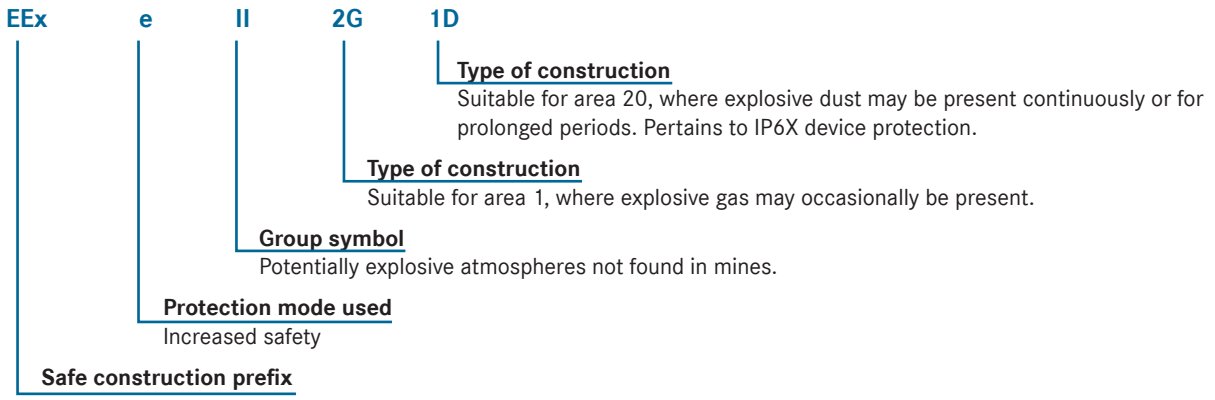
The category applicable to SKINTOP® products is EEx nA. It is applicable to non-sparking appliances, namely those that do not produce arcs, sparks, or hot-spots during normal operation, e.g.: junction & connector boxes, fuse holders, lighting appliances, etc. The nA category bases the protection criteria on increased safety provisions. Those that apply to SKINTOP® glands are as follows:

- protection levels suitable for the environment
- possible loss-proof gaskets
- recommended minimum resistance of the enclosure to impacts: 5J (> IK08)
- resin housings with adequate resistance to temperature and surface current effects
- the maximum temperature of any surface in contact with the outside air must not exceed the limits acceptable to the temperature class

ATEX Compliance Marking

ATEX-compliant products must be clearly marked to show the specifics of the compliance. Products may be marked in several different ways. There can be a combined gas/dust marking, or gas and dust can be marked separately. The ATEX construction symbol (Ex) may be used instead of the Safe Construction Prefix.

A combined mark for ATEX SKINTOP® would be:



An alternate marking (using separate gas/dust markings and the ATEX construction symbol) would be:

Ex II 2G Ex II 1D IP6X

Chemical Resistance of Plastics

– **Not tested**
⛒ **High resistance** no to slight reaction
✖ **Limited resistance** slight to moderate reaction
✖ **No resistance** moderate to strong reaction

Reagent	Concentration	at °C	Polyamide PA 6	Polyamide PA 6.6	Polyamide PA 12	Thermoplastic polyurethane PU	Polypropylene PP	Polyethylene HD-PE	Polyethylene LD-PE	Polystyrene PS	Nitrile butadiene rubber NBR
Exhaust gases containing CO_2	all	60	–	–	–	–	–	⛒	⛒	–	–
Exhaust gases containing SO_2	low	60	–	–	–	–	–	⛒	⛒	–	–
Acetaldehyde	40%	20	✖	✖	⛒	–	⛒	–	–	–	20°C ⛒
Acetone	100%	20	⛒	⛒	⛒	✖	⛒	✖	✖	–	✖
Acrylic acid	100%	> 30	✖	✖	✖	–	–	–	–	–	✖
Alums, aqueous	diluted	40	–	–	–	–	⛒	⛒	⛒	⛒	20°C ⛒
Allyl alcohol	96%	20	✖	✖	⛒	⛒	⛒	⛒	20% ⛒	–	–
Aluminum chloride, aqueous	diluted	40	–	–	–	–	⛒	⛒	⛒	⛒	20°C ⛒
Aluminum sulfate, aqueous	diluted	40	–	–	–	–	⛒	⛒	⛒	⛒	20°C ⛒
Formic acid, aqueous	10%	20	✖	✖	⛒	–	⛒	⛒	–	⛒	–
Ammonia, aqueous	saturated	20	20% ⛒	20% ⛒	20% ⛒	–	⛒	⛒	⛒	25% ⛒	–
Ammonium chloride, aqueous	saturated	60	–	–	–	3% ✖	⛒	⛒	⛒	–	20°C ⛒
Ammonium nitrate, aqueous	diluted	40	–	–	–	–	⛒	⛒	⛒	⛒	20°C ⛒
Ammonium sulfate, aqueous	diluted	40	–	–	–	–	⛒	⛒	⛒	–	✖
Aniline, pure	100%	20	✖	✖	✖	–	⛒	⛒	⛒	✖	–
Aniline hydrochloride, aqueous	saturated	–	–	–	–	–	⛒	✖	✖	–	–
Benzaldehyde, aqueous	saturated	20	pure ✖	pure ✖	pure ✖	–	⛒	–	–	✖	✖
Benzine	100%	20	⛒	⛒	⛒	–	✖	✖	✖	✖	✖
Benzoic acid, aqueous	all	40	20% ✖	20% ✖	–	–	⛒	⛒	⛒	⛒	✖
Benzole	100%	20	⛒	⛒	⛒	–	✖	✖	✖	✖	✖
Bleach liquor	12.5 Cl	20	✖	✖	✖	3% ✖	⛒	⛒	⛒	✖	–
Drilling oil	all	20	✖	✖	✖	–	✖	✖	✖	✖	✖
Chrome alum, aqueous	diluted	40	–	–	–	–	⛒	⛒	⛒	–	20°C ⛒
Cyclohexanol	–	20	⛒	⛒	⛒	–	⛒	⛒	⛒	⛒	⛒
Diesel fuel	–	85	⛒	⛒	⛒	20°C ⛒	20°C ⛒	20°C ⛒	20°C ⛒	–	–
Ferric chloride, aqueous, neutral	10%	20	⛒	⛒	⛒	–	⛒	⛒	⛒	⛒	⛒
Glacial acetic acid	100%	20	–	–	–	–	⛒	⛒	⛒	–	✖
Acetic acid	10%	20	✖	✖	⛒	3% ✖	⛒	⛒	⛒	✖	–
Ethyl alcohol, aqueous	10%	20	40 vol% ⛒	40 vol% ⛒	40 vol% ⛒	–	–	⛒	–	⛒	–
Ethylene chloride	100%	20	–	–	–	–	✖	✖	✖	–	✖
Ethylene oxide	100%	20	–	–	–	–	✖	–	–	–	–
Ethyl ether	100%	20	–	–	–	–	✖	–	–	–	✖
Potassium ferrocyanide, aqueous	saturated	60	–	–	–	–	⛒	⛒	⛒	–	–
Fluorine	50%	40	pure ✖	pure ✖	pure ✖	✖	✖	✖	–	–	–
Formaldehyde, aqueous	diluted	40	pure ⛒	pure ⛒	pure ✖	–	40% ⛒	40% ⛒	40% ⛒	30% ⛒	20°C ✖
Glucose, aqueous	all	50	–	–	–	–	⛒	⛒	⛒	–	–
Urea, aqueous	up to 10%	40	20% ⛒	20% ⛒	20% ⛒	–	⛒	⛒	⛒	⛒	–
Flame-retardant hydraulic fluid	–	80	⛒	⛒	⛒	–	–	–	–	–	–
Hydraulic oils H & HL (DIN 51524)	–	100	⛒	⛒	⛒	–	–	–	–	–	–
Hydroxylamine sulfate, aqueous	up to 12%	30	–	–	–	–	⛒	–	–	–	–
Caustic potash, aqueous	50%	20	⛒	⛒	⛒	–	⛒	⛒	⛒	⛒	–
Potassium bromide, aqueous	all	20	10% ⛒	10% ⛒	10% ⛒	–	⛒	⛒	⛒	⛒	–
Potassium chloride, aqueous	10%	20	⛒	⛒	⛒	–	⛒	⛒	⛒	⛒	⛒
Potassium dichromate, aqueous	40%	20	5% ✖	5% ✖	5% ✖	–	⛒	⛒	⛒	–	⛒
Potassium nitrate, aqueous	all	20	10% ⛒	10% ⛒	10% ⛒	–	⛒	⛒	⛒	⛒	⛒
Potassium permanganate, aqueous	saturated	20	–	–	–	–	⛒	–	–	⛒	–
Hydrosilicofluoric acid, aqueous	up to 30%	20	✖	✖	–	–	⛒	⛒	⛒	–	–

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However, it must be treated as a non-binding guideline only; in many cases, tests must be carried out under working conditions to reach a definitive conclusion.

Chemical Resistance of Plastics

– **Not tested**
⛒ **High resistance** no to slight reaction
✖ **Limited resistance** slight to moderate reaction
✖ **No resistance** moderate to strong reaction

Reagent	Concentration	at °C	Polyamide PA 6	Polyamide PA 6.6	Polyamide PA 12	Thermoplastic polyurethane PU	Polypropylene PP	Polyethylene HD-PE	Polyethylene LD-PE	Polystyrene PS	Nitrile butadiene rubber NBR
Carbon dioxide, dry	100%	60	–	–	–	–	⛒	⛒	⛒	50°C ⛒	20°C ⛒
Carbonic acid	100%	60	⛒	⛒	⛒	–	–	–	–	–	20°C ⛒
Cresylic acid, aqueous	up to 90%	20	pure ✖	pure ✖	–	–	⛒	⛒	✖	✖	✖
Coolant (DIN 53521)	–	120	✖	✖	–	–	–	–	–	–	–
Copper chloride, aqueous	saturated	20	–	–	–	–	⛒	⛒	⛒	–	⛒
Copper sulfate, aqueous	saturated	60	–	–	–	–	⛒	⛒	⛒	–	20°C ⛒
Magnesium carbonate, aqueous	saturated	100	–	–	–	–	⛒	–	–	50°C ⛒	–
Magnesium chloride, aqueous	saturated	20	10% ⛒	10% ⛒	10% ⛒	–	⛒	⛒	⛒	⛒	⛒
Methyl alcohol	100%	20	⛒	⛒	⛒	–	40°C ⛒	⛒	⛒	⛒	⛒
Methylene chloride	100%	20	✖	✖	✖	–	✖	✖	✖	–	–
Lactic acid, aqueous	up to 90%	20	10% ⛒	10% ⛒	10% ⛒	3% ✖	⛒	⛒	⛒	80% ⛒	⛒
Mineral oil	–	–	⛒	⛒	⛒	–	20°C ⛒	20°C ⛒	20°C ⛒	–	–
Sodium chlorate, aqueous	saturated	20	10% ✖	10% ✖	10% ✖	–	⛒	⛒	⛒	–	–
Sodium hydroxide, aqueous	10%	20	⛒	⛒	⛒	3% ✖	⛒	⛒	⛒	⛒	–
Nickel chloride, aqueous	saturated	20	10% ✖	10% ✖	10% ✖	–	⛒	–	–	⛒	⛒
Nickel sulfate, aqueous	saturated	20	10% ✖	10% ✖	10% ✖	–	⛒	⛒	⛒	–	⛒
Nitroglycerin	diluted	20	–	–	–	–	–	✖	✖	–	–
Oil and grease	–	20	⛒	⛒	⛒	–	✖	–	–	–	–
Oleic acid	–	20	⛒	⛒	⛒	–	⛒	⛒	⛒	⛒	✖
Oxalic acid	all	20	10% ✖	10% ✖	10% ✖	3% ✖	⛒	⛒	⛒	⛒	✖
Ozone	pure	–	✖	✖	✖	–	✖	✖	✖	–	–
Petroleum	100%	80	⛒	⛒	⛒	–	20°C ⛒	20°C ⛒	20°C ✖	✖	–
Phosgene, gaseous	100%	20	–	–	–	–	✖	✖	✖	–	–
Phosphoric acid, aqueous	diluted	20	10% ✖	10% ✖	10% ✖	3% ✖	⛒	⛒	⛒	86% ⛒	✖
Phosphorus pentoxide	100%	20	–	–	–	–	⛒	–	–	–	–
Mercury	pure	20	⛒	⛒	⛒	–	⛒	⛒	⛒	⛒	⛒
Nitric acid, aqueous	50%	20	✖	✖	✖	3% ✖	✖	✖	✖	30% ⛒	✖
Hydrochloric acid, aqueous	30%	20	20% ✖	20% ✖	20% ✖	3% ✖	⛒	⛒	⛒	15% ⛒	✖
Lubricating grease, ester oil base	–	110	✖	✖	–	–	–	–	–	–	–
Polyphenyl, ester base	–	110	⛒	⛒	⛒	–	–	–	–	–	–
Lubricating grease, silicone oil base	–	110	⛒	⛒	⛒	–	–	–	–	–	–
Carbon disulfide	100%	20	⛒	⛒	⛒	–	⛒	✖	✖	✖	✖
Sodium sulfide, aqueous	diluted	40	–	–	–	–	⛒	⛒	⛒	–	–
Sulphuric acid, aqueous	10%	20	✖	✖	✖	3% ✖	50% ⛒	50% ⛒	50% ⛒	⛒	✖
Sea water	–	40	⛒	⛒	⛒	20°C ⛒	⛒	⛒	⛒	⛒	20°C ⛒
Soap solution, aqueous	all	20	diluted ⛒	diluted ⛒	diluted ⛒	⛒	⛒	⛒	–	⛒	–
Carbon tetrachloride	100%	20	⛒	⛒	⛒	–	✖	✖	✖	✖	–
Toluene	100%	20	⛒	⛒	⛒	✖	–	✖	✖	✖	✖
Trichloroethylene	100%	20	✖	✖	✖	–	✖	✖	✖	–	–
Vinyl acetate	100%	20	–	–	–	–	⛒	–	–	–	–
Hydrogen	100%	60	20°C ⛒	20°C ⛒	20°C ⛒	–	⛒	⛒	⛒	–	20°C ⛒
Xylene	100%	20	⛒	⛒	⛒	–	✖	✖	✖	✖	✖
Zinc chloride, aqueous	diluted	60	10% ✖	10% ✖	–	–	⛒	⛒	⛒	50°C ⛒	20°C ⛒
Zinc sulfate, aqueous	diluted	60	–	–	–	–	⛒	⛒	⛒	–	20°C ⛒
Zinc chloride, aqueous	diluted	40	–	–	–	–	⛒	⛒	⛒	✖	20°C ⛒
Citric acid	up to 10%	40	20°C ⛒	20°C ⛒	20°C ⛒	3% ✖	⛒	⛒	⛒	⛒	20°C ⛒

The information presented in this table is accurate to the best of our knowledge and experience.
However, it must be treated as a non-binding guideline only; in many cases, tests must be carried out under working conditions to reach a definitive conclusion.

Optimal Screening: Problems with the Use of Cable Glands

Article by U. Bochler (Dr.-Ing.) & M. Jacobsen (Dipl.-Ing.)

In industrial environments, motors, controls, and automatic welding machines can seriously impair electromagnetic compatibility (EMC). Particular problems are caused in industrial installations by long cable runs for power supply or data transmission between individual components; appropriate preventive measures are therefore essential.

Due to the antenna radiation effect of such cables, unwanted radio interference can be picked up, blanketing the useful signal. This results in functional disturbances in the connected equipment – from undetected false readings to the breakdown of an entire production line. Conversely, cables can function as transmitters, causing radio interference. Installing electronic components in an earthed switch cabinet with shielded cables has proven to be an effective countermeasure. In practice, however, the location of the cable duct frequently constitutes a weak point in the switch cabinet. Insufficient contact between the cable shielding and the metal housing often destroys the desired shielding effect. It is here that the SKINTOP® and SKINDICHT® cable glands from Lapp prove their worth. The newly developed SKINTOP® MS-SC-M and SKINTOP® MS-M BRUSH in particular are distinguished by their excellent EMC characteristics in addition to ease of handling. It enables the use of various different cable designs within a large diameter range.

Shielding concepts

With the interference phenomena typically found in the industrial environment, we must distinguish principally between cable-linked and field-linked interference. Field-linked interference emissions are either radiated directly from a circuit board or exercise an effect upon it, and can be effectively checked by installing electrical or electronic assemblies in closed metal housings such as switch cabinets. If the housing does not have any particularly large apertures, a Faraday shield is produced, which affords efficient protection against electromagnetic interference. In practice, this type of shielding is generally extremely expensive and is hardly practical in the case of moving machine components. Cables with a braided shield provide an alternative solution. In this case, the quality of the shielding depends to a great extent on the texture and thickness of the braiding. In addition, optimum attachment of the cable shield to the housing must be ensured by suitable mechanical elements in order to prevent penetration of the interference. This is where the bleeder resistance, which is the resistance that a wave faces when it hits the wall of the enclosure, plays a crucial role.

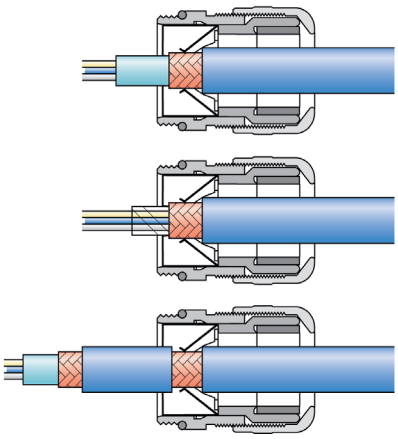
Practical requirements

To improve EMC, we have a series of practical requirements for optimum contact:

- The connection between the cable shield and the housing potential must be of low impedance. To ensure this, the contact surfaces must be as large as possible. Under ideal conditions the cable shield, together with the housing wall, constitute a closed connection and form a continuation of the housing, without permitting any openings to be formed.
- The connection must be of low induction. This means that the cable screening must be led to the housing wall via the shortest possible path and with the widest possible cross-section. Preferably a type of contact should be chosen which completely surrounds the internal conductor. The common attitude of figuring out where and how to ground a cable only after installing the cable into the housing makes effective shielding almost impossible.
- For practical application, simplicity of handling and installation are desirable. An electrician must be able to carry out installation without difficulty.

SKINTOP® and SKINDICHT®

Lapp's SKINTOP® and SKINDICHT® cable glands guarantee, in addition to perfect mechanical contact, the necessary low impedance and low induction connection.



These easy-to-install glands are available in different versions and sizes. With SKINDICHT® SHVE-M, the cable shield is pressed between an earthing sleeve and a conical seal, permitting 360° contact over a wide area. In the case of SKINTOP® MS-SC-M, the contact is produced by means of cylindrically arranged contact springs. The SKINTOP® MS-M BRUSH offers a 360° contact with an EMC brush. Only the cable sheathing in the area of the contact springs must be removed, and it is not necessary to open the screen braiding.

This article will focus on the SKINTOP® MS-SC-M. In a number of tests, excellent shielding properties were demonstrated. Since the appropriate standard for cable glands does not define a particular set-up of test equipment, two possible measuring procedures and their evaluation are described below:

- **Bleeder resistance & attenuation:**
  Bleeder resistance is being used as a parameter to assess the quality of the cable connection to the wall of the enclosure (reference potential). This provides information as to what extent charges on the cable shield can be derived against the potential of the housing. To determine the screen attenuation factor of a cable, the derivation attenuation is calculated: the potential at the derivation resistance is related to the maximum available potential in a 50 W reference system. The derivation attenuation is obtained as follows:

  aA (in dB) = 20 log (2RA / (2RA + 50 W)).

- **Triaxial method:**
  In the triaxial method, measurement is carried out in accordance with the German Defense Equipment Standard VG 95373 Pt 40 or 41.

  These set-ups employ a coaxial structure in a graduated tube (hence the term triaxial), and are designed for a male/female socket pair, or a piece of cable of defined length. The values of the screen attenuation mass aS and the coupling impedance ZK are determined for evaluation of the shielding effect of the connectors depending upon their material characteristics and their construction, according to the formula:

  AS = 20 log(50 W / ZK).

  In order to comply with the standards for measurement, the supply cable bring used must have a solid shield (usually this is accomplished with the help of conduit). However, this results in screen attenuation

Optimal Screening: Problems with the Use of Cable Glands

Article by U. Bochler (Dr.-Ing.) & M. Jacobsen (Dipl.-Ing.)

	Triaxial Method	Measurement of the Derivation Impedance
Application	Pairs of connectors and shielded cable	Cable glands
Measurement	Shield attenuation mass from which the interaction impedance is calculated	Derivation impedance is determined directly
Reference to later application	Description of how effectively re-radiation is suppressed by field-linked interference	Description of how effectively interference on the shield can be derived to an earthing mass (e.g.: wall of switch cabinet)

values of almost 100 dB; for practical applications on a switch cabinet wall, depending upon the conditions, these can be achieved only with difficulty or not at all.

- **Comparison of both methods:** In order to provide a description of practical use of the a/m products, the Measurement procedure of the derivation impedance and conversion into screen attenuation has been used (see table above).

Measurement Results

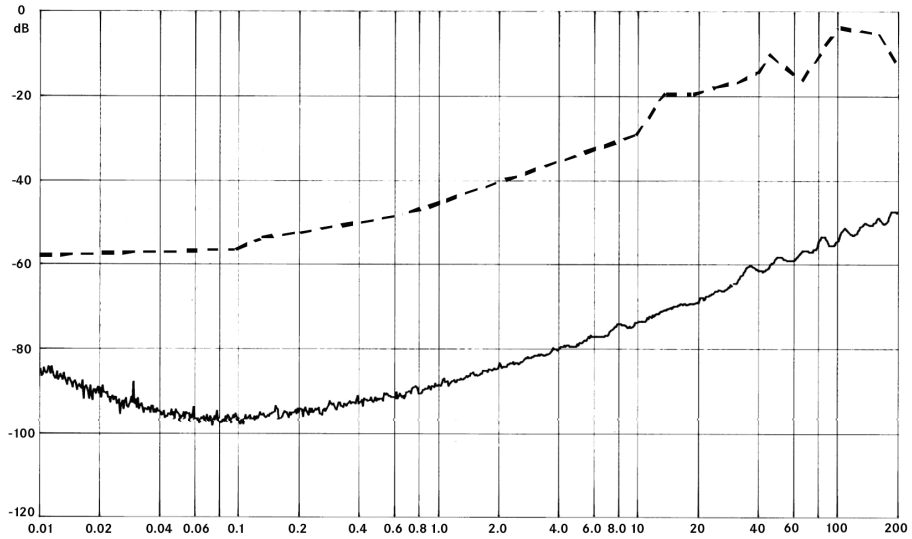
Measurements were taken using both methods with SKINTOP® MS-SC-M glands of various sizes with shielded ÖLFLEX® CY cable with diameters of 6 – 22 mm.

- **Measuring the derivation impedance:** In order to determine the derivation impedance, the cable glands were in each case connected to a piece of cable approx. 10 cm long. At frequencies up to 10 MHz, all glands reveal a derivation impedance of < 1W. This results in attenuation values of 30 – 50 dB (assuming a 50 W reference system). The amplitudes of disruptive high-frequency components located in this range are thus reduced by a factor of at least 30, at maximum 300. Only at frequencies above 3 – 4 MHz does the achievable attenuation sink to values < 40 dB (factor 100). At higher frequencies (100 MHz), derivation impedance values in the range of 5 - 10 W are obtained. The measurement values confirm the assumed favorable EMC characteristics. Even up to high frequencies, low derivation impedance – or high derivation attenuation values – can be obtained. With effective cable shielding, optimum protection against cable-conducted interference signals can be achieved.
- **Triaxial measurement:** Measurements were performed as described above, in accordance with the German Defense Equipment Standard VG 95373, Procedure KS 01 B. The DC resistance of the glands equals 1 mW; this produces shielding attenuation values, which, depending upon the size and type of the gland, can reach at least 100 dB.
- **Comparison of results:** The results reveal a clear difference between derivation attenuation and the screening attenuation in a system with identical components. The curve for derivation attenuation is nearly 40 dB higher than the screening attenuation curve (see chart below). Nevertheless, these values are more meaningful with regard to cable-conducted interference, because in reality, attenuation values of between 80 and 100 dB are rarely achieved.

Conclusion

The different measurement methods give different values for the attenuation rate and using these values, different characteristics are expressed. On the one hand, the value “screening attenuation” expresses how effectively the re-radiation or the irradiation is suppressed by field-linked interferences (Triaxial Method); the value “derivation attenuation”, on the other hand, expresses how effectively interferences on the screening can be derived to an earthing mass (measurement of derivation impedance). This means that attenuation values cannot simply be compared without further consideration. However, it can be assumed that since the triaxial method relies on cable shielding, results gained from the “derivation attenuation” method are more relevant for cable glands.

Comparison of Measurement Results:
derivation attenuation (dotted) vs. triaxial (solid)



SKINTOP® & SKINDICHT® Overview

	SKINTOP® SL/SLR	SKINTOP® SLM/SLRM	SKINTOP® CLICK/CLICK-R	SKINTOP® ST-HF-M	SKINTOP® SOLAR/SOLAR (plus)	SKINTOP® SLM FLEX	SKINTOP® SL FLEX/SLR FLEX	SKINTOP® SLN FLEX/SLRN FLEX	SKINTOP® SOLAR/SOLAR (plus)	SKINTOP® SLM FLEX	SKINTOP® SL FLEX/SLR FLEX	SKINTOP® SLN FLEX/SLRN FLEX	SKINTOP® CLICK FLEX	SKINTOP® BT/BT-M	SKINTOP® K-M/KR-M ATEX plus	SKINTOP® CUBE	SKINTOP® MS-NPT/MSR-NPT	SKINTOP® MS/MSR	SKINTOP® MS-M/MSR-M	SKINTOP® MS-M-XL/MSR-M-XL	SKINTOP® MS-M ATEX/MSR-M ATEX	SKINTOP® INOX/INOX-R	SKINTOP® COLD/COLD-R	SKINTOP® MS-SC NPT	SKINTOP® MS-M BRUSH
page	508	509	510	511	512	513	513	513	512	513	513	513	514	515	516	518	520	521	523	524	525	526	527	528	530
Properties																									
IP protection rating/NEMA	68	*	68	68	68	68	68	68	68	68	68	68	68	68	68	64	68	68	*	*	68	*	68	68	*
NPT thread								✔				✔					✔							✔	
PG thread	✔						✔				✔			✔				✔							
Metric thread		✔		✔	✔	✔			✔	✔				✔	✔				✔	✔	✔	✔	✔		✔
For round cables	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
For flat cables																									
Metal													✔				✔	✔	✔	✔	✔	✔	✔	✔	✔
Plastic	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔									
Angled																									
Strain relief	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Vibration protection	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔									
Anti-kink protection						✔	✔	✔		✔	✔	✔	✔	✔											
Shield connection																								✔	✔
Suitable for Ex safety area															✔						✔				
Halogen-free				✔																					
Approvals																									
UL	✔				✔		✔		✔		✔						✔							✔	
cULus		✔	✔			✔				✔			✔						✔	✔	✔				✔
UR	✔				✔		✔		✔		✔						✔							✔	
cURus		✔	✔			✔				✔			✔						✔	✔	✔				
CSA	✔				✔		✔		✔		✔						✔							✔	
TÜV	✔	✔																							
VDE		✔	✔	✔		✔				✔			✔						✔	✔			✔		✔
DNV		✔	✔			✔				✔			✔		✔				✔	✔	✔				✔
ATEX															✔						✔				

* IP68/69K

	SKINDICHT® CN/CN-M	SKINDICHT® SVRE	SKINDICHT® SVRE-M	SKINDICHT® SH	SKINDICHT® SHZ	SKINDICHT® SHZ-M	SKINDICHT® SK	SKINDICHT® SKZ	SKINDICHT® SKZ-M	SKINDICHT® SHV	SKINDICHT® SHV-M	SKINDICHT® SHVE	SKINDICHT® SHVE-M	SKINDICHT® SR	SKINDICHT® SR-M	SKINDICHT® RWV	SKINDICHT® SVF	SKINDICHT® SVFK
page	531	532	532	533	534	534	535	536	536	537	538	539	539	541	541	543	143	143
Properties																		
IP protection rating/NEMA	68	54	54	20	55	55	20	55	55	68	68	68	68	65	65	55	54	54
NPT thread																		
PG thread	✔	✔		✔	✔		✔	✔		✔		✔		✔		✔	✔	✔
Metric thread	✔		✔			✔			✔		✔		✔		✔		✔	
For round cables	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		
For flat cables																	✔	✔
Metal	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
Plastic																		✔
Angled																✔		
Strain relief	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
Vibration protection																		
Anti-kink protection														✔	✔			
Shield connection												✔	✔					
Suitable for Ex safety area																		
Halogen-free																		

The information presented in these tables is accurate to the best of our knowledge and experience. However, it must be treated as a non-binding guideline only; in many cases, tests must be carried out under working conditions to reach a definitive conclusion