1. General

The **resistance** of the product materials in the application environment, correct product assembly and subjected load in the context of permitted limit values (technical data) have a significant impact on the safety and durability of our products. Notes on product usage and technical data can primarily be found on the catalogue product pages, both in the text sections and the tables provided.

Selection tables A1–A15 provide an overview of similar products and enable comparisons on the basis of important product properties (e.g. "permitted temperature range", "permitted bending radius") and main application parameters (e.g. "outdoor use, unprotected"), thus facilitating the selection process.

The "**technical tables**" (T1–T31) focus on the following:

- Chemical resistance (T1, T24), radiation resistance (T28), weather and oil resistance (T15)
- Assembly of Profibus and Industrial Ethernet cables (T2), assembly of cables for power chains (T3), assembly of cables for conveyor technology (T4, T5)
- Assembly/installation/fastening of cables in special cases (T19)
- Assembly, thread dimensions and tightening torques of cable glands (T21)
- Electrical load capacity, conversion factors, installation type according to VDE, Germany (T12)
- Electrical load capacity, installation type according to NEC, USA (T13)
- Load capacity with regard to thermal stress and tensile strain (T19)
- Conductor cross-sections with different measurement systems (T16)

This and the following information on special product groups/topics represent guidelines on the use and application of our products, but do not cover the competent project planning of electrical equipment in all its aspects.

Cables might contain talc which as with most dusts or particulate materials can cause temporary discomfort and skin irritation due to allergic reaction.

Questions?

Contact us; we are happy to help: **info@lappkabel.de**

2. Cables and wires

The applications of cables and wires are extremely diverse and thus governed by a whole range of application standards in the various standard groups (IEC, EN, NEC, ...).
One example is the international standard IEC 60204-1:2009, Electrical equipment of machines – Part 1: General requirements) with reference to the requirements of cables and wires as well as their application conditions.

In all cases, meeting these **general** specifications requires the user to perform a professional examination as to the existence of **specific** product standards with other/extended requirements that may take precedence.

In this case, support is provided by the catalogue product pages in the form of product and application standards – e.g. "Oil resistance according to VDE 0473-811" or "Railway applications: DIN EN 50306-2". In the area of low voltage harmonised cables (e.g. H05VV5-F/ÖLFLEX® 140), DIN EN 50565-2 (VDE 0298-565-2) in table 1A provides a list of requirements and criteria that are largely applicable to other low voltage cables as well as notes on recommended applications.

In addition, the application information provided in IEC publication 62440:2008-02 Ed. 1.0 must be observed for electrical cables with nominal voltages up to 450/750 V.

A summary of the most important information on cable and wire applications contained in the aforementioned documents is provided below.

General

Conductors, cables and wires must be selected such that they are suitable for the relevant operating conditions (e.g. voltage, current, protection against electric shock, bundling of cables and wires) and external influences (e.g. ambient temperature, presence of water or corrosive materials, mechanical stress, incl. stress experienced during installation, fire risks).

Electrical voltage

The control and connecting cables listed in the catalogue are subject to the **"low voltage directive" 2014/35/EU for electrical equipment with a nominal voltage between 50 and 1000 V (alternating current) and between 75 and 1500 V (direct current)**.

The nominal voltage is the reference voltage for which cables and wires are constructed and tested. The nominal voltage of cables and wires used with AC supplies must be greater than or equal to the nominal supply voltage. More information for DC supply or operating voltage in Europe can be found in EN 50565-1 for harmonized cable types and in VDE 0298-3 for cable types without harmonization, for example.

The nominal voltage of cables and wires is expressed by the ratio U_0/U in volts, whereby:

- **U_0** is the effective voltage between a phase conductor and the earth (metal sheath/screening of the cable/surrounding medium/protective grounding conductor)
- **U** is the effective voltage between two phase conductors of a multi-core cable or a system of single core cables

For cables and wires subjected to voltages over 50 V AC or 120 V DC, the test voltage is a minimum of 2000 V AC for a duration of 5 minutes. For alternating currents with a maximum of 50 V and direct currents with a maximum of 120 V (typical values for SELV or PELV systems), the test voltage must be a minimum of 500 V AC for a duration of 5 minutes.

2. Cables and wires – continued

Explosive atmospheres

The family of standards IEC 60079-14 →DIN EN 60079-14 →VDE 0165-1, Oct 2014 is also applicable in the development and selection of cables and wires for explosive atmospheres.

1. **Quotation from standard VDE 0165-1, 1. Scope**
   "This part of the IEC 60079 series contains the specific requirements for the design, selection, erection and the initial inspection of electrical installations in, or associated with, explosive atmospheres."
2. **Quotation from standard VDE 0165-1, 4.5 Qualifications of personnel**
   "The design of the installation, the selection of equipment and the erection covered by this standard shall be carried out only by persons whose training has included instruction on the various types of protection and installation practices, relevant rules and regulations and on the general principles of area classification. The competency of the person shall be relevant to the type of work to be undertaken. (see Annex A)."
3. **The normative Annex A** describes the necessary knowledge/competencies for the persons responsible. (This includes, for example, considerations of the equipment design and its impact on the protection concept.) LAPP is pleased to provide details about its range of catalogue items and their properties. In terms of the required competencies for the development, selection and erection of explosion-protected equipment and installations, the responsibility for the correct use of the item shall lie with the ordering party.
4. **VDE 0165-1, 9.3.2 Cables and wires for fixed installation**
   These are generally cables and wires which are equipped with a solid conductor and with an extruded filler material that occupies the intermediate spaces of the core. Examples include the types NYY, NAYY, NYM, (N)HXMH.
   If there is a possibility of longitudinal expansion of a liquid or a gas medium inside a cable or wire where this is not permitted, then the use of suitable Ex "d" cable entries on the equipment is an approved alternative. See also VDE 0165-1, Annex E.
5. **VDE 0165-1, 9.3.3 Flexible cables and wires for fixed installation**
   These cables and wires normally do not contain any extruded filler material. Examples include rubber cables such as H07RN-F and NSSHÖU or plastic-insulated cables with resistant (VDE 0165-1, 9.3.3 e) designs such as ÖLFLEX® 540P (or similar). Connecting cables with a comparably robust structure are also used with mobile and portable equipment. See also DIN VDE 0165-1, 9.3.4.

DIN VDE 0298-3:2006-06, tables 4 and 5 display further standard-compliant cables and cable designs which are suitable for use in explosive atmospheres.

Conductor cross-sections with different measurement systems

IEC 60228 is an important international standard that describes cables with metric cross-sections. North America and other regions currently employ conductor cross-sections according to the AWG (American Wire Gauge) system with kcmil" used for larger cross-sections. A table is provided under T16 to support safe, alternative usage of cables from both these measurement systems.

Tensile strain

The following applies to **all** conductors up to maximum tensile strain of 1000 N: Max. 15 N per mm² conductor cross-section (excl. screening, concentric conductors and divided protective conductors) for static tensile strain when **using** moving/flexible cables and cables for/in fixed installation. Max. 50 N per mm² conductor cross-section (excl. screening, concentric conductors and divided protective conductors) for static tensile strain when **assembling** cables for/in fixed installation.

Flexible use – stationary use/Definitions

- **Continuous Flexing**
  Cables are in constant linear motion in automated applications. They are subjected to continuous forces applied during bending motions.
  Typical application:
  Horizontal and vertical c-tracks power chains, automated assemblies, etc.
- **Flexible/occasional flexing**
  Cables are moved randomly in a non-automated application.They are susceptible to occasional uncontrolled conditions of movement.
  Typical application:
  Flexible cable tray routings, machine tools, residential electronics, portable power equipment, etc.
- **Stationary use/fixed installation**
  Cables are installed and left in their original position. They are only moved for purposes of maintenance, repair or retrofitting.
  Typical application:
  Cable trays, conduits, wire ways installed in buildings, machines, manufacturing facilities, etc.

Cables for use in power/drag chains

These cables are indicated by the code "FD" or "CHAIN" in their product names. In addition to the generally applicable information on assembly and project planning contained in technical table T3, particular attention must be paid to the specifications relating to individual cables that are provided on the relevant product pages in the catalogue.

These are specifically:

- Restrictions of the traversing path length (e. g.: "... up to 10 m").
- Restrictions of the minimum bending radius for flexible applications. The radius implemented with the power/drag chain must not be lower than the minimum bending radius! The minimum bending radius is defined as the inner radius relative to the surface of the curved cable.
- Restrictions at operating temperature. The specified temperature range shall be observed and must not be undershot or exceeded. Flexible cable operation at lower and upper temperature range limit can lead to reduced service life.

Torsion movement in wind turbine generators

The torsional motion of wind turbines is very different from those in robotic applications. In comparison to the quick, highly dynamic movements of robots, the motion in the loop between the nacelle and tower of a wind turbine is slow. Moreover, the rotation of the cable on its axis about 150° per 1 m cable and the rotational speed with 1 revolution per minute is less than usual robotic applications. To confirm these requirements, our cables are tested in our in-house testing facility. To take the different materials into account, different tests are performed in order to achieve meaningful results even at the temperature resistance of the cables.

Based on the test results the cables are classified to the LAPP-internal rating for torsion in wind turbine generators which is adapted to the requirements of leading manufacturers of wind turbines:

	Number of cycles	Temperature range	Torsion angle
TW-0	5.000	≥ +5 °C	± 150 °/1 m
TW-1	2.000	≥ -20 °C	± 150 °/1 m
TW-2	2.000	≥ -40 °C	± 150 °/1 m

2. Cables and wires – continued

Transport and storage

Cables and wires that are **not** designated for outdoor use must be stored indoors, in dry conditions and protected from direct sunlight. If stored outside, all cable and wire ends must be sealed to prevent the ingress of water.

The ambient temperature for transport and storage must be between -25 °C and +55 °C (max. +70 °C for no longer than 24 hours).

Particularly in the lower temperature ranges, mechanical stress through vibration, shock, bending and twisting must be avoided. This is especially important for PVC-insulated cables and wires. The following guidelines apply for the maximum storage of cables and wires before use and without prior testing:

- One year if stored outdoors
- Two years if stored indoors

3. Industrial connectors

For Industrial Connectors please see (NEW) Technical Table T31.

4. Cable glands and cable bushings

SKINTOP® and SKINDICHT® cable glands and cable entries represent highest quality levels and over 30-years of expertise in the relevant areas of application.

Along with quality, the correct usage of these products with regard to operational safety is the most important factor. For this reason, we would like to remind you to observe all relevant standards for your intended application. In addition to the technical data on the product pages, please also refer to the technical tables in our main catalogue (T21 – thread dimensions for cable glands, tightening torques and installation dimensions for cable glands/T22 – protection ratings according to EN 60529), as well as the supplied package leaflets describing product usage (e.g. package leaflet for products acc. to DIN EN 60079-0, DIN EN 60079-7).

5. Cable protection and guiding systems

SILVYN® cable protection systems offer additional protection for cables and wires. If used in a specified system and professionally fitted by a certified electrician, SILVYN® products will meet the properties detailed on the catalogue pages.

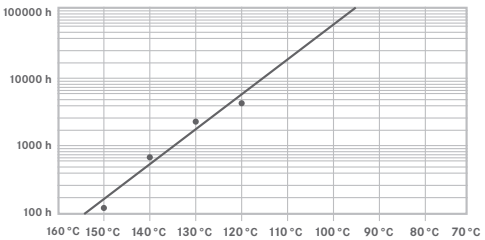
When configuring and assembling the SILVYN® CHAIN energy supply systems, the assembly instructions detailed in table T3 “Assembly guidelines for ÖLFLEX® FD and UNITRONIC® FD cables in power chains” must be followed. With regards to the correct installation of a SILVYN® CHAIN energy supply system, please refer to the information in our current special SILVYN® CHAIN catalogue.

6. Ready-to-use parts, tools and printers

Products in the area of cable accessories are system-tested to ensure optimal assembly. The commissioning and processing of these products must only be performed by authorised electricians and following the supplied information.

7. Service life

The average service life of cables is dictated not just by the mechanical and chemical stress, but also by the operating or ambient temperature. As is customary in mechanical engineering, the continuous temperature range of a cable, as specified in our technical data, refers almost exclusively to a period of at least 20,000 h. The adjacent example of an ageing curve according to Arrhenius illustrates the behaviour of an insulating material on the basis of time and temperature. The material tested here has a temperature index of approx. +110 °C at 20,000 h. The material can also be specified with an index of +135 °C, but in this case only for a duration of approx. 3000 h.



8. Connection technology

The quality of an electrical connection greatly depends on the choice of suitable components in the relevant nominal cross-sections and the use of recommended tools for processing.

Size differences between the cable and the tubular cable lug/conductor end sleeve are attributable to the fact that class 5 and 6 conductors can be pressed with just one crimp contact – even if the conductors have different structures (bunched, stranded or compressed conductors). Despite the sleeves appearing to be too large for the relevant cross-sections, the correct combination of conductor, contact and tool will ensure gas-tight crimping. The dimensional accuracy at the aforementioned connection points is governed by standards, incl.:

- DIN EN 60228 (VDE 0295), September 2005 – "Conductors for cables and insulated leads"
- DIN 46228 – 4, September 1990 – "Tubular end-sleeves with plastic sleeve"
- Crimping quality according to DIN 46228-1 and DIN EN 50027

9. Testing and inspection

The operator must ensure that the correct functioning and condition of electrical systems and equipment is checked by or under the supervision of a certified electrician. This must occur prior to initial commissioning and before reactivation following any modifications or maintenance work.

Inspection intervals must be set such that any problems that can reasonably be expected are identified in good time. In many cases, the service life of LAPP products can only be established empirically in the relevant applications. Indicators for inspection intervals can be based, for example, on the temperature load (see "Service life") or the number of permitted alternating bending cycles for drag chains (see information on relevant product pages in the catalogue).

As a rule, cables and wires in fixed installations will have a longer service life and will thus also be suitable for longer inspection intervals.

Shorter intervals are recommended for cables and wires used at the limit of their permitted parameters. This applies to the following in particular (see also "Technical data" and "Application" on the relevant product pages in the catalogue):

- Minimum bending radius
- Temperature range
- Presence of radiation (e.g. sunlight)
- Existence of tensile strain
- Influence of surrounding chemical substances and unverified resistance
- In the case of water accumulation or condensation in the area of the connection points. Cables and wires should be subjected to a visual inspection to identify any changes to their appearance. This should be done no later than when the cables or wires are likely to have been exposed to excessive loads (be they electrical, thermal, mechanical or chemical).

10. Fire properties

The behaviour of products in the case of a fire (reaction to fire) is of great importance to building installation. The EU has converted the various national regulations throughout Europe into a uniform rating system. The Construction Products Regulation (directive (EU) no. 305/2011) of 09/03/2011 came into force on 01/07/2013 and is binding for all member states.

Please find more details in this catalogues appendix under Technical tables T14.

11. Copyright and updated standards

We aim to observe the copyright of the images/graphics and texts used in this catalogue, and to primarily utilise our own or licence-free images/graphics and texts.

By specifying standards and using extracts from standards, we aim to support our customers with important information on safe use of our products.

Please note that as the catalogue gets increasingly old, the specified standards/standard extracts may no longer be fully up to date.

To preserve copyright and ensure that standards are up to date, we recommend that our customers and users of this catalogue refer to the latest applicable standards from an authorised source.

Example: Technical table T12 – Load capacity

Extracts from DIN VDE 0298-4 (issued 2013-06) are used in the pending catalogue edition, with approval 162.013 from DIN (Deutsches Institut for Normung e. V.) and the VDE (Verband der Elektrotechnik Elektronik Informationstechnik e. V.). Application of the standards is based on the versions with the most recent issue date.

These are available from VDE VERLAG GmbH, Bismarckstraße 33, 10625 Berlin, www.vde-verlag.de and
Beuth Verlag GmbH, Burggrafenstraße 6, 10787 Berlin.