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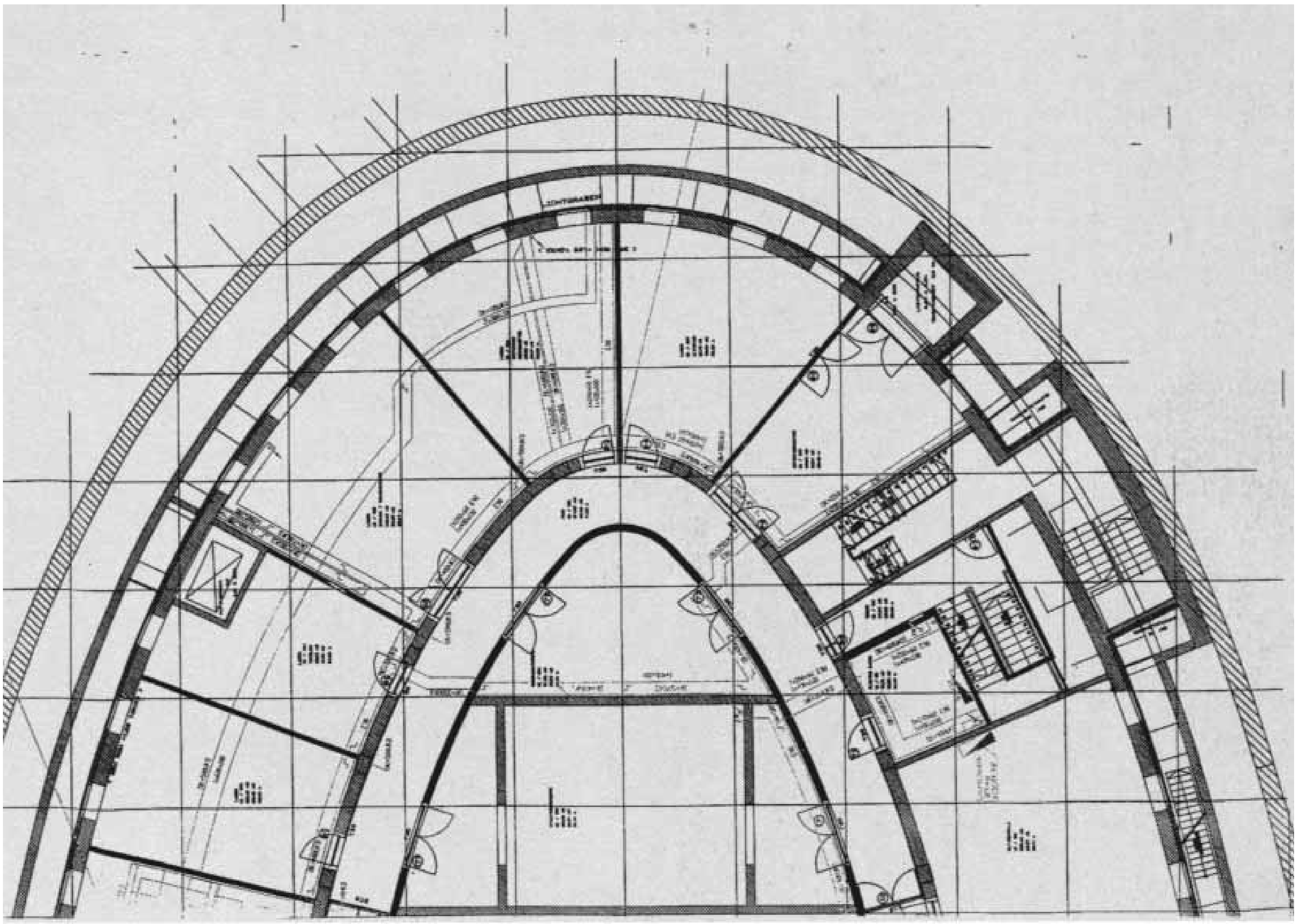
The technical information is provided to help you use the PUK-catalogue in a professional way.

It
- informs you about protective measures against corrosion, consistence of materials, norms and other technical details,
- helps you find the suitable cable support systems for your application,
- explains load capacity diagrams and details about possible loads.

In order to make the use of this catalogue easier for you, we use tokens and symbols. You can find the explanations on the inner pocket of the title page. The symbols used in this part of the catalogue will be explained subsequently.

If you should have any technical questions or requests regarding available non-standard products we are glad to help you at our headquarters in Berlin or our branch offices at any time.

Subject to technical modifications.



Corrosion Prevention

Prior to choosing materials for the passing of cables it is recommended to take a look at the corrosive environmental conditions at the construction site and to determine the corrosion prevention accordingly.

For installations in regular environment, zinc coatings have proven to be protective for steel against corrosion. However, the protective zinc coat is being reduced by various climatic influences throughout the years. The following table shows the loss of coating per year:

Environmental influence and corrosion risk

Corrosion-category	Loss of thickness µm/year	Typical environment outdoors	indoors
C1 inconsiderable	≥0,1	-	Heated buildings like offices, stores, schools, hotels
C2 slight	>0,1 until 0,7	Little pollution, like rural areas	Not heated buildings with formation of condensate like store houses and coliseums
C3 moderate	>0,7 until 2,1	City and industrial environments with moderate pollution	Production plants with high humidity, like laundry, brewery and dairy
C4 strong	>2,1 until 4,2	Industrial areas and coastlines with moderate salt impact	Chemical plants, swimming pools
C5-I very strong (industrial)	>4,2 until 8,2	Industrial environment with high humidity and aggressive atmosphere	Buildings or areas with almost permanent condensation and pollution
C5-M very strong (ocean)	>4,2 until 8,2	Coastlines and offshore areas with high salt impact	Buildings or areas with almost permanent condensation and pollution

(Source: EN ISO 12944-2).

The loss of thickness per year multiplied with the expected life span of the construction determins the necessary thikkness of zinc coating. There are mainly three zinc coatings that differ in thickness of coating, adhesive strength and appearance.

- **Galvanic zinc (DIN 50961)**
  The small parts are zinced by means of electrolysis bath in which the zinc ions apply very evenly to the metal. The zinc coat is app. 5 µm thick, light glossy, and has an additional protection by succeeding bi chromium conditioning against abrasion.

  Nuts and bolts (without further marking) in the PUK catalogue are galvanic zinc coated. They are used for connecting Sendzimir zinc coated construction elements.

- **Hot galvanized according to the Sendzimir procedure**
  (**DIN EN 10326/10327**, formerly **DIN EN 10147/10142**)
  The steel strapping (thickness up to 2 mm) is coated in the steel-mill with zinc (flow path procedure). The result is an evenly spread and highly adhesive zinc coat with an average thickness of 19 µm.

  Damage to the zinc coat caused by cutting, punching or drilling does not result in progressing corrosion because the neighbouring zinc is dissolving under the impact of (air-) humidity and builds a protective, brown coating layer of zinc hydroxide over the blanc metal. The "migration" of zinc ions protects free areas up until app. 2 mm width.

- **Hot dip galvanized**
  (**DIN EN ISO 1461**, formerly **DIN 50976**)
  The parts are hot dip galvanized after processing in liquid zinc (app. 450 C). Chemical reactions lead to various zinc-iron alloys, which are especially firmly connected to the steel core. These alloys are usually coated with a "pure zinc layer". Depending on the speed of the reaction, steel composition, time of dipping, cooling process etc., a "growing through" to the surface of the zinc-iron alloy is possible as well.

  Therefore the appearance of the surface varies from dull dark grey to light glossy. This is no indication of thickness of zinc coating or quality of corrosion prevention. Humid environment can also cause a forming of zinc-hydroxide-carbonate (so called white rust). This does not influence the efficiency of the corrosion prevention.

  Cutting edges need to be protected with cold zinc paint (see catalogue page G4).

  According to DIN EN ISO 1461 the average local thickness of the coating is at least
  45 µm for material thicknesses up to 1.5 mm
  55 µm for material thicknesses from 1.5 up to 3 mm
  70 µm for material thicknesses from 3 up to 6 mm

  The DIN EN ISO 1461 complies basically with
  BS EN ISO 1461 in Great Britain
  EN ISO 1461 in France
  ASTM A123/A 123M in USA

  Hot dip galvanized material can be used in humid environment (corrosion classes C3 and limited C4). These articles are marked with the symbol F.

- **High-grade steel**
  Considering the aspects of high corrosion resistance, easily cleanable surface, ability of recycling, and fire resistance, high-grade steel becomes increasingly the material of first choice. Especially for the chemical, paper, textile and food industry, in sewages, refineries, car tunnels and in off-shore areas it is being commonly used.

  Regarding the long lasting life cycle of such constructions, high grade steel is often times the economically most suitable solution in spite of the higher initial investment. In case of insufficient corrosion resistance the investments are accelerated by business interruption, rearrangement of cable loads, exchange of structural components.

Compared to various plastic materials high-grade steel features through high firmness, resistance against fire and heat, as well as the emission free mannor in case of fire and mechanical processing.

The commonly used material No.: 1.4301 is marked with the short description X5CrNi 18-10 according to EN 10088-3 and has been approved by the German Institute for Construction Engineering in Berlin under the general admittance Z-30.3-6 for construction processes.

Assignment to recent and outdated norms:

EN 10088-3	: 1.4301 X5CrNi 18-10
AISI	: 304
UNS	: S 30400
BS	: 304 S15- 304 S31
AFNOR	: Z7CN 18-09
DIN	: 17440

PUK offers a complete high-grade steel program made of this material: Bracket supports, brackets, cable trays, ladders, vertical ladders, channels and cable clamps.
Nuts and bolts comply to steel-group A2 (according to DIN ISO 3506). This is indicated with the symbol **E**.

The high-grade steel program is available on request in material No. 1.4571 with the short appellation X6CrNiMoTi17-12-2 (according to EN 10088-3) and has been also certified by the German Institute for Construction Engineering in Berlin.
Nuts and bolts comply to steel-group A4 (according to DIN ISO 3506).

Assignment to recent and outdated norms:

EN 10088-3	: 1.4574 X6CrNiMoTi17-12-2
AISI	: 316 Ti
UNS	: S 31635
BS	: 320 S31
AFNOR	: Z6CNDT 14-12
DIN	: 17440

This program is marked with **E4**.
Other materials of the same corrosion category available on request.

- For special applications (light- and cable support constructions in car tunnels according to ZTV-ING) the high alloyed material No. 1.4529 is available.

Plastic Coating
For the use in zinc aggressive environments (pH index < 6 or > 12.5) or for indication through colours, zinc-coated construction parts can be coated with plastic on request (for example with epoxy or polyester).

Choice of Products

Cable trays
The choice is made under consideration of

1. the number or volume of cables to be passed in a cable tray
   → load carrying capacity of the tray

2.a the load of cables to be passed in a cable tray
  b the distance between the support points of the tray
   → load carrying capacity of the tray

At 1. **Cable capacity / usable diameter**

If the cable volume (type of cables, size, number) is not known, table 1 can help with the estimation: For cables of any size the volume needed is multiplied with the number of cables in order to determine the total sum. The result is the minimum cross section area of the cable tray needed, which may have to be extended by a standby factor). In any case the regulations of the VDE 0100 regarding the load of cable trays are to be kept.

Table 1: Space needed for cables of type NYY

Cable NYY	Diameter (mm)	Space per cable (app.)	X	Number of cables	
4 x 1,5	12,5	1,5 cm^2	X		=
4 x 2,5	14	1,8 cm^2	X		=
4 x 6	16,5	3,0 cm^2	X		=
4 x 16	22	5,0 cm^2	X		=
4 x 35	31	12,0 cm^2	X		=
4 x 70	41	16,0 cm^2	X		=
				A ≥	Σ cm^2

The usable diameter-area (A) of each cable tray is specified in the catalogue. Several cable trays need to be built parallel in some cases.

At 2. **Carrying Capacity**

All specifications for carrying capacity given in this catalogue relate to the product. The carrying capacity of the installed system depends on the actual configuration and especially on the operational discharge of load into the building.

a. Weight of Cable

If the total weight of the cables is unknown, table 2 can be helpful for the estimation.

For obtaining any cable size, the cable weight is multiplied with the number of cables and the total sum determined. The result is the estimated cable load (Q).

Table 2: Weight of cables type NYY

Cable NYY	Kabelgewicht (app.)	x	number of cables	
4 x 1,5	2,3 N/m	x		=
4 x 2,5	3,0 N/m	x		=
4 x 6	5,2 N/m	x		=
4 x 16	11,0 N/m	x		=
4 x 35	22,0 N/m	x		=
4 x 70	41,0 N/m	x		=
				Q = Σ N/m

With regard to security, the highest possible cable load is crucial. This is calculated by multiplication of usable diameter with specific cable weight*. The result (Q_{LK}) is specified for each cable tray in this catalogue.

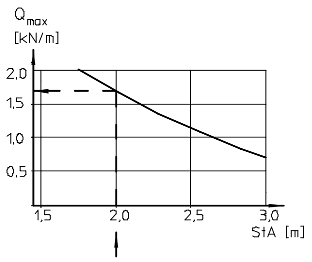
b. Distance between supports (StA)

The recommended distance between supports is 1.5 meters. Nevertheless, the actual possible distance between supports can be considerably higher (up to 10 m), depending on available points of fastening (pillars, supporting structures).

The capacity diagrams of the cable trays determine

- the maximal load capacity (Q_{max}) a cable tray can carry securely.

  Example cable ladder type LG 60-634,
  Distance between supports = 2,0 m.

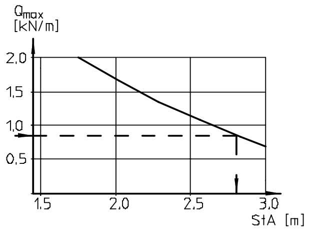


The difference between maximal load capacity and possible cable load results in the highest permissible additional load:

Q_{max} = 1,70 kN/m
Q_{LK} = -0,58 kN/m
add.load ≦ 1,12 kN/m

- the maximal permissible distance between supports regarding the known load

  Example: cable ladder type LG 60-634,



Cable load = 0,60 kN/m
Allowable load = 0,25 kN/m
Q_{max} = 0,85 kN/m

→ maximal distance between supports = 2,7 m

The load capacity diagrams include a security reserve of at least 70% until possible failure (according to DIN VDE 0639, see page J8). Nevertheless cable trays may not be used for walking!

If the maximal load capacity (Q_{max}) or the maximal distance between supports of the chosen cable tray is not sufficient, types with a higher load capacity have to be considered. If these do not meet the demands either, a different sort of cable tray has to be chosen:
Wire mesh cable tray → cable tray → cable ladder → wide span cable ladder (with inlay sheet LEBL).

Wide span cable trays

Are suitable for wide distances between supports. The load carrying capacity of such "cable bridges" mainly depends on the firmness and thus height of the side profiles. Increased side height also means increased volume capacity and thereby increased maximal cable load.
This leads to danger of unplanned overload / overstress - therefore PUK-wide span cable trays confront this danger with

- elevated cable tray bottom
- electrically welded connection of side rail and rung
- almost symmetric torsion free arbour profiles
- at least 70 % security reserve in the specification of load carrying capacity* (see explanations of DIN VDE 0639, page J7).

Cable trays may not be used for walking or as ladders.

Wide span cable trays may have a higher volume capacity than load carrying capacity depending on the distance between supports. Specifications of load carrying capacity in dependence of distance between supports need to be regarded.

* type of cable tray	Cable	Specific cable weight
Cable ladder	Control line cables (Q_{LK}) (according to DIN VDE 0639)	2,8 N/m x cm^2
Cable tray, wire mesh cable tray	Voltage line cables (Q_{SK})	1,5 N/m x cm^2

* This is valid regarding the type WL 200 only if wide span beam reinforcement (WLHS) is being mounted at the support point (bracket).

Supporting structures

Usually, supporting structures for the trace route contain
On ceilings: of steel bracket and ceiling bracket support (stem)
On walls: of wall bracket
or bracket support and stem bracket

In order to choose construction pieces of a sufficient weight loadability, firstly the load of each cable tray at the support point has to be determined:

Bracket load **P** = (cable load **Q** + weight of cable tray **w** + additional load) **x** distance between supports **StA**

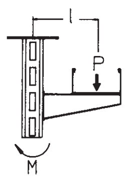
1. <u>Bracket (extension)</u>
The load carrying capacity of the bracket needs to be higher than the above determined bracket load (P).
Please note that the load carrying capacity of the cable tray depends on the width of the cable tray (B) . The tables of load carrying capacity always assume the respective size of cable tray / bracket (L≈B).

If the bracket is considerably longer and the cable tray is laid flush on the bracket's tip this is valid by approximation:

$$P_{zul} \approx P_{max} \left(\frac{L}{2\,L - B}\right)$$

The specifications of load carrying capacities are in accordance with the values tested and certified by the DIN VDE 0639, see page J7.

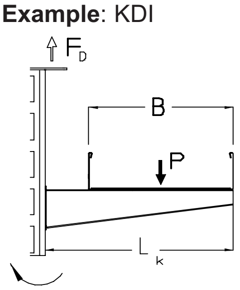
2. <u>Ceiling bracket support (stem)</u>
Ceiling bracket supports are stressed mainly by bending forces in case of one sided mounting of cable trays. Each single bracket causes a so called bending moment (M_i) in the stem which is determined by bracket load (P_i) and overhang length (l_i) - (M = P x l). The overhang length depends on bracket length (L) and width of cable tray (B).



The sum of the single bending moments (M_i) may not exceed the allowable moment (M_{max}).
M_{max} is determined for every stem in the catalogue

When mounting cable trays to both sides of the stem the above mentioned has to be valid for both sides, because single sided cable load (during the process of passing cables) can usually not be excluded.

Example: KDI



B	Lk	Pmax	Pmax	F_D / P
		L>1000	L<1000	
mm	mm	kN	KN	
100	120	20,0	14,5	1,3
200	220	13,8	10,0	1,6
300	320	10,5	7,6	1,9
400	420	8,5	6,2	2,3
500	520	7,1	5,2	2,6
600	620	6,1	4,4	3,0

L ≤ 1000: M_{max} = 1600 Nm
L > 1000: M_{max} = 2200 Nm

In order to make the choice of the right stem easier, the maximal bracket load (P_{max}) is determined for every cable tray width (B) with corresponding racket length (L).

If only one single cable tray needs to be fastened to the stem on one side (or only cable trays of equal width) the table determines directly if ≦ P_{max} (resp. $\Sigma P_i \leqq P_{max}$).

When mounting cable trays of different width one sided to the stem you need to calculate the fraction of maximal load for each width of cable tray:

$$\frac{P_B}{P_{B\,max}}$$

For the chosen stem the sum of all these fractions need to be ≦ 1,0:

$$\sum \frac{P_B}{P_{B\,max}} < 1$$

<u>Example:</u>

2 cable ladders, type L 60, of width:	B_1 = 400 mm	B_2 = 600 mm
mounted to brackets of length:	L_1 = 420 mm	L_2 = 620 mm

single sided to a ceiling bracket support.
The distance between supports is 1.5 meters.

Cable load (acc. Catalogue):	Q_{LK} = 580 N/m	Q_2 = 880 N/m
Plus weight of cable ladder:	30 N/m	33 N/m
Sum of load:	610 N/m	913 N/m

Sum of load	610 N/m	913 N/m
multiplied with distance between supports	x 1,5 m	x 1,5 m
results in bracket load:	P_1 = 915 N	P_2 = 1.370 N

For the bracket support KDU 52
Determined (according to catalogue): $P_{max\,400}$ = 2,7 kN $P_{max\,600}$ = 1,9 kN
This results in the
Sum of load fractions:

$$\sum \frac{P_B}{P_{max\,B}} = \frac{915\text{ N}}{2.700\text{ N}} + \frac{1.370\text{ N}}{1.900\text{ N}} = 1{,}06 \quad (> 1)$$

That means that a bracket support of higher load capacity has to be chosen, or the distance between supports is to be minimized.

The specifications of load carrying capacities are in accordance with the values tested and certified by the DIN VDE 0639, see page J7.

⚠ **During the process of passing cables high additional loads can occur. These additional loads may not be discharged into the cable support system.**

Operational discharge into parts of the structure

All specifications of load carrying capacities are related to the respective product. The load carrying capacity of the installed system depends on the respective configuration and especially on the operational discharge into parts of the structure.
During the process of passing cables high additional loads can occur. These additional loads may not be discharged into the cable support system.

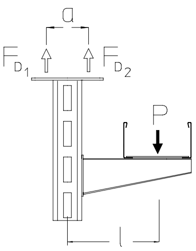
The following explanations can only be of help for the use of plug approvals, valid are solely the specifications in the approval:

Allowable plug load F_{zul}
The vectorial interaction of various components of force that operate on a point of fastening (for example shear stress and vertical extraction force) result in the plug strain. This strain has to be smaller or equal to the allowable plug strain given in the approval (usually also applicable for angular extraction force, too). The permissible plug load is usually depending on bracing material (grade of concrete, model of stone in brickwork etc.) as well as on their tension strain:
- wrenched concrete strain-zone
- detected concrete pressure-zone (for example concrete wall, support, upper half of concrete binder)
In case of doubt the responsible stress analyst needs to be consulted.

Reduction
The allowable plug load needs to be reduced
- if the distance between several plugs is smaller than the dimension a*
- if the distance between plug and edge of part of the structure is smaller than dimension a*.

For the calculation of plug load F_D the catalogue shows factor $\frac{F_D}{P}$ (valid for the plug with higher stress).

Example: Ceiling bracket support



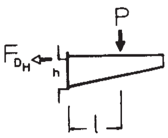
$$F_{D1} = \frac{P}{2}$$

$$F_{D2} = \frac{P}{2} + P \cdot \frac{l}{a}$$

$$\Rightarrow \frac{F_D}{P} = \frac{1}{2} + \frac{l}{a}$$

The higher plug stress is always minimized by double-sided installation.

Example: Wall bracket



$$F_{DV} = P$$

$$F_{DH} = P \cdot \frac{l}{h}$$

$$\Rightarrow \frac{F_D}{P} = \sqrt{1 + \left(\frac{l}{h}\right)^2}$$

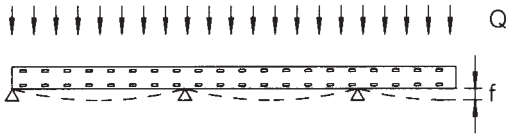
VDE 0639

- **Cable support systems**

DIN VDE 0639 specifies the following, among other things:

- The testing procedures according to which mechanical properties of cable support elements are to be tested.

  - Cableways including connections in special configurations (en field, middle field, jib):



(The conditions do not correspond to those of the most advantageous continuous support applications.)

  - and brackets as individual components (i. e. without the stiffening effect of mounted cableways).

- The load bearing capacity specifications are based on the measured loads at permitted deformation (f_{zul}) of the test samples. Cable support elements in the particular standard version (Sendzimir/hot dip galvanized) were tested.

Cableways
were tested under a specially developed testing condition, which ensures that components which bend elastically under loads are strained evenly across the surface.
f_{zul} (longitudinal direction) = 0,005 x support spacing
f_{zul} (transverse direction) = 0.05 x cableway width, (but ≦ 20 mm)

Arms/brackets
The tips of the arms are allowed to sink under a vertical load by:
f_{zul} = 0,05 x arm length (but ≤ 20 mm)

Studs (bracket holders)
Studs are bent by the effects of sideway forces.
The permitted offset is
f_{zul} = 0,01 x stud length

The greatest stud length was always tested.

*a = axis spacing
a_r = edge spacing
Please see the permit, which we would be glad to send.

- Safety
  The tested elements must withstand a load, which exceeds their permitted load by at least 71 %. Possible failures are not equivalent to the breakage of the component (total failure), but rather consist of deformation great enough that no further increase of load bearing capacity can be registered (hammock).

  This is why cable support elements made of metal indicating its load condition (including overloading) by deformation, are preferable to spontaneously breaking support systems made of plastic.

Equipotential bonding

PUK cable ladders and cable trays are installed with screw connections. Flange nuts with stamped stop teeth lead to an electrically conductive connection of the cableway and guarantee equipotential bonding.