

Universal plug-in cable connections and solutions for Transformer and GIS



Agenda

**General overview of
CONNEX Products**

**Function of
pluggable cable
terminations**

**Case
Studies**

**Outlook and
future
Developments**

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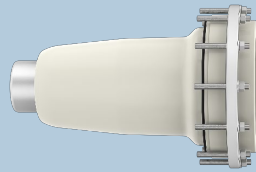
ONE SYSTEM FOR ALL STANDARDS

CONNEX

Transformer

Test: IEC 60137

Dimensions: EN 50299



Gas-Insulated Switchgear (GIS)

Test: IEC 62271-203

Dimensions: IEC 62271-209

Separable Cable Connector

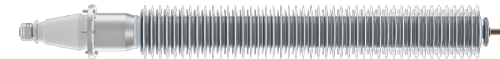
IEC 60840 / IEC 62067



72,5kV-550kV

Pluggable Bushing

IEC 60137



72,5kV-362kV

Pluggable Surge Arrester

IEC 60099-4



72,5kV-170kV

Dummy Plug



72,5kV-362kV

CONNEX product range

medium to high voltage

24 kV
Size 0



36 kV
Size 1



42 kV
Size 2



42/52 kV
Size 3/3S



72.5 kV
Seanex 3A



72.5 kV
Size 4



145 kV
Size 5S



170 kV
Size 6



245 kV
Size 6S



CONNECTION SYSTEM PORTFOLIO

HIGH VOLTAGE (HV)



Size	4	5-S	6	6-S
U_m [kV]	72.5	145	170	245
I_N [A]	2.500	2.500	2.500	2.500
Max. Cross section [mm ²]	1.600	1.600	2.500	2.500
Max. diameter over conductor/insulation [mm]	55.9 / 78.5	50.4 / 76.0	65 / 113.5	65 / 113.5

CONNECTION SYSTEM PORTFOLIO

EXTRA HIGH VOLTAGE (EHV)



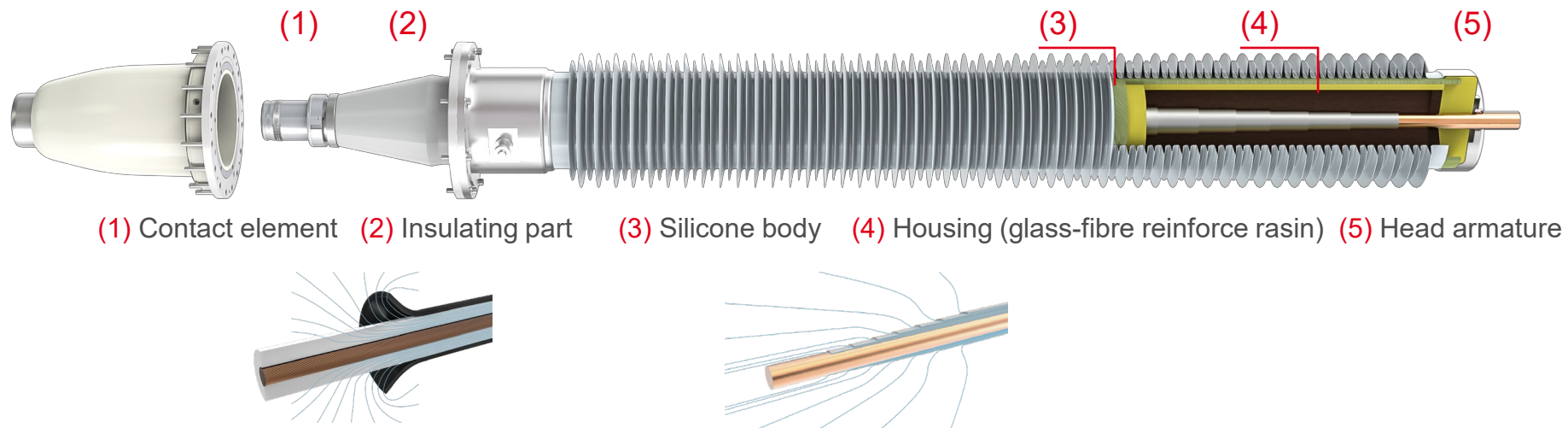
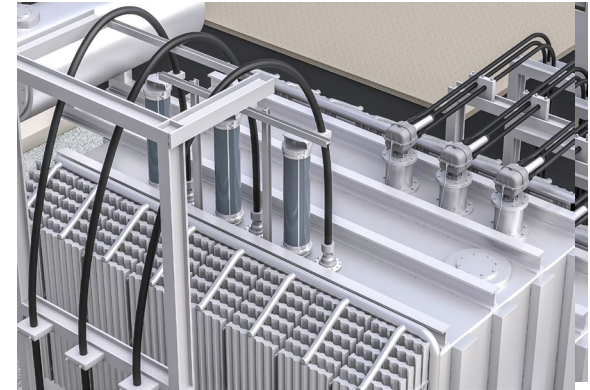
Size	7	7-S	8	9
U_m [kV]	300	362	420	550
I_N [A]*	4.000	4.000	4.000	4.000
Max. Cross section [mm ²]	3.000	3.000	3.000	3.000
Max. diameter over conductor/insulation [mm]	72.5 / 131	72.5 / 131	72.5 / 144	72.5 / 144

* depending on cable cross-section

CONNEX BUSHING

CONNEX bushing with socket

- Up to 362 kV
- Maintenance-free and leak-free thanks to solid insulation
- Combination of geometrical and capacitive grading
- Multiple pluggable - simplified transport and testing of transformer
- Pluggable: unit can be exchanged within short time
=> no need to open the transformer
- The bushing can be replaced with CONNEX cable terminations



CONNEX SURGE ARRESTER

CONNEX surge arrester with socket

- Up to 170 kV
- Maximal safety: Surge arrester is placed next to the main connection
- Geometrical field control
- Designed for overvoltage and high energy surge events
- Compact solution: it can be installed in closed building
- Pluggable: unit can be exchanged within short time

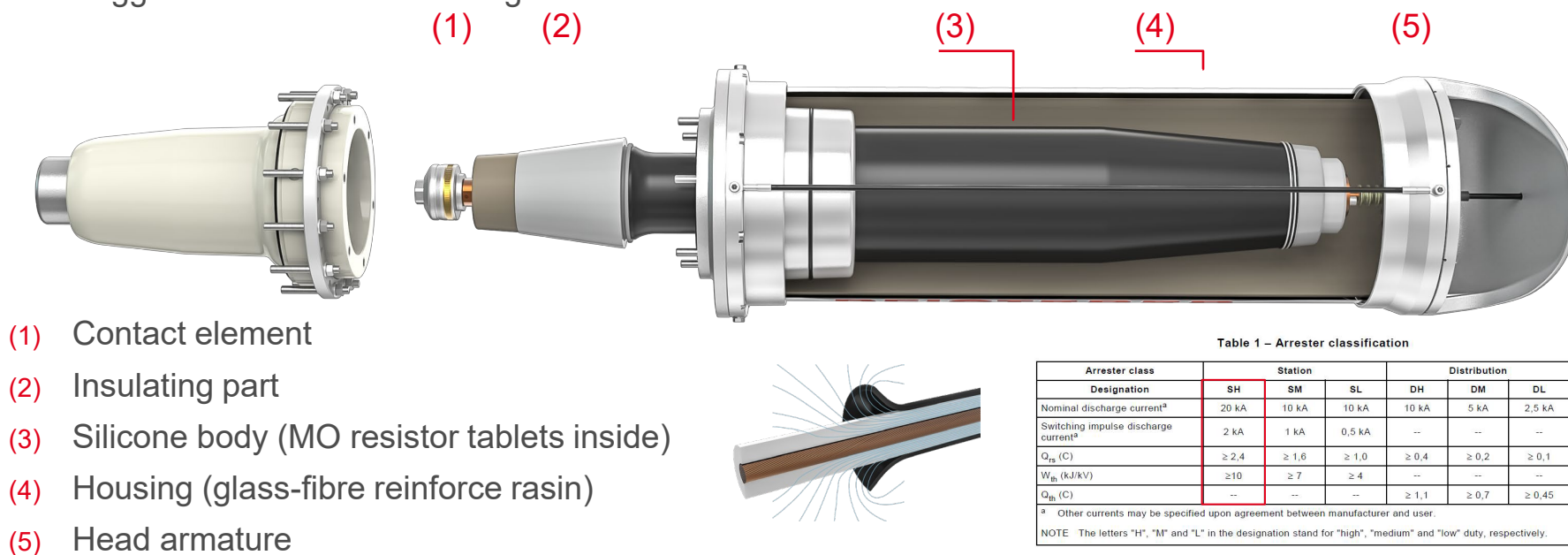
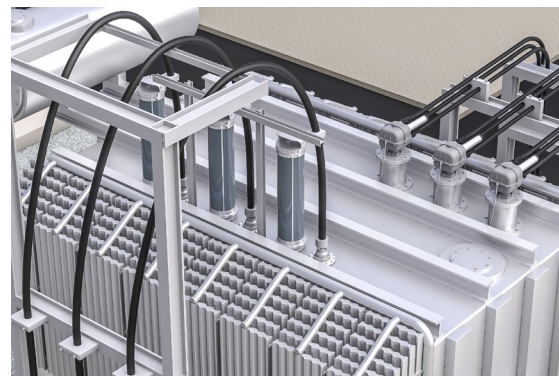


Table 1 – Arrester classification

Arrester class	Station			Distribution		
Designation	SH	SM	SL	DH	DM	DL
Nominal discharge current ^a	20 kA	10 kA	10 kA	10 kA	5 kA	2,5 kA
Switching impulse discharge current ^a	2 kA	1 kA	0,5 kA	—	—	—
Q_{15} (C)	$\geq 2,4$	$\geq 1,6$	$\geq 1,0$	$\geq 0,4$	$\geq 0,2$	$\geq 0,1$
W_{th} (kJ/kV)	≥ 10	≥ 7	≥ 4	—	—	—
Q_{th} (C)	—	—	—	$\geq 1,1$	$\geq 0,7$	$\geq 0,45$

^a Other currents may be specified upon agreement between manufacturer and user.

NOTE: The letters "H", "M" and "L" in the designation stand for "high", "medium" and "low" duty, respectively.

SURGE ARRESTERS IN COMPARISON

Combination of advantages of CONNEX Surge Arrester and AIS Surge Arrester

CONNEX Surge Arresters



Pros

- + No Frame construction needed (less costs)
 - + Space requirement
 - + Minimum influence by climatic conditions
 - + Optimum distance for protection of overvoltages
 - + Encapsulated - touch proofed systems
- => indoor use possible

Cons

- Complex assembly time
- FAT testing of equipment
- In the event of an overvoltage, relatively longer down time
- (SF₆ insulation gas)



AIS Surge Arresters



Pros

- + Easy, quick assembly
- + FAT testing of equipment with minimal effort
- + Testing of equipment at site with minimal effort
- + In the event of an overvoltage, relatively short down time

Cons

- Frame construction needed (costs)
- High space requirement
- Huge influence by climatic conditions
- Positioning crucial
- Air insulated - not touch proofed



CONNECTION SYSTEM PORTFOLIO

CONNEX SF6-JOINTS UND EP-JOINTS

- Connects all kind of cables
- Aluminium housing (SF6) and Epoxy resin (EP)
- Independently if both cables have different conductor cross sections, insulation diameter or even insulation types.
- Compact and very robust (wide range of application f.e. Offshore)
- Underground installation possible (Universal repair kit solution)

With insulating SF6-gas
Available also for alternative gases
(EconIQ, Clean Air, g3)



up to 550 kV (Sizes 4-9)



up to 245kV (Sizes 5-S, 6 and 6S)



up to 245kV (Sizes 4 – 6S)

Dry-type pluggable joint



Size 4 (up to 72,5kV)



Size 6 (up to 170kV)

CONNECTION SYSTEM PORTFOLIO

SUMMARY

Connector



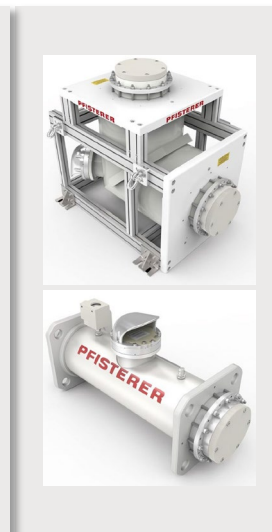
Bushing



Surge Arrester



SF6-Joints



EP-Joints



Size	4 - 9	4 – 7S	4 and 6	4 - 9	4 and 6
U_m [kV]	72,5 - 550	72,5 – 362	72,5 - 170	72,5 – 550	72,5 – 170
I_N [A] max	2.500- 4000	1250-2600	(10-20kA)	2.500-4000	2.500
Max. Cross section [mm ²]	1.600 - 3000	-	-	2.500	2.500
Max. diameter over conductor/insulation [mm]	72,5 / 144	-	-	72,5 / 144	65 / 113.5

LARGEST PRODUCT PORTFOLIO

TOOLS AND SPECIAL EQUIPMENT

Earthing and protective cap



Current testing plug



Mechanical compensation clamp



Dummy plug



Gas-insulated blind cover
only for testing



FrontCon



Agenda

**General overview of
CONNEX Products**

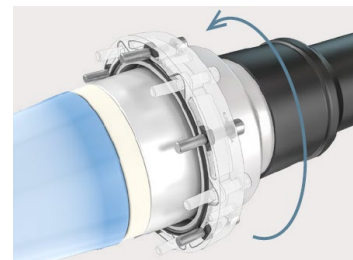
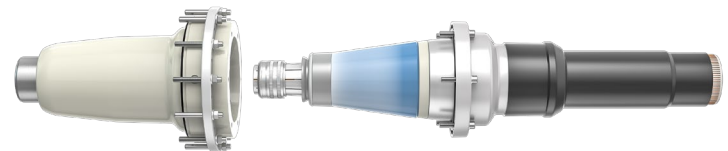
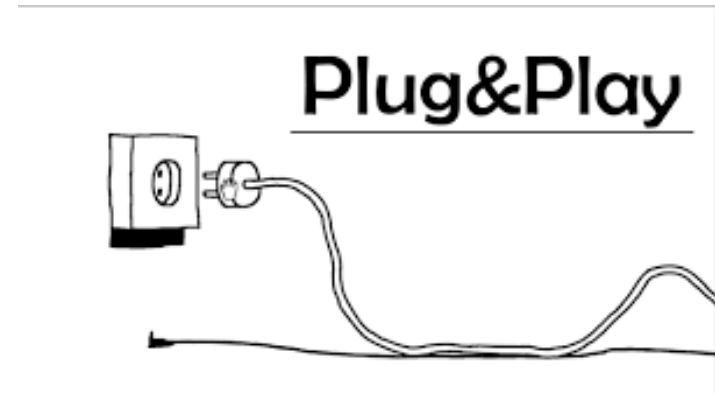
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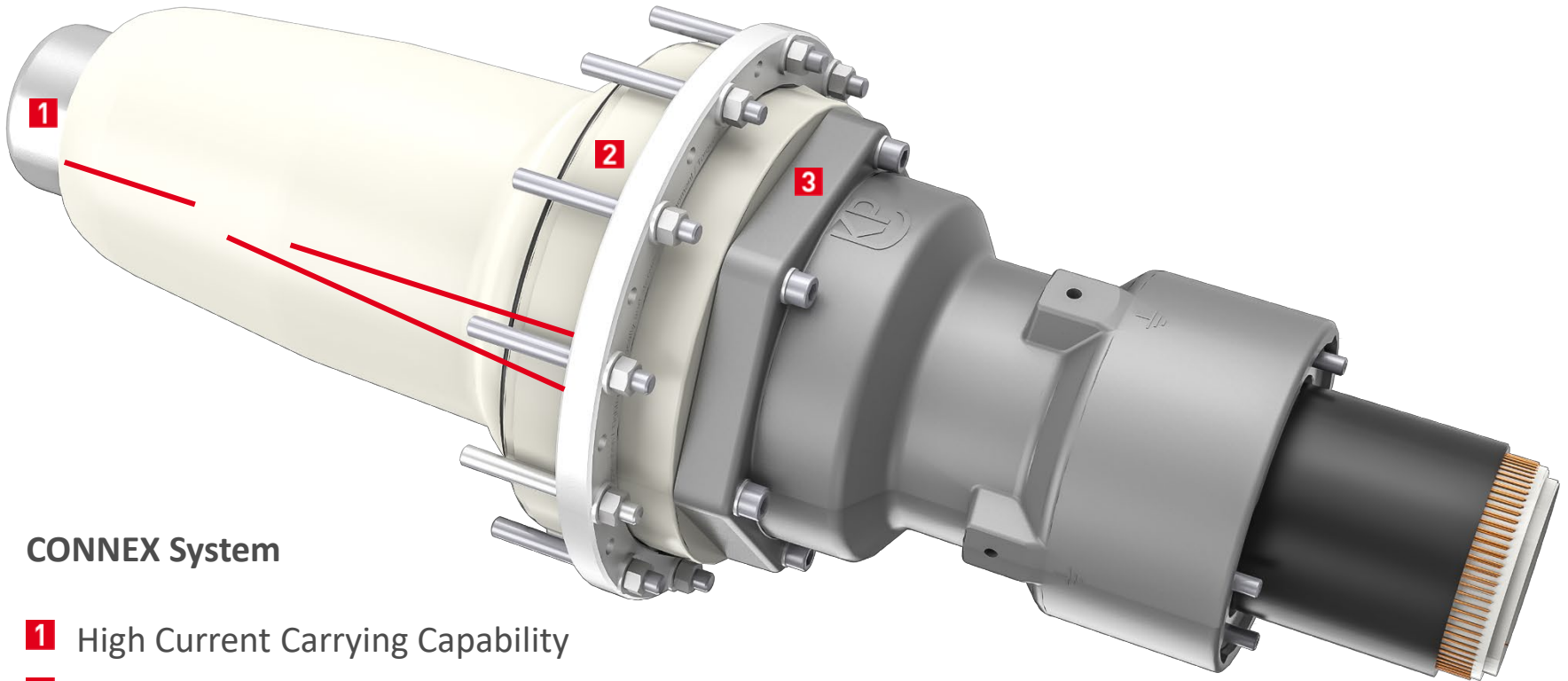
**Outlook and
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The Alternative: Plug and play

- Pre-installed system with “socket”
- Bushings or cable with male part for multiple plugs
- Pre-tested accessories and ready to plug in
- No opening of the Transformer or GIS
- Installation possible before and after Transformer or GIS
- Max. flexibility with rotating bell-flange



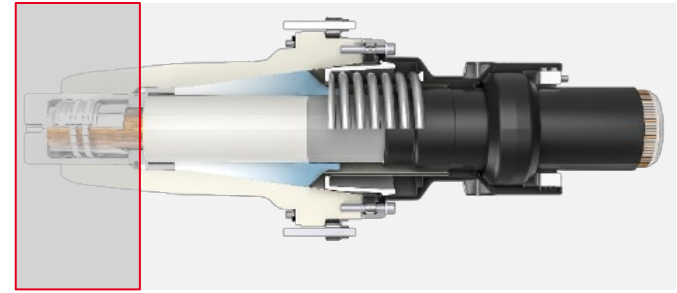
CONNEX - Technical Features of the System



CONNEX System

- 1** High Current Carrying Capability
- 2** Insulating high voltages
- 3** Robust mechanical design

Current Carrying Capability

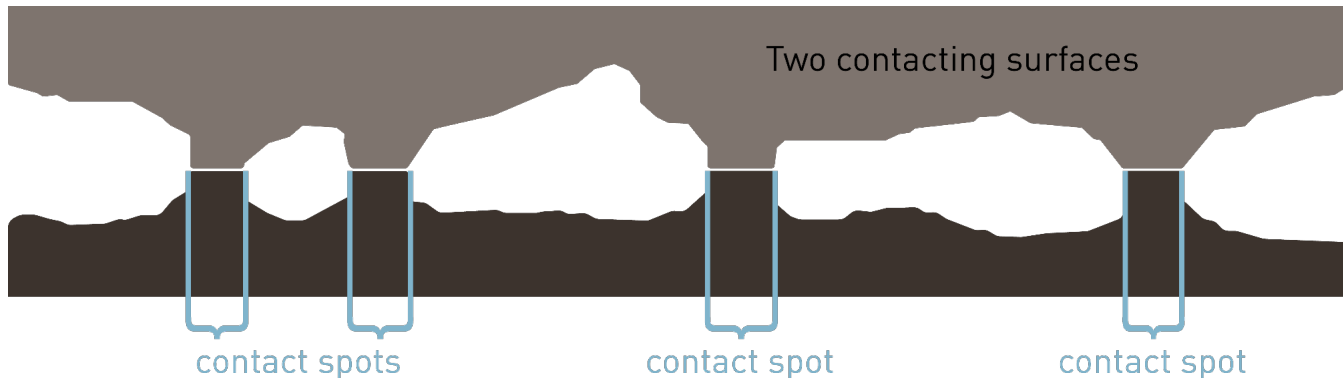
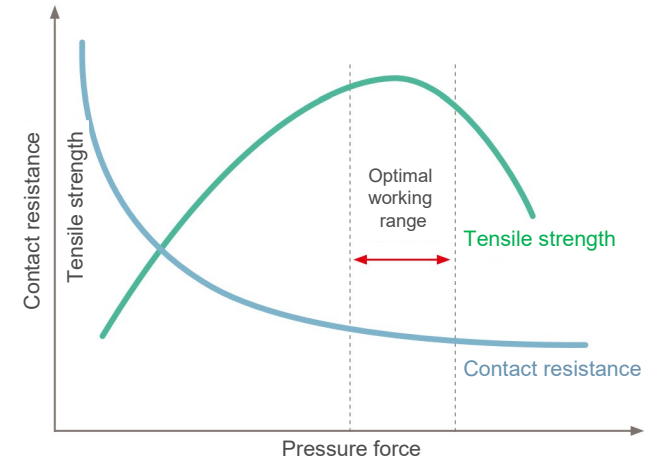


Conventional principle: contacting surfaces

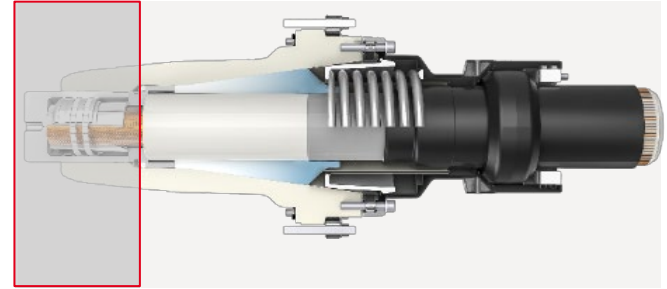
- Electrical contacts made at asperity peaks
- Only 5% of the surface for current carrying

PFISTERER solution:

- Line contacts for current connections



Current Carrying Capability



Contact System of CONNEX Cable Connector

1 Contact cone

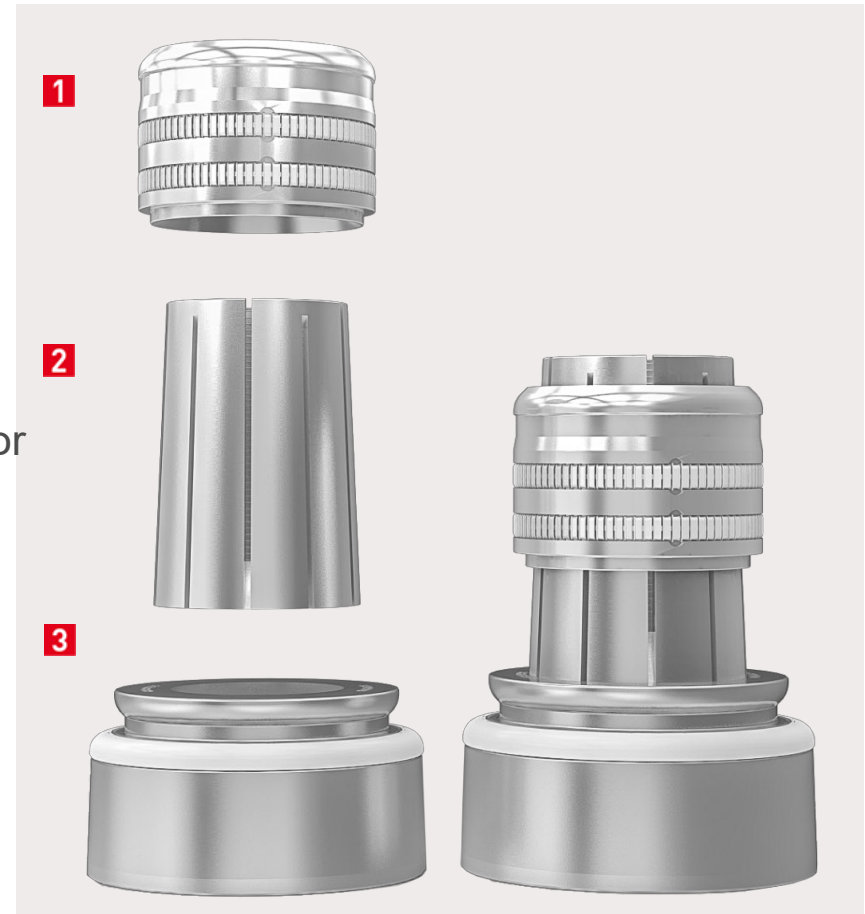
- Line contact via lamellas
- Allows movement of the conductor
- Contact to socket

2 Tension cone

- Line contact via grooves on the inside
- Contact between cone and cable conductor

3 Thrust piece

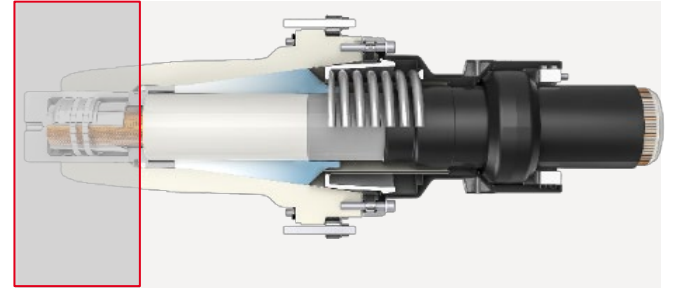
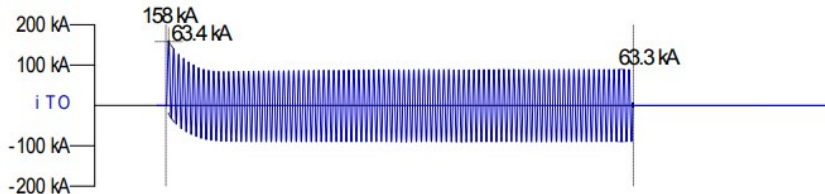
- Mechanical fixation



Current Carrying Capability

Robust contact system

- High current carrying capability
- Short circuit capability up to 63 kA, 3 sec
- Easy installation and simple removal
- Silver coated contacts



Current Carrying Capability

Contact ageing test acc. DIN 61238-1

- 6 test objects and reference conductor
- Electrical Resistance measurements
- Temperature measurements $T_{\text{object}} < T_{\text{reference}}$
- Heat cycling tests
- Short-circuit test for connectors up to 45kA, 5s

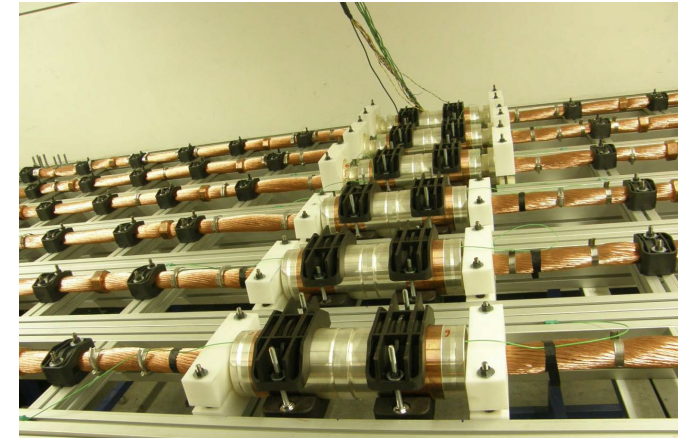
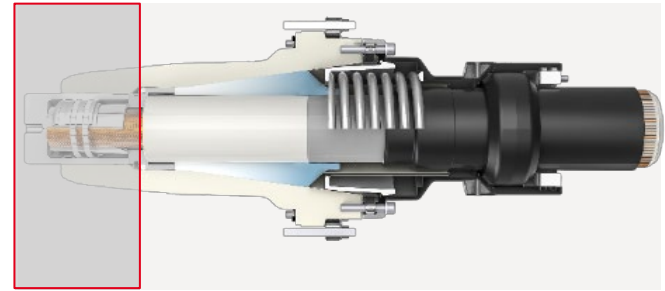
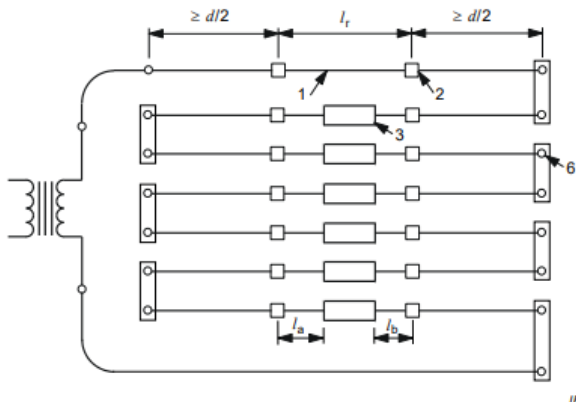


Table 1 – Minimum period of temperature stability

Nominal conductor cross-sectional area A (mm ²)	for aluminium:	$A \leq 300$	$300 < A \leq 630$	$630 < A \leq 1\,000$	$A > 1\,000$
	for copper:	$A \leq 240$	$240 < A \leq 400$	$400 < A \leq 800$	$A > 800$
Minimum period (min)		15	20	30	60



Mounting

Measuring of the resistance factor k_0

First heat cycle

Second heat cycle

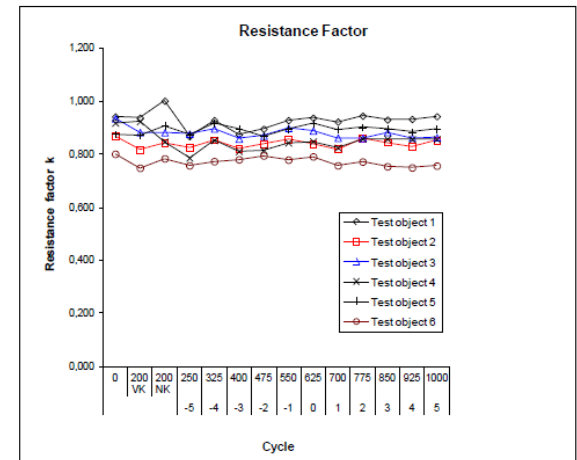
Heat cycles 3 - 200

Measuring of the resistance factor k_2

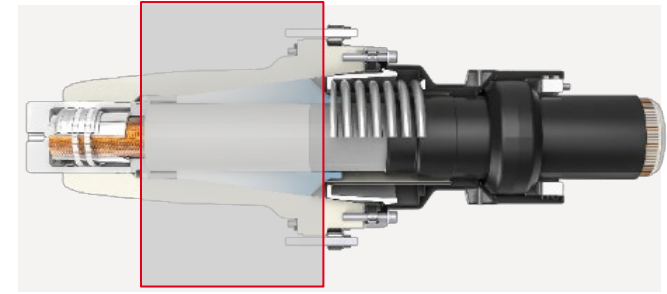
Thermal short circuit

Measuring of the resistance factor k_3

Heat cycles 201 to 1000 and measuring of the resistance factor after 250 cycles and thereafter every 75 cycles.



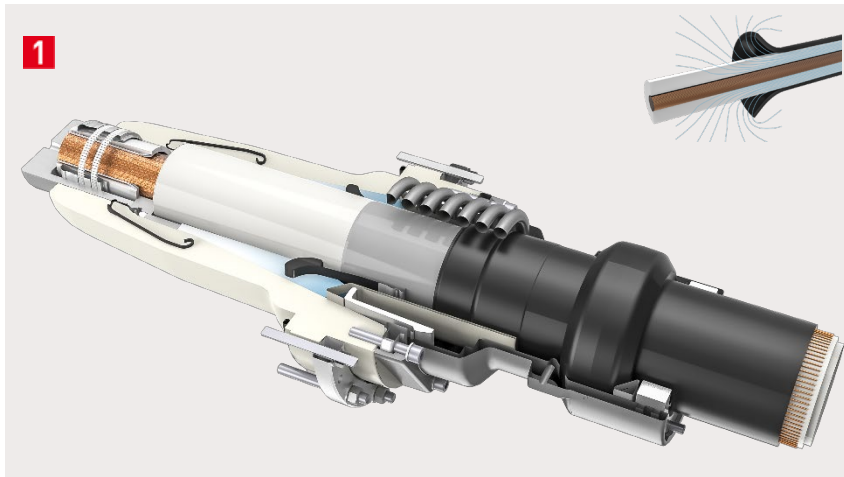
Insulating High Voltages



1 Geometrical grading

- Semiconductive deflector in silicone part of cable connector
- Electrode inside socket

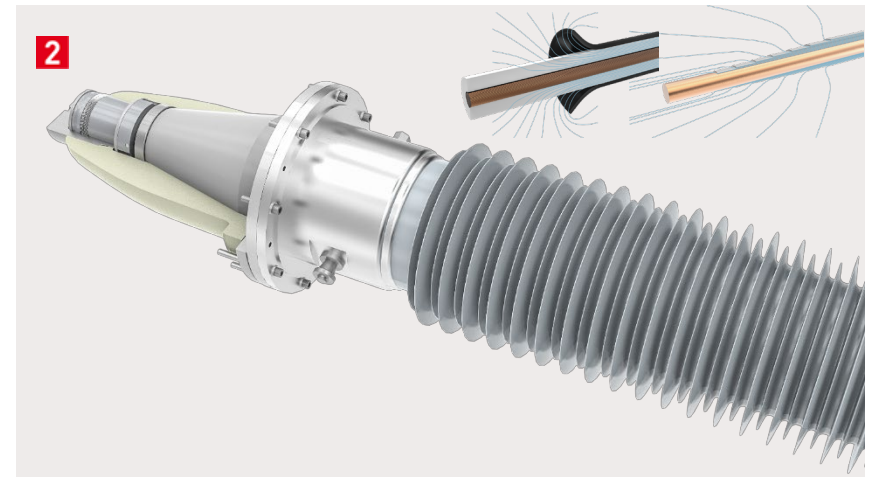
➤ Perfectly controlled electric field



2 Combination of geometrical and capacitive grading

- Combination of both techniques

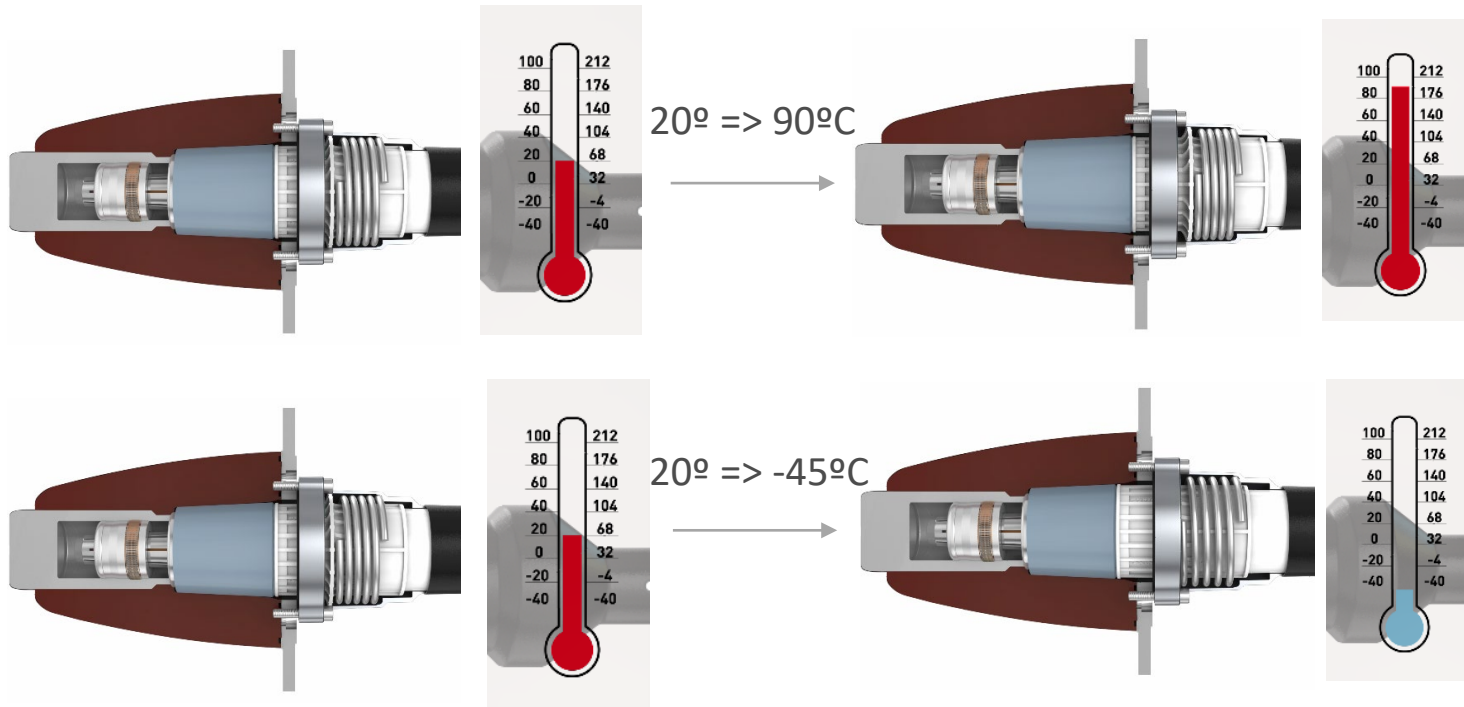
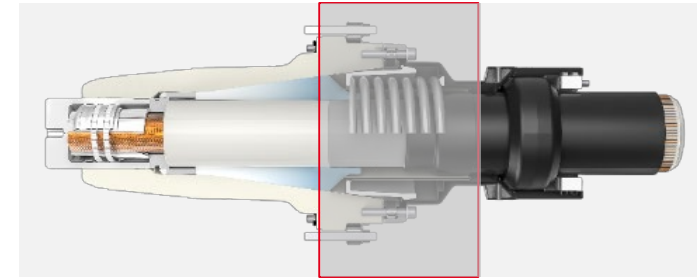
➤ Most compact design with perfectly controlled electric field



Robust Mechanical Design

Spring System inside CONNEX System

Necessity of constant contact pressure between connector and socket despite material changings during temperature fluctuation.



The world of power supply is going through a process of fundamental change.



World's population grows and energy demand increases



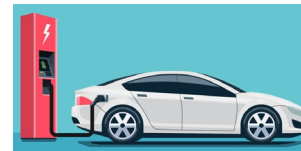
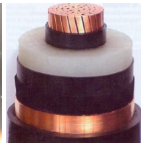
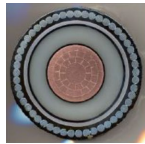
Renewable energy requires new grid concepts



Time and cost pressure on power supply companies is increasing

Challenges for cable industry

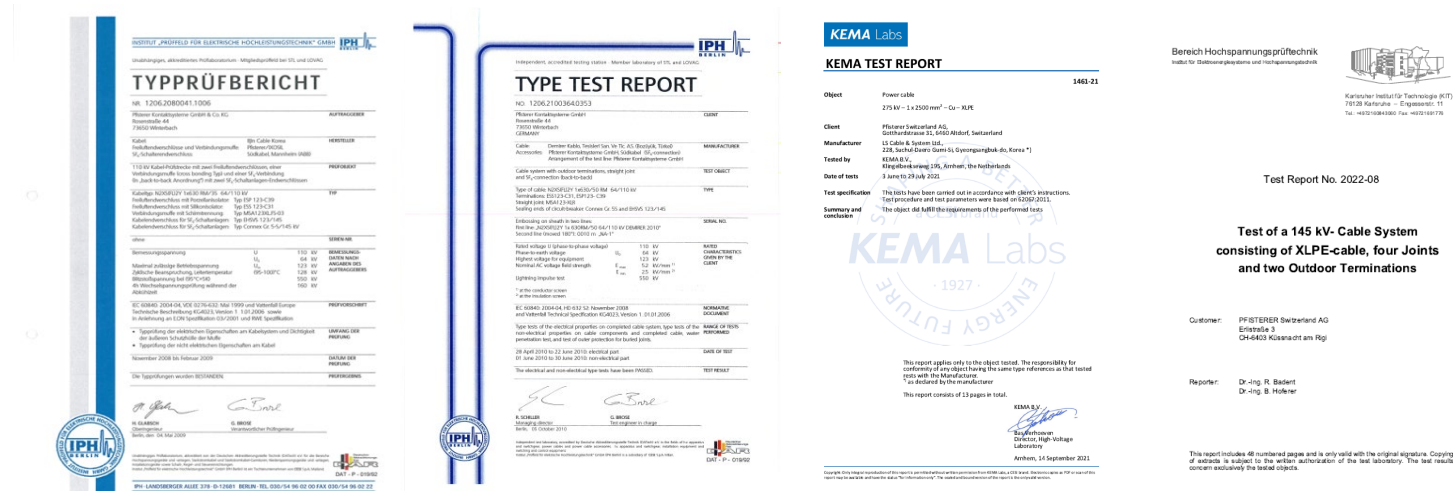
- Cable industry is facing a lot of new challenges
 - concept designs
 - new applications (offshore, solar, electric)
 - New cable designs



- Over 50 different cable manufacturer for high-voltage cables
- Demand on Type tests and prequalification is rising

CONNEX

Type-tested System for all applications



- Type Test Reports with over 50 cable manufacturers
- Different cable types and cross-sections
- All voltage ranges with different cable accessories
- > 150 different type test reports successfully passed

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Case Study

Offshore Plattform Dolwin Gamma

- Description
Offshore Converter Plattform the North Sea for connection of eight Wind Parks with 900MW to the land station, by converting AC 155kV to 320kV DC
- Years of application: 2016-2018
- Products: CONNEX Size 6 connectors and sockets, EP-Joints Size 6, Dummy Plugs

First application of highly flexible 155kV rubber cable Feltoflex with CONNEX



Case Study

Cable system Magdeburg

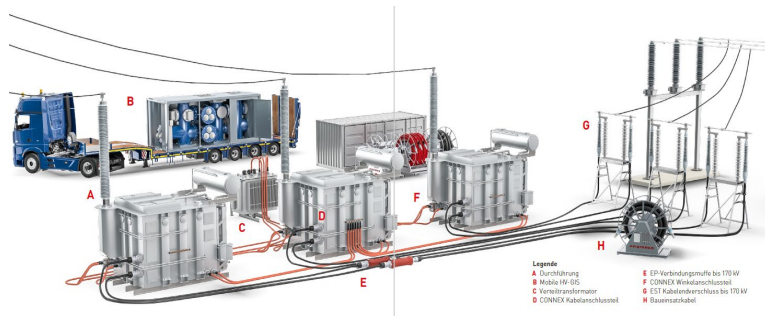
- Substation with AIS has to be replaced
- Years of application: 2021-2022
- New GIS building is build next to the old
- 27 pcs. CONNEX Size 6 connectors



Case Study

Mobile substations – new flexible innovation on the road

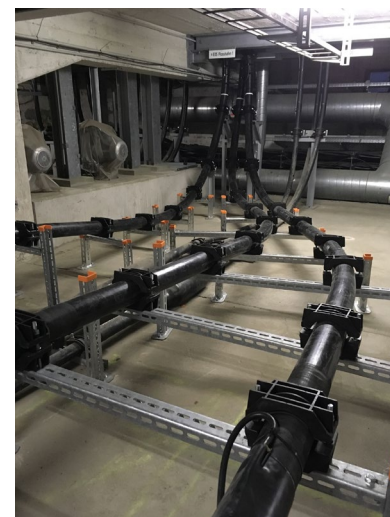
- Mobile Substation for the US Market
- Innovated solution that saves costs and time with Plug and Play Cables
- Mobile GIS, transformers, switchgear and underground cable were dry connected with CONNEX Accessories and EP-Joints



Case Study

Repair solution for old GIS

- Old GIS with old oil-filled GIS termination is phase out model, no more spare parts from the supplier
- 15 infields with one free chamber
- Target: universal repair solution and reduction of down time in case of a failure with quick installation in one infield of the GIS
- Solution: the free chamber equipped with CONNEX sockets and T-Joints Size 6 as an interface, one side connected with biggest cross-section and other side prepared for two sockets for possible connection of two phases in case of an failure.



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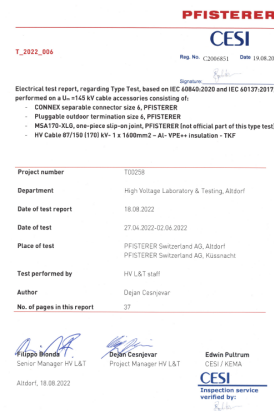
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New Product

Pluggable CONNEX-Termination 145kV

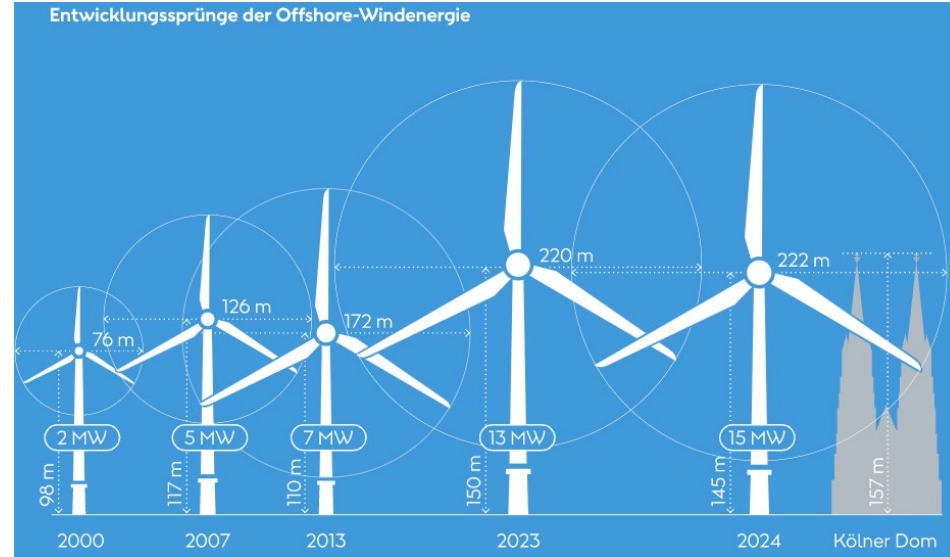
- Pluggable CONNEX-Termination up to 145kV
- Type Test available
- Retrofit and testing
- Reduced LI up to 550kV (+650kV)
- First orders from Schleswig-Holstein Netz AG and for Offshore-Plattform testing



Development Projects

SEANEX 145kV

- Increase of system voltage of the wind turbines from 66kV up to 145kV and transmission power up to 15MW



- Development of new Seanex Portfolio for 145kV, based on the established system for 66kV
- Full product range with EP-Joint, Socket, Connector, Surge Arrester by end of 2024

Vision and Outlook

- Maximum flexibility and new opportunities with “plug and play” technology
- Increased System Availability and Assure Maximum Safety
- Inner cone systems are a flexible solution for simple and safe network installations
- Complete substation indoors





Many thanks for your attention

PFISTERER
the power connection