Superconducting cables and links for grids and industrial applications.

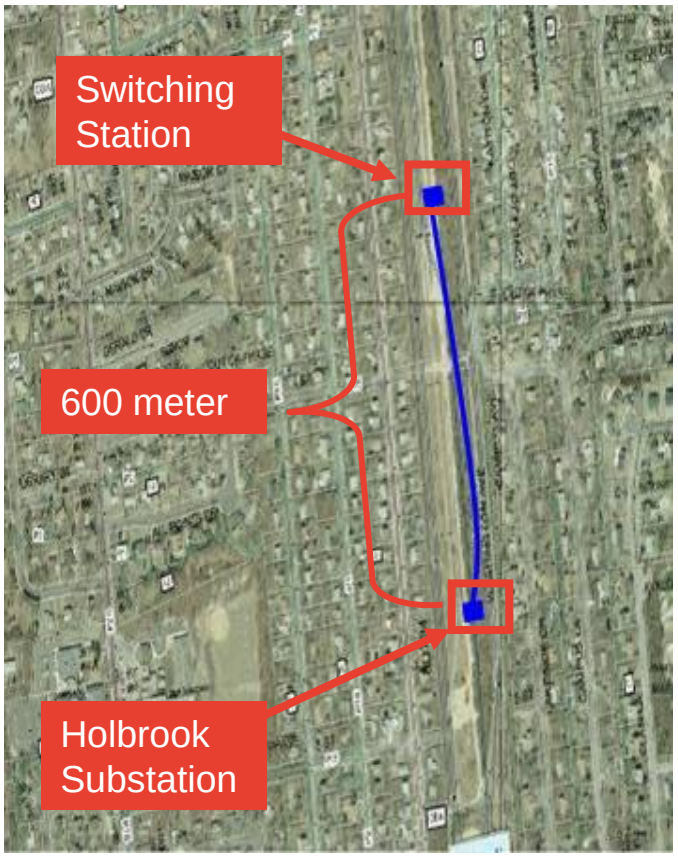
C.E.BRUZEK, Nexans France

Tiara meeting, CERN Genève
05 December 2012

AC transmission cable: LIPA1 project Overview

World's first installation of a transmission voltage HTS cable

- Long Island Power Authority – Holbrook Substation
- 600 m long cold dielectric cable system 138kV/2400A ~ 574MVA
- 1G HTS tapes
- Design fault current: 51 kA @ 12 line cycles (200ms)
- 600 meter cable pulled in underground HDPE conduit



AC transmission cable: LIPA1 project Installation

Cable successfully energized on April 22, 2008

Opportunities of DC cables and links

Infrastructures

- Long distance HVDC grids
- HVDC Inter-connections of different regional grids

Energy production

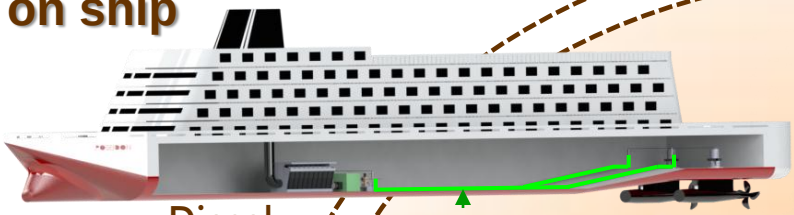
- LVDC et MVDC local grids for renewable energy farms (solar, wind, hydro, …)

On board distributions and high current level distribution

- Efficiency increase of local LVDC distribution (Ships, Data centers, campus, industries,…)

Applications

Power distribution on ship



- Diesel motor
- Generator
- Terminations
- Cooling system

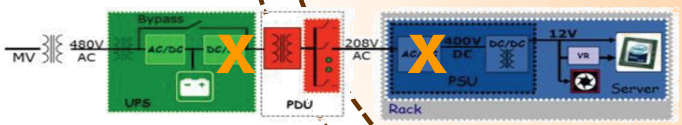
HTS cable

- Terminations
- Motors
- Ship propellers

smelting plant

Bus bar 250 kA

Data center



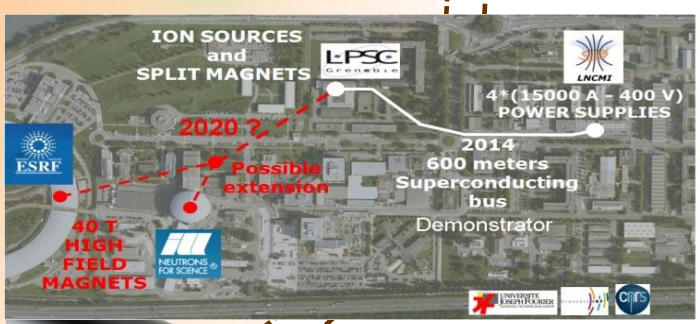
Conventional 480 VAC

Superconducting cable

Facility Level 400 VDC

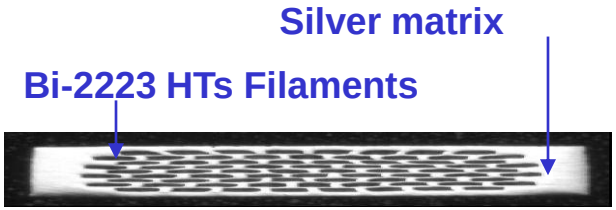
Pratt, A., P. Kumar, and T.V. Aldridge. *Evaluation of 400V DC Distribution in Telco and Data Centers to Improve Energy Efficiency.* in *29th International Telecommunications Energy Conference, INTELEC 2007.* 2007. Rome, Italy: IEEE

Campus

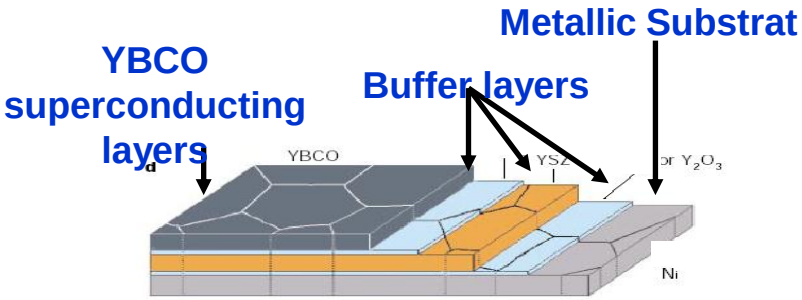


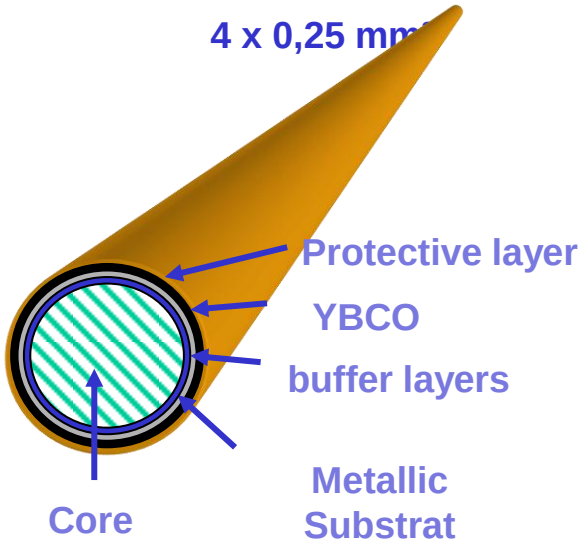
Superconducting tapes and wires for current transportation

- 1st generation: multifilamentary Bi 2223 tapes

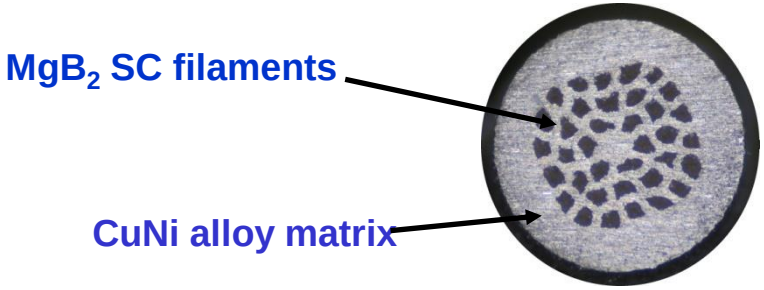


- 2nd generation : YBCO Coated conductor tapes and wires





- MgB_2 wires

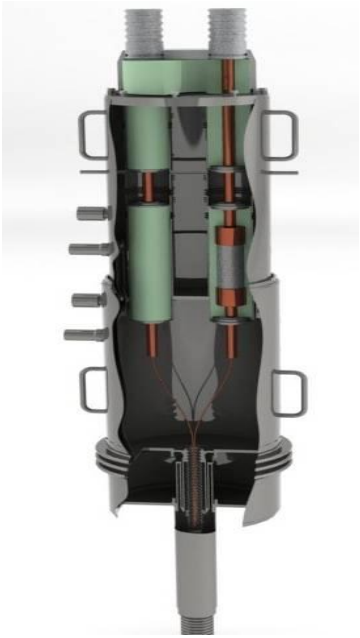


Others specific components

Cryogenic envelope: *Thermal insulation*

Accessories: *Connections*

- Terminations
- Joints



Cryo-cooler: *Generate cold power*

Flexible, coaxial cryogenic envelopes

2-Tube coaxial Transfer Line

1. Corrugated inner pipe
2. Spacer
3. Super insulation
4. Vacuum space
5. Corrugated outer pipe
6. Jacket

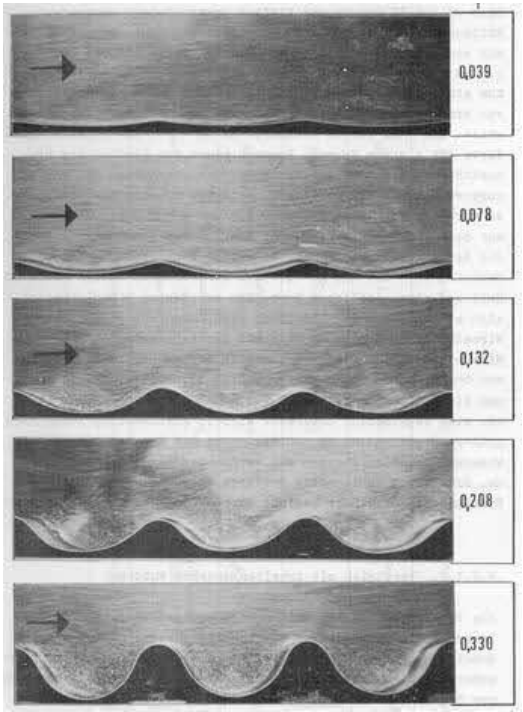
4-Tube coaxial Transfer Line:

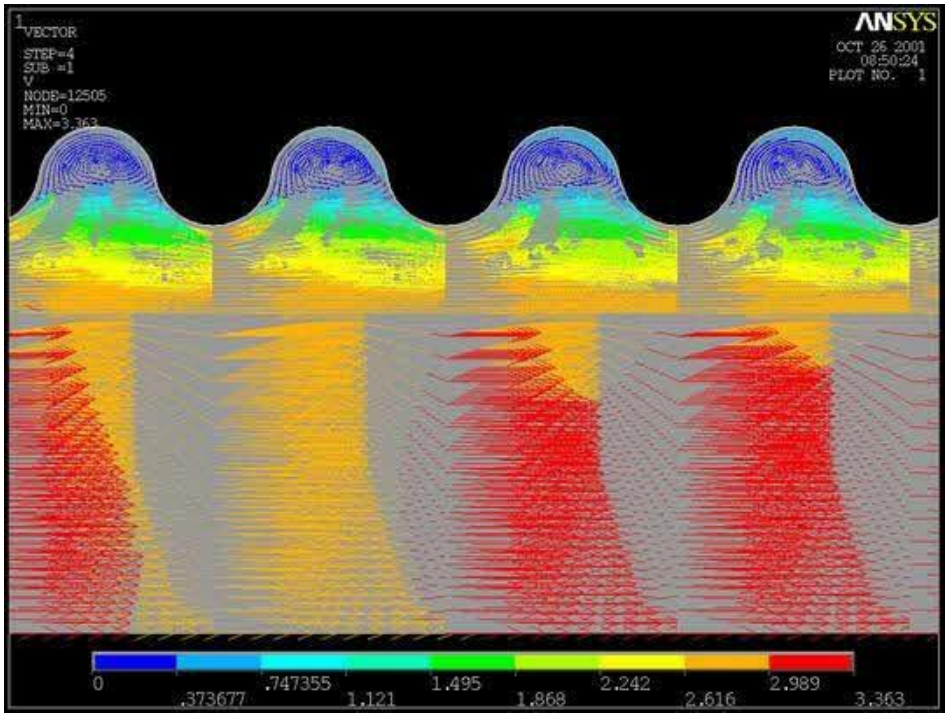
- flexible
- vacuum insulated
- extremely low heat inleak
- 2 flow channels

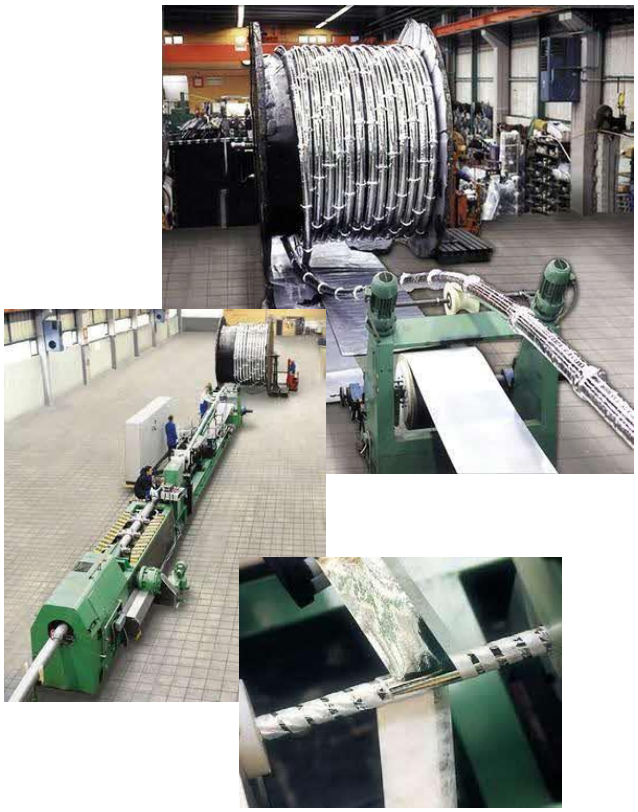
CRYOFLEX Optimization

Various corrugated tubes with different diameters and shapes have been examinated.

- optimum design for maximum flow, flexibility and stability
- certified max. operating pressure: 20bar







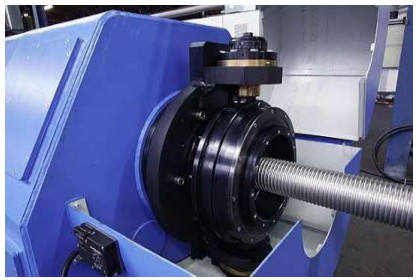
Unique manufacturing Process:

- longitudinal welding and corrugation of stainless steel in one step
- Automated winding of several layers of superinsulation and spacer

➡ Automated Tube production

- no length limitation
- constant quality standard
- cost leading

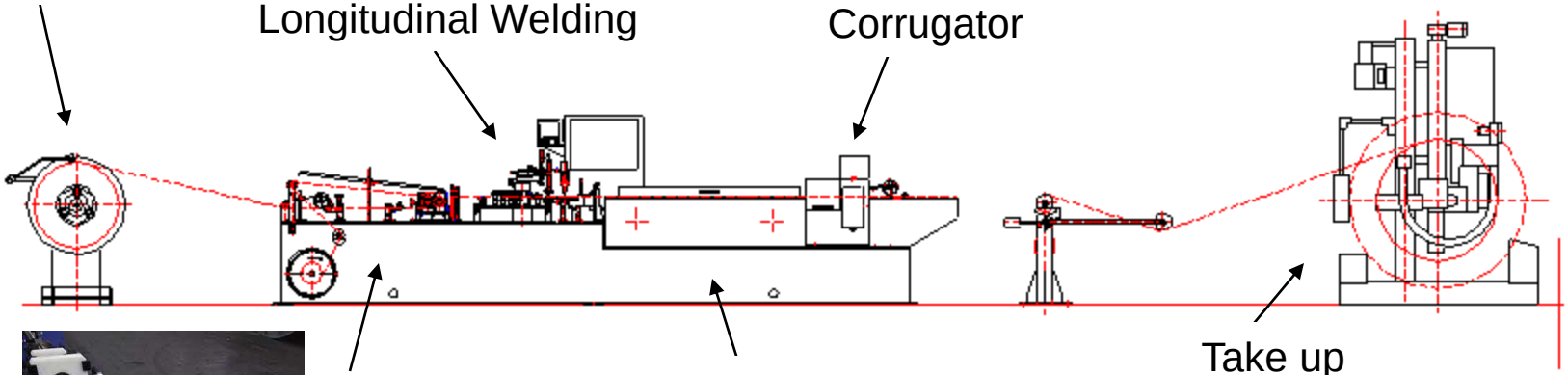
Layout of Tube Production Line



Strip pay off

Longitudinal Welding

Corrugator



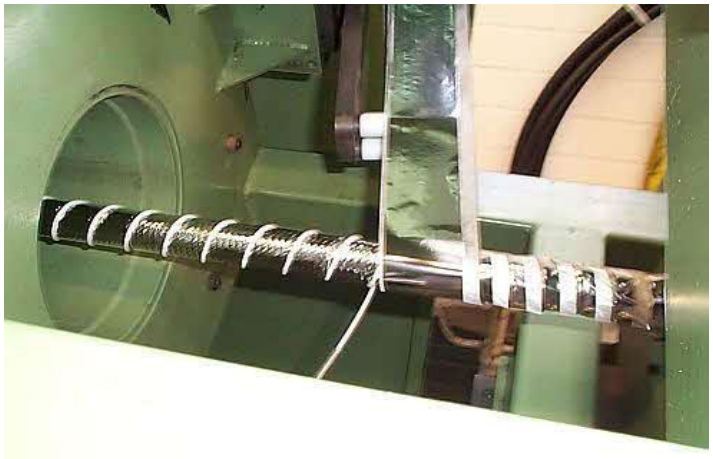
Tube forming

Caterpillar

Take up

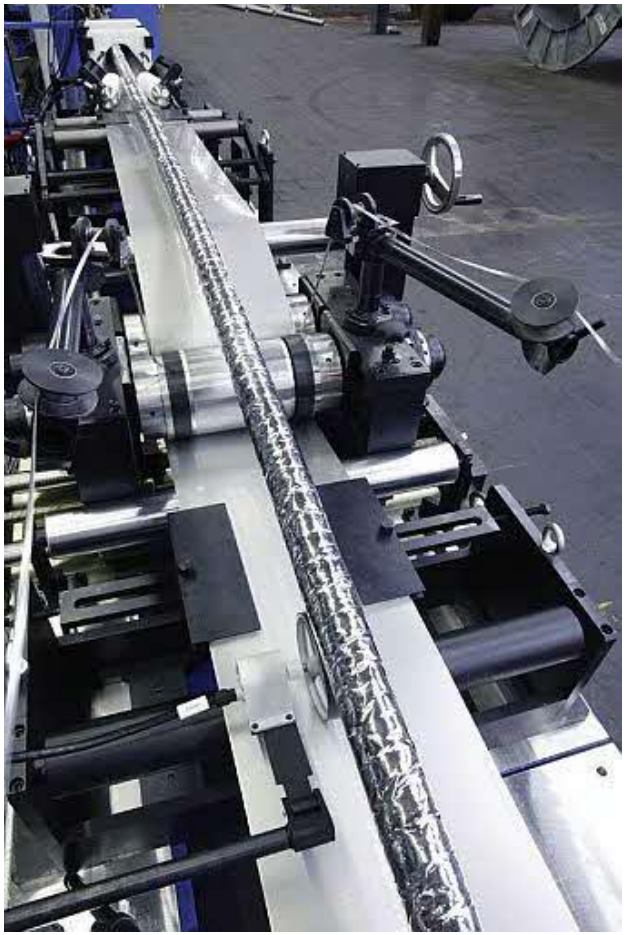
Superinsulation

Ultra Sonic Cleaning

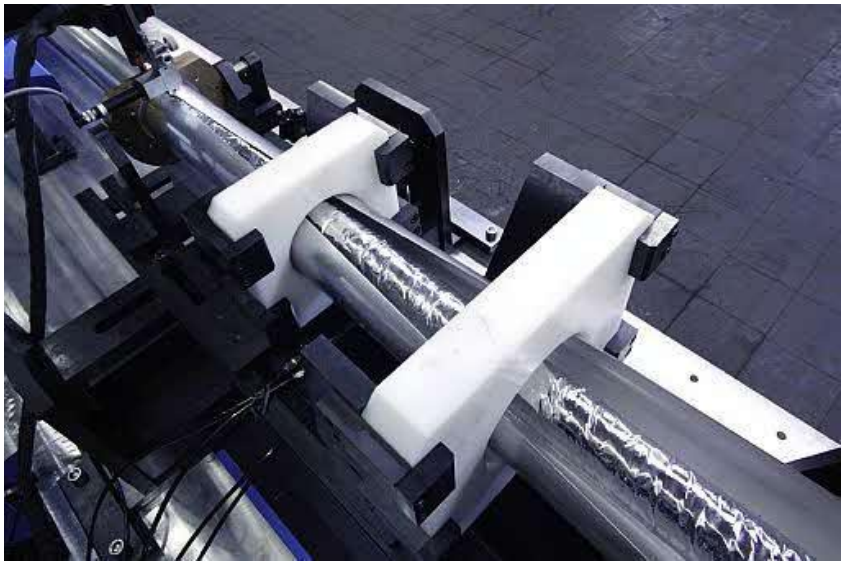


Automated winding of Superinsulation and Spacer

Cryoflex Manufacturing



Manufacturing of the outer Tube



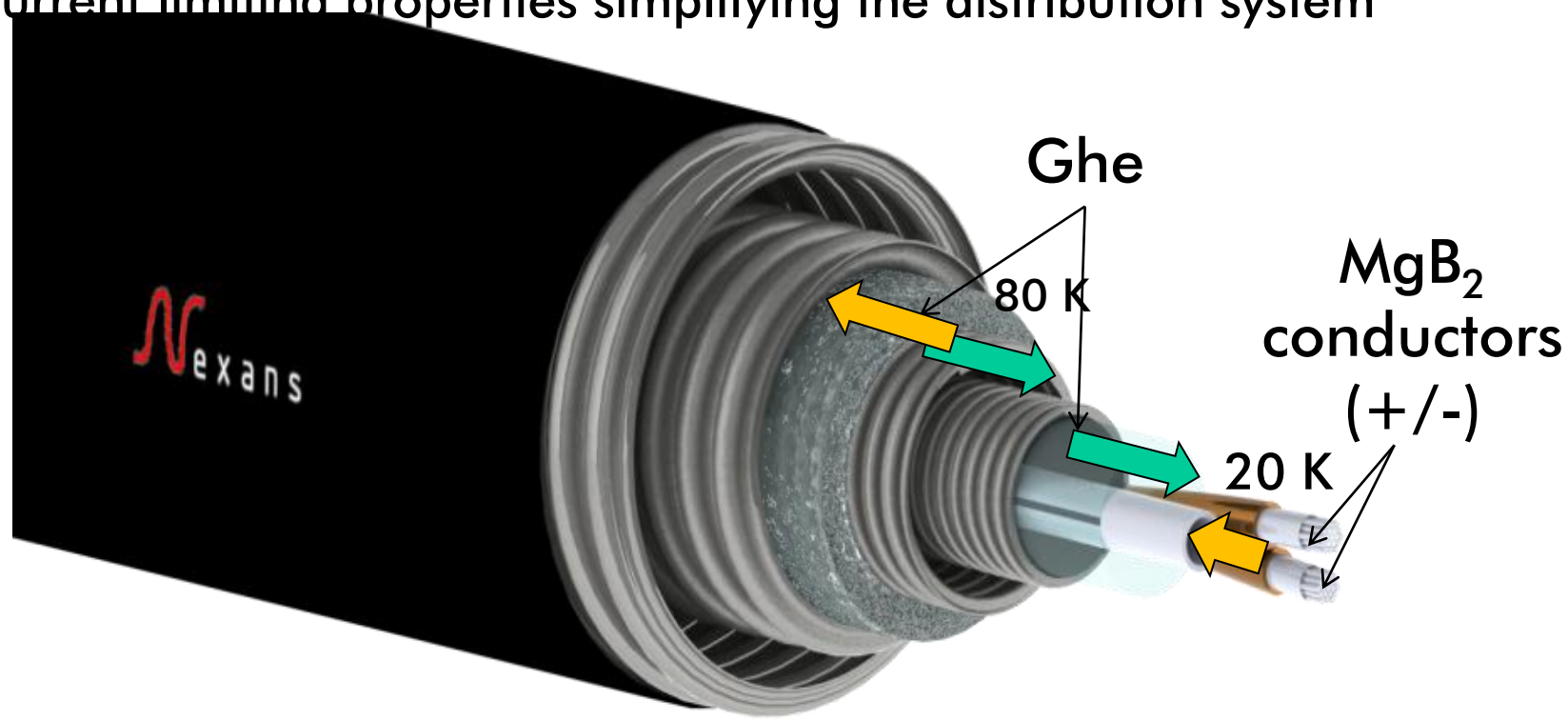
Installation

Cryoflex performances

	2 wall envelopes 			4 wall envelopes 	
Model	***Small envelope***	***Medium envelope***	***Large envelope***	***Small envelope***	***Medium Envelope***
Int /Ext Diameters (mm)	21/44	60/115	120/150	21/44/60/115	75/125/147/220
Bending radius (m) *(Several bends)*	0,7	1,8	2	2	3
Losses at Top /Shield* (W/m)	0,6	1,2	1,5	0,06 / 1,2*	0,1 / 1,5*
Weight kg / m	0,8	4	6	5	10

Ex: Superconducting power cables for ships (1)

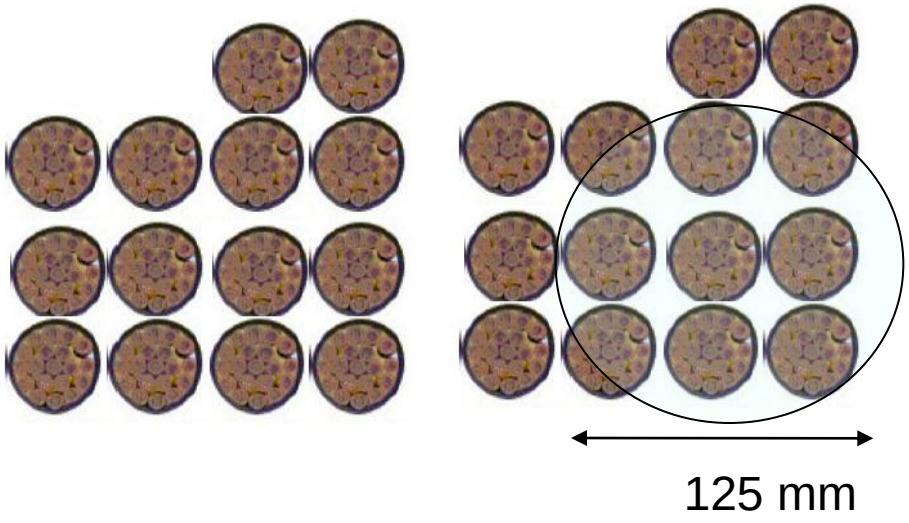
1. Distribution of high power possible at low voltage (<1000V) and in DC
2. Significant reduction of the losses for distributed power P> 5MW
3. Current limiting properties simplifying the distribution system



Ex: Superconducting power cables for ships (2)

3. No environmental impact *(thermal or electromagnetic)*
4. Very compact and light cable
   - D ext = 125 mm for bifilar SC cable 10 kA cable with a few kV (> 10 MW)
   - Cryogenics system footprint between 1 to 5 m^2

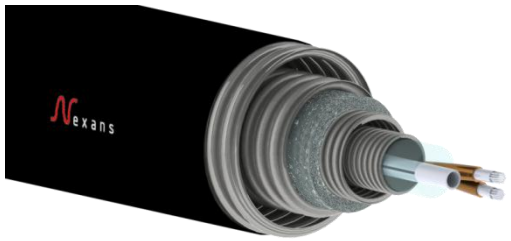
+/-



Ext diameter 125 mm

+/-

=



Conclusions

1. DC power distribution and transportation will be more and more used in electrical grids in the next future.
2. HTS superconductivity offers a unique possibility to suppress dispensable equipments (transformers, converters…) and can reduce investments in comparison with conventional systems.
3. DC superconducting cables and links offer an environment friendly approaches with an improvement of the efficiency of electrical systems.
4. For superconducting cable systems, high performance cryogenic envelopes are commercially available in kilometric piece lengths.

Merci pour votre attention !

Cartoon by

Thomas Kodenkandath

(*The Week*, 1988)