Max. Length of HTS Cables in the Future

K. Schippl, Nexans Deutschland Industries, Hannover, Germany

TOPICS:

Limitation of the cable design:

1. Physical limitations
2. Shipping limitations
3. Maintenance and repair problems

Superconducting Cable

- The first development of a superconducting cable took place in 1970
- Nexans started its new HTS Cable development program in 2002
- The focus of the development is the cold dielectric design which is more compact, provides
- A higher current

  transmission capacity and

  is environment-friendly

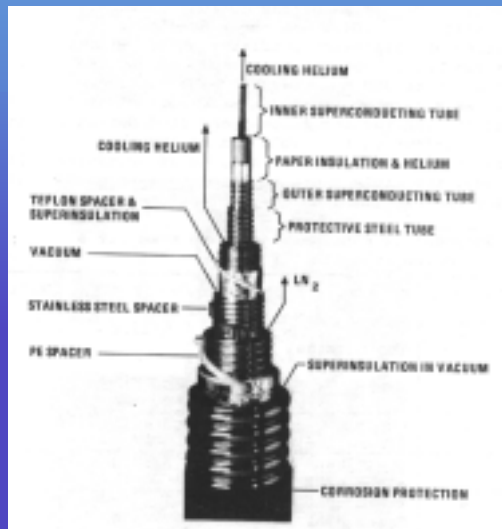
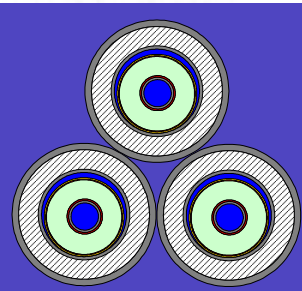


Fig. 1. Superconducting cable sample using "All-Wellmantel" construction.



3 independent phases

LIPA Project

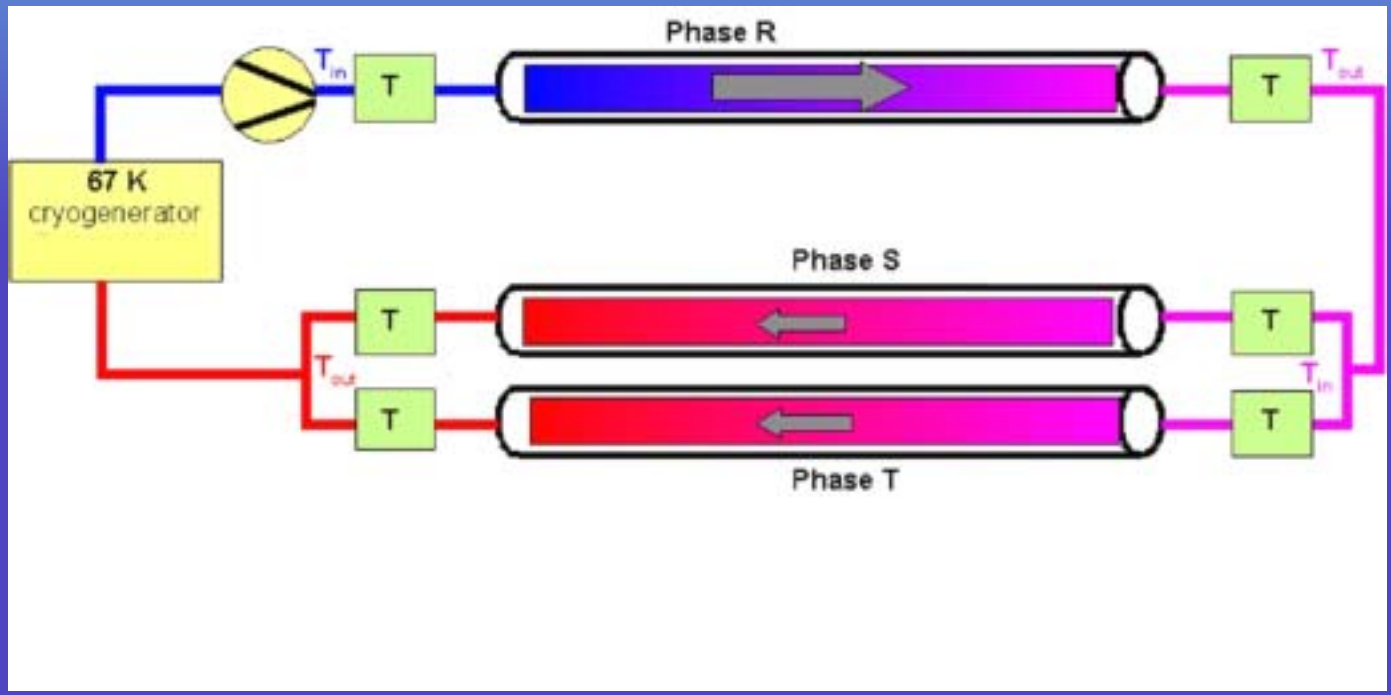
- Long Island Power Authority – East Garden City Substation
- Electrical Operating Characteristics
  - Operating Voltage/Current – 138kV/2400A ~ 600MVA
  - Design Fault Current – 69,000A @ 15 line cycles (250ms)
- Physical Characteristics
  - Installation – One 12” Pipe
  - Length – 620m
  - HTS Conductor Length – 128km
  - Cold Dielectric Design
- Hardware Deliverables
  - Three 620m long Phase Conductors
  - Six 138kV Outdoor Terminations & Accessories
  - One Refrigeration System

Worlds First Installation of a Transmission Voltage HTS Cable in the World

Physical Limitations

1. Physical limitations:
   - Pressure drop and heat inleak reduce the max. length to a cooling station.
   - The necessary good insulation vacuum limits the max. length of the vacuum space.

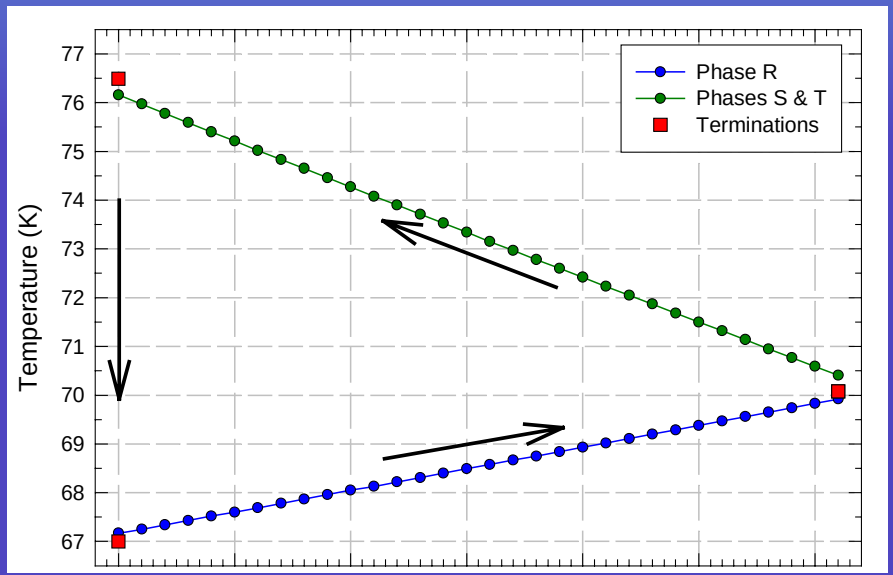
Physical Limitations

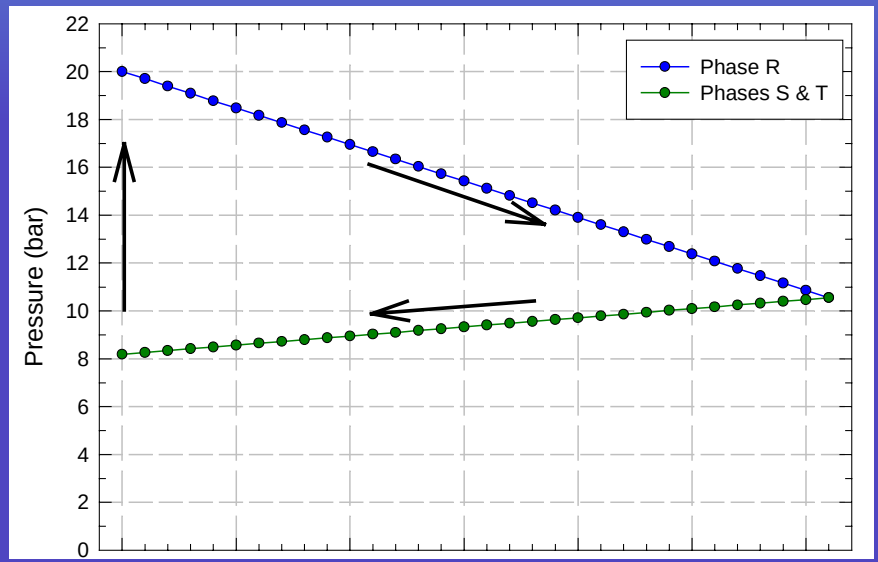


Flow of LN_2 in single phase and back in two phases

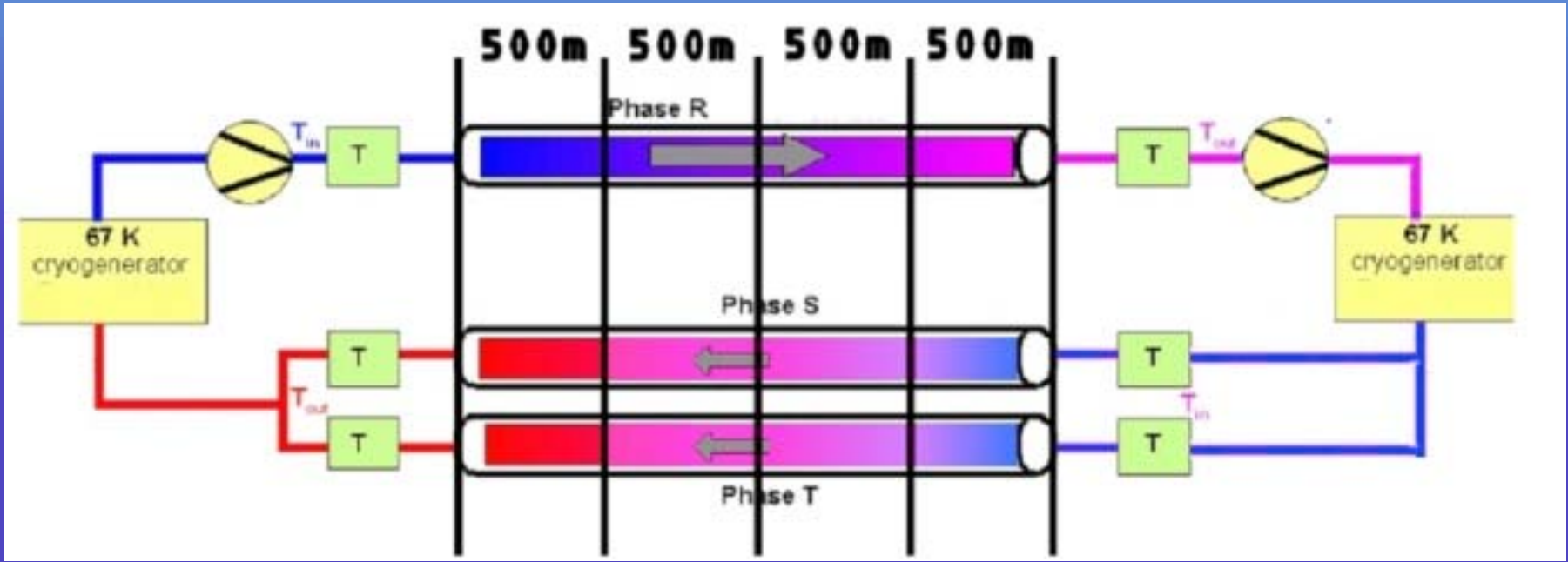
Calculations on pressure loss with single refrigeration and pump

Physical Limitations



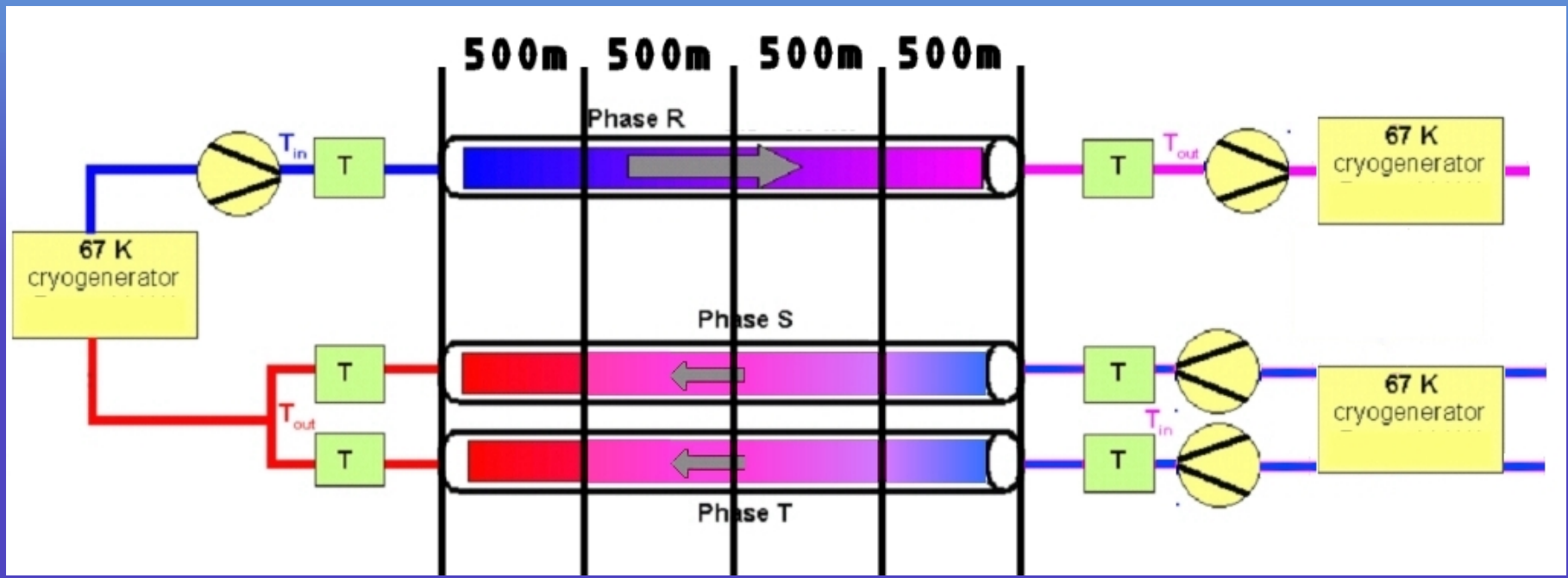


Physical Limitations



Flow of LN_2 in single phase and back in two phases with 2 refrigeration and pump stations

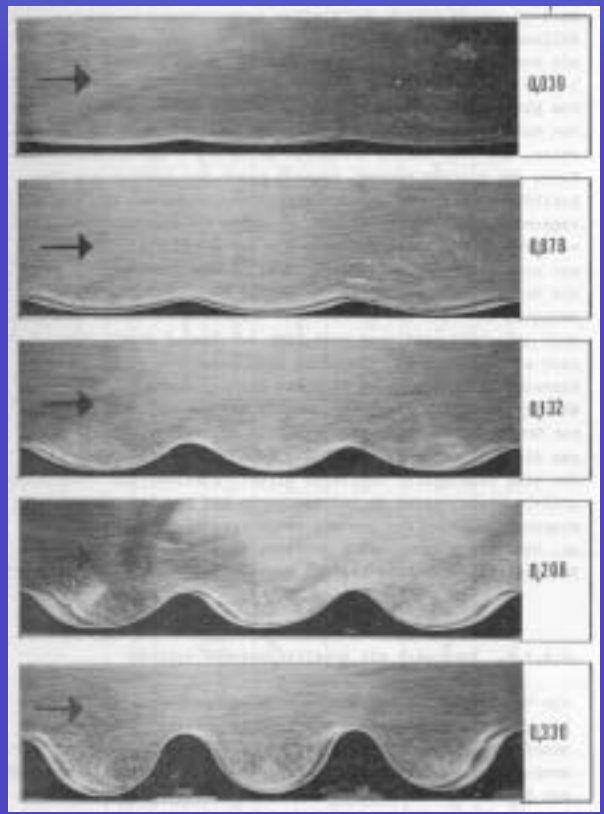
Physical Limitations

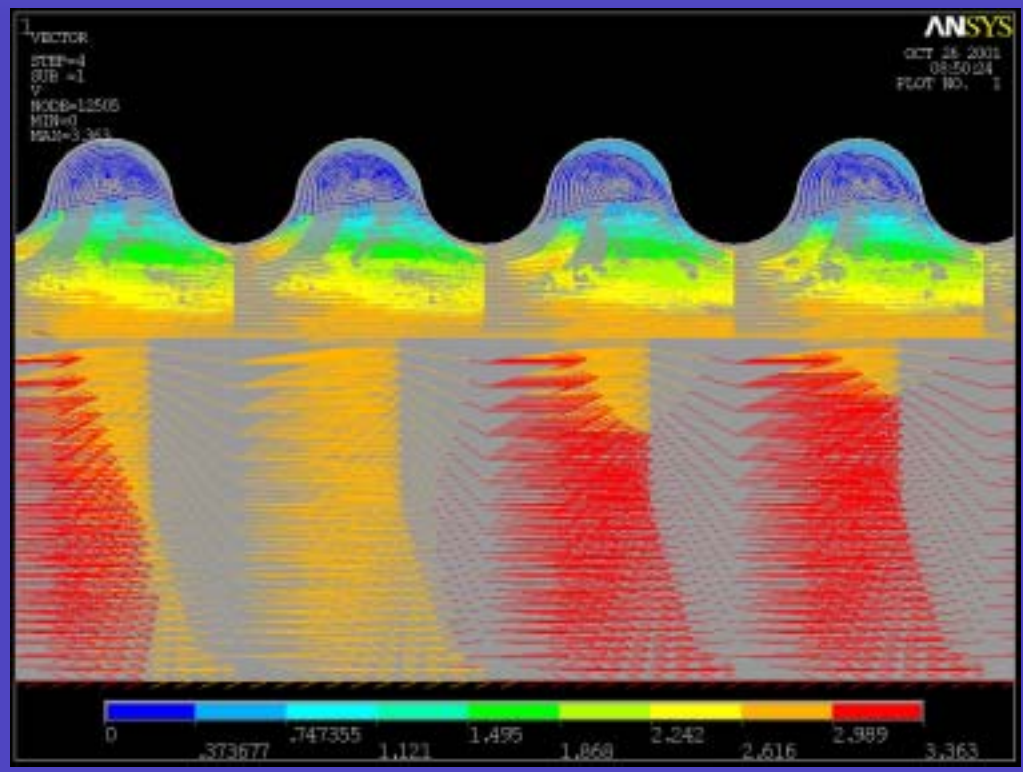


Flow of LN_2 in single phase and back in two phases with several refrigeration and pump stations

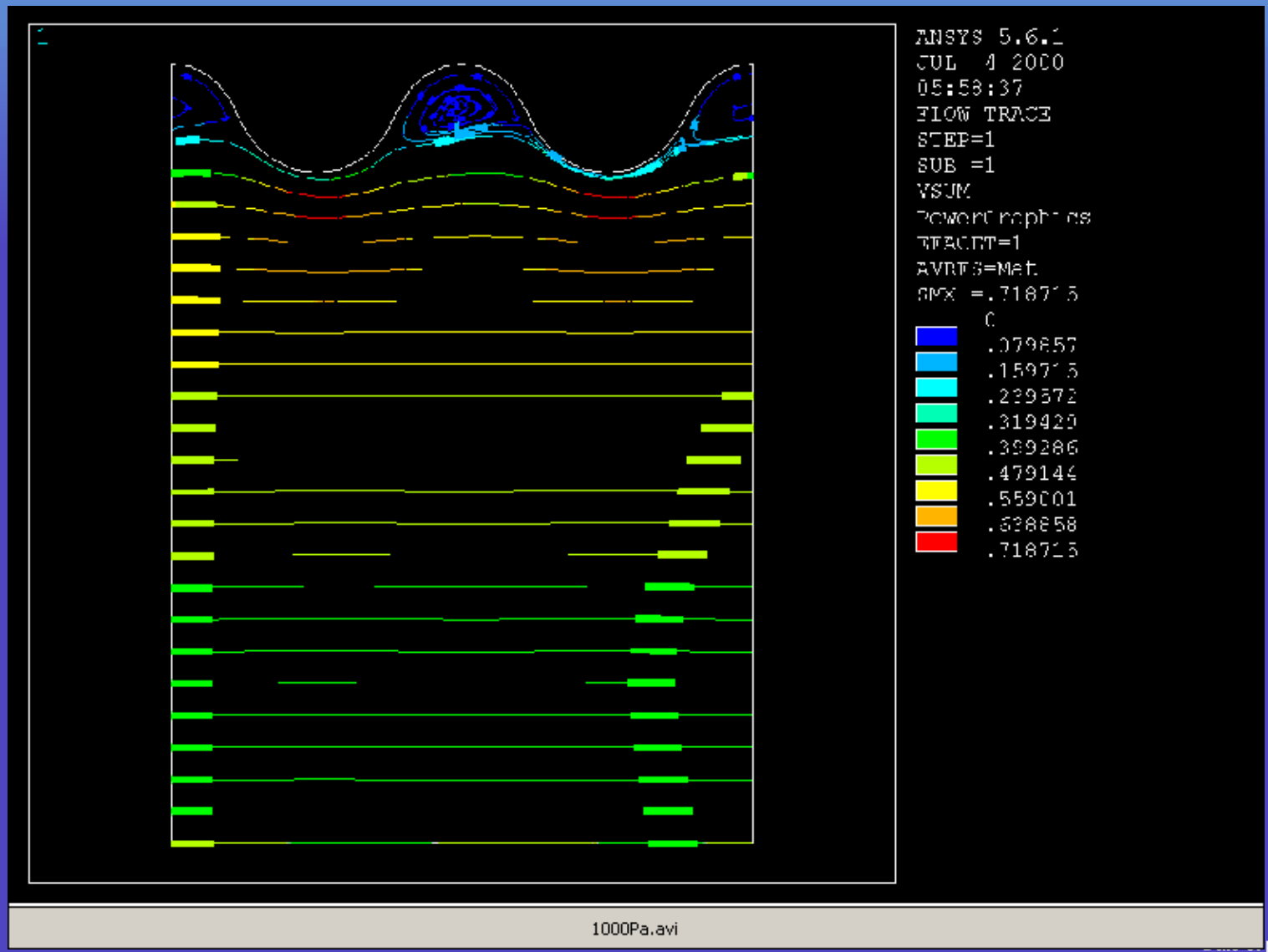
Physical Limitations

Different corrugated tubes with different diameters and corrugations have been examinated. The max. flow of gas for different tube design is established.

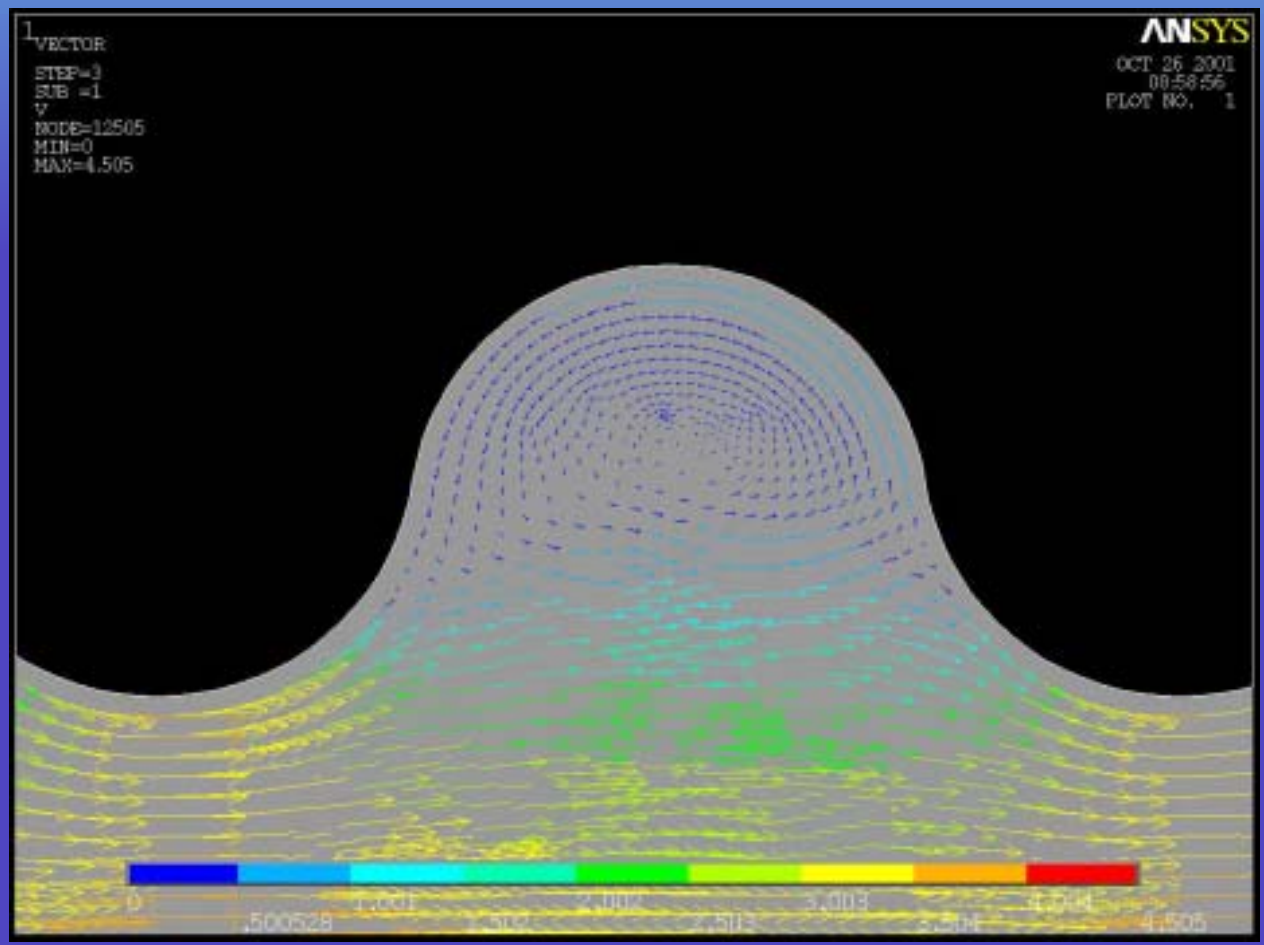




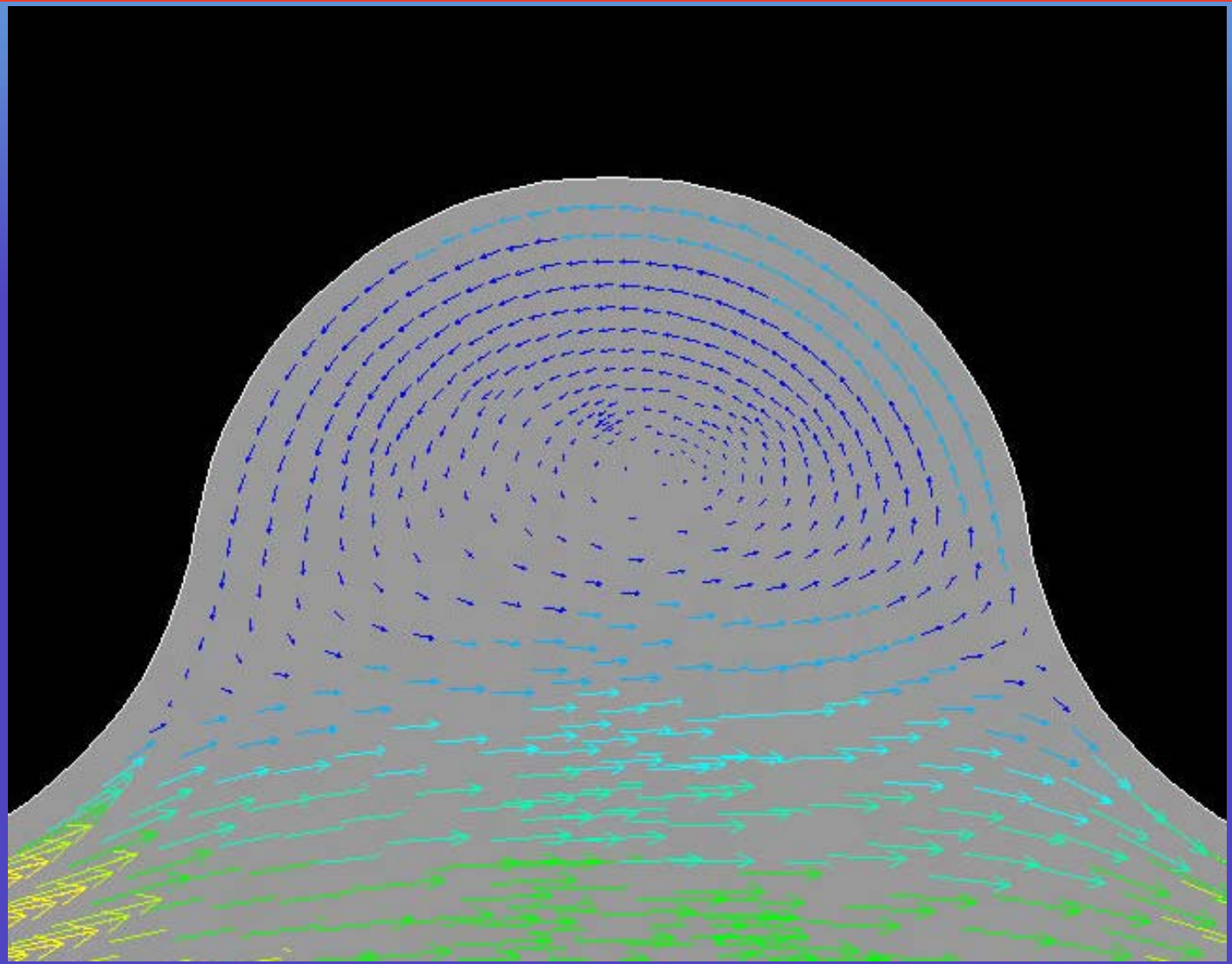
Physical Limitations



Physical Limitations



Physical Limitations



Physical Limitations

DataPerfect

Maß	Ergebnis	Einheit	Maß	Ergebnis	Einheit
V	1200.000000	kg/h	V	1.425461	m3/h
Xa	0.000000	1	Xe	0.000000	1
Pa	6.000000	10e5 Pa	Ta	70.000000	°K
Pe	4.340905	10e5 Pa	Te	81.695304	°K
DP	1.659095	10e5 Pa	DT	-11.695304	°K
Q zu	4.000000	W / m	Q To	8000.000000	W
ý	0.039000	m	L	2000.000000	m
v	0.353067	m / s	Lam	0.069264	Kauda
Re	83000.99610		Qg	0.000000	kg/h

Max. length due to pressure drop and heat inleak is in the range 2000m for a workable tube diameter

Summary Physical Limitations

- Max. length due to pressure drop and heat inleak will be in the range of 2000 m
- Insulation vacuum needs to be better than 1*10E-5 mbar
- Evacuating through an insulation gap is restricted to 100 m due to experience

Shipping Limitations

Shipping Limitations

Shipping limitations: about 600 m

Maintenance and repair problems

1. Leak of vacuum jacket

Decreasing of the vacuum inside the vacuum jacket

Repair:

- Rewelding the leak
- Leak testing
- Reevacuation:

Depending on vacuum decreasing, in the worst case vacuum pumping through all the pumping ports

2. **Breakage/Cutting of the cable including the cryogenic envelope**
   - Rising of the pressure inside the vacuum jacket up to 1 bara along the whole distance of the vacuum space length of about 600m
   - Decreasing of the temperature of the vacuum jacket to about 230 K
   - Condensing of humidity and forming of ice on cold parts inside the vacuum jacket including SI

Maintenance and Repair Problems

Repair:

- Replacing/rewelding the destroyed element including the conductor
- Leak testing
- Drying of the SI and all parts inside the vacuum jacket. Venting the vacuum jacket with dry nitrogen and reevacuating

If the drying process is not possible:

- Cutting off the section of wet length
- Replacing this section by a new one including the conductor.

Conclusion

1. Max. length of a HTS-Cable with one cooling station is limited to about 2000m due to pressure drop and heat inleak

2. Max. length for shipping with cable drum is restricted to about 600m

3. Evacuating through an insulation gap is restricted to 100 m due to experience