Report On The 2010 Workshop on HTS Wires

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Background

More than 60 representatives of the electric utility industry, universities, equipment manufacturers, Federal government agencies, interest groups and national laboratories attended the Workshop on High Temperature Superconducting Wires. The workshop sought to:

- Highlight significant HTS application opportunities and challenges
- Identify and elaborate key issues for the development of commercially viable 2G wires for these applications:
  - Discuss major 2G wire challenges and needs;
  - Develop effective action plans to address these needs; and
  - Identify top metrics and targets that will effectively measure the progress in 2G wire RD&D.

Background II

Organization:

- One Plenary Session
  - HTS Cables / S. Ashworth, LANL
  - HTS FCL / R. Duckworth, ORNL
  - Other HTS Applications / D. Larbalestier, NHMFL
  - Manufacturers' Perspective / AMSC & Superpower
- One Day of Breakout Working Groups

Article of Faith

- “Superconducting technology is a major part of a modern grid strategy that will reduce the demand for additional power generation, increase the capacity, functionality and reliability of the delivery infrastructure, and minimize our dependence on foreign oil and reduce greenhouse gas emissions.”

HTS Cables / S. Ashworth

- New opportunities in DC transmission
- Barriers to acceptance
  - Not considered ready for prime time by utilities
  - Conductor contributions to high system cost
  - Price, performance and availability in sufficiently-long piece lengths

HTS FCLs / R. Duckworth

- Barriers to acceptance … insufficient operation, reliability and maintenance data for the technology to be considered part of the utility planners' tool set.
- Wire challenges include price, performance and availability in sufficiently long lengths.
- Engineering issues including uniformity, normal state resistance, stability, AC losses, splice quality, etc., etc.

Other HTS Applications / D. Larbalestier

- DC generators, very high field magnets, motors, MRI, induction heaters, SMES…
- Challenges
  - Maximize in field J_c and J_e
  - Minimize I_c anisotropy
  - Length
  - Engineering issues:
    - Multi-filamentary and transposed
    - Round or lightly aspected shape
    - Capable to wind in un-reacted form

AMSC

- RABiTS/MOD production of 40 mm-wide, 500 m-long tapes, 200 to 250 A/cm.
- AMSC strongly believes that HTS system cost is the dominant factor for market penetration. Wire price is a contributor.
- Wire availability is the main issue. Production capacity is limited.

SuperPower, Inc.

- IBAD production of wires of 1 km length.
- Strongly believes that Cost/Performance is the leading barrier to HTS technology adaption.
- Company R&D efforts address both the cost and performance limitations.

Cables Working Group-1

Key Technical Barriers

- HTS (J_c, rate; area); number of steps
- J_c decrease with thickness
- J_c (self-field)
- Micro-structural inhomogeneities
- Processing cost
- Capital cost
- Yield
- Performance
- Piece length

Cables Working Group-2

Key Research and Development Needs

I_c Needs

- Improve understanding
- Improve HTS formation process
- Improve substrate/buffer quality
- Process stability improvements
- Mitigate surface roughness issues
- Suppress texture degradation
- Suppress second phase formation and control

Cables Working Group-3

Key Research and Development Needs

Throughput Needs

- Increase growth rate
- Increase nucleation rate
- Improve J_c
- Increase area of deposition
- Increase thickness per layer
- Substrate/buffer quality
- In-situ diagnostics and control
- Improve process stability
- Multifunctional buffer development
- In-situ diagnostics

Cables Working Group-4

Comments

"Additionally, there are micro-structural inhomogeneities of the YBCO layer that can cause issues with developing long lengths of high performance wire. For instance, over long lengths of wire there can be drop outs in I_c that result in the wire being cut to take the highest performing piece lengths. This is undesirable since the industry is driving to longer length piece lengths. The barriers for price/performance are generally shared with throughput and critical current."

FCL Working Group

- Price is important but disagreement if it should be included in the metrics. Wire/Price ratio may be more important
- Development to increase production rate
- $I_c(T)$ over longer lengths >10 meters
- Homogeneity of I_c
- Stabilization and AC loss issues

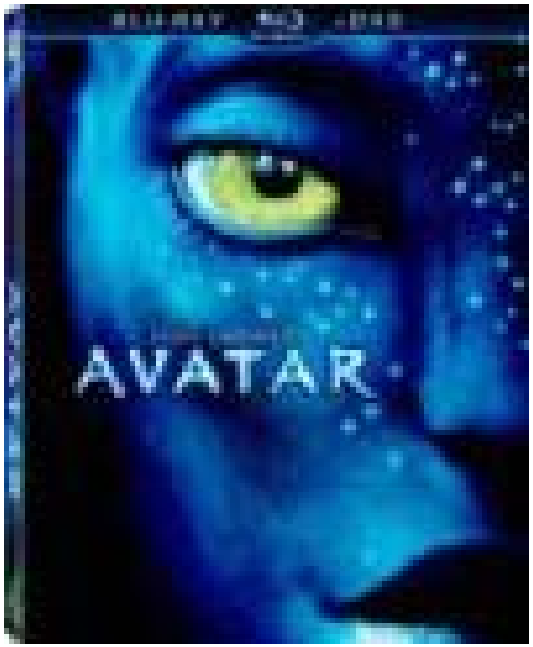
Other HTS Applications WG

- Discussion of Wire Cost-Price versus Supply-Availability. A reflection of the two predominant industry views.
- “Insufficient information concerning the practicality of various proposed approaches to reduce cost and enhance performance…”
- Technology and other metrics mirror the other groups.

Other HTS Applications WG-2

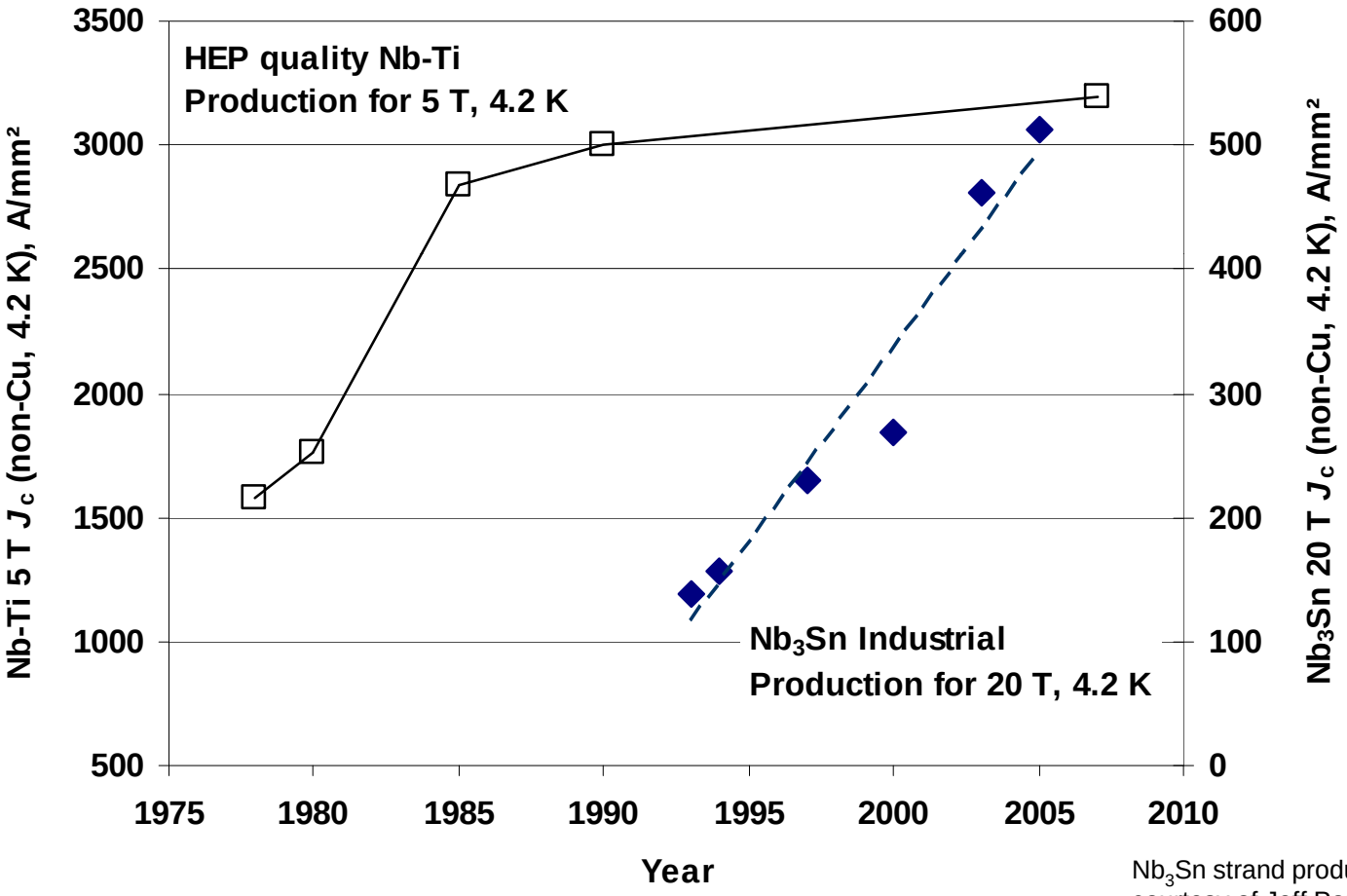
In addition, the following needs were discussed:

- Flux creep at high fields;
- Quench characteristics and stability of wires and trade-offs with AC loss reduction strategies;
- High mechanical strength and tight bend radius to ensure system reliability and compactness, especially for rotating machineries and high field magnets;
- Tightness of wire against cryogen infiltration (hermetic sealing);
- Inductance issue related to multi-kA cables to be used in magnets;
- Durability and potential degradation of wires after long-term storage;
- Insulation challenges;
- Helium availability and price for 4.2K operation, which has been predicted to become a critical issue about 2016;
- Need for industry, ASTM/IEEE/ASME etc. and international standards;



Unobtanium (pronounced *un-ub-TAIN-e-um*) is a highly valuable mineral found on the moon Pandora which humans mine to save the Earth from its energy crisis. Bluntly, they need it for their survival. It is a room temperature superconductor for energy, which makes it very valuable: it is worth $20 million per kilogram (about 2.2 pounds) unrefined (worth $40 million per kilogram refined) on Earth. However, It is expensive to mine on Pandora as humans are unable to breathe in the Pandoran toxic atmosphere.

HEP Quality Nb-Ti and Nb_3Sn Production Progress



Nb_3Sn strand production data courtesy of Jeff Parrell (OI-ST)

Where to from here?

- Production is capacity limited for any big project.
- Lots of admirable goals but no research plan.
  - Moving ahead in all directions.
- Improve conductor manufacturer and user interface.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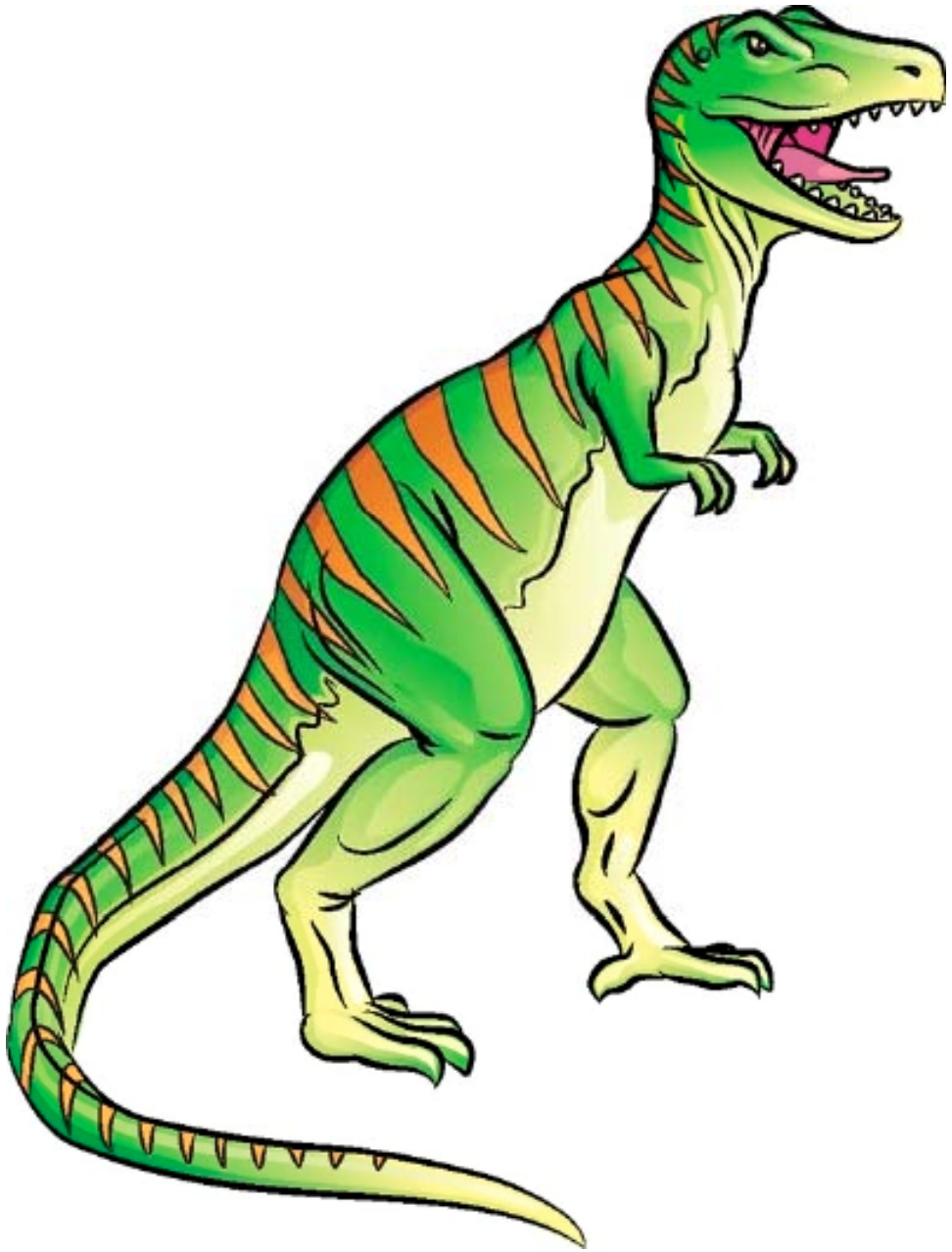

	NbSn	density	Strand Ø mm	Lenght km	weight (kg)	Cost in $	
1	11 T DS dipole - 1.5 m model	9	0.7	38	168	251,370	by 2011-12
2	IT Quad - 1.5 m long	9	0.8	27	156	194,400	by 2011-13
3	Fresca 2 13 T dipole 1.5 m	9	1	55	495	742,500	by 2011-12
					0		
4a	MgB2 strands (for cable) R&D	7.5	1.1	120	1089	120,000	by 2010-11
4b	MgB2 strands (for cable) cons	7.5	1.1	1200	10890	1,200,000	by 2012-13
5	YBCO tape (for cable) R&D	7.5	4.1x0.1 mm2	120	369	??	by 2010-11