WP10.2 – Status

L. Bottura December 1st, 2015

tapes

Tape ID	Delivery	Length	Width	Thickness	Substrate	REBCO	Ag	Cu	lc(77	(, s.f.)	Ic(4.2 K, 18 T)	Je(4.2 K, 18 T)
									minimum	average		
		(m)	(mm)	(µm)	(µm)	(µm)	(µm)	(µm)	(A)	(A)	(A)	(A/mm**2)
E2B-T003	13.6.2013	2	4.05	130	97	1	1	30		110	120	228
E2B-T002-C	19.7.2013	2	4.05	150	97	3.8	1	50		130	235	387
E2B-T053-C	8.2.2014	1.5	12	160	97	2.2	1.2	30		210		
E2B-T189D-C	8.2.2014	22	4	150	97	1.7	1.8	25		52	334	557
E2B-T190D-C	24.3.2014	2	4.2	195	97	2	1.8	45		47	502	613
E2B-T191D-C	11.4.2014	2	4.2	200	97	2	1.8	50		54	420	500
SP-KIT-2013030			12	100					362	364		
SP-KIT-20130729			12	100					278	283		
E2B-14-T254	11.12.2014	21	12	155	97	1.3	1.8	20		125	684	368
E2B-14-T252D	18.12.2014	17.8	12	150	97	1.5	1.8	20		145	933	518
E2B-14-T255D	18.12.2014	18	12	150	97	1.3	1.8	20		126	808	449
E2B-15-T270D-1	8.1.2015	13	12	140	97	1.8	1.8	20		130	1284	765
E2B-15-T270D-2	8.1.2015	22.1	12	140	97	1.8	1.8	20		130	1284	765
E2B-14-T253	3.6.2015	20	12									1
E2B-15-T280D	Q1 2015	20	12							129	913	1
E2B-15-T281D	30.4.2015	23.2	12		97					133	940	1
E2B-15-T283D	15.6.2015	36	12	140	97	1.6	1.8	20		130	1188	705
E2B-15-T284D	15.6.2015	25	12	140	97	1.5	1.8	20		120	1001	596
E2B-T278D	26.6.2015	7.3	4.2	195	97	1.7	1.8	47		47	343	419
E2M-T12500-150611-02	13.6.2015	100	12.1	105					568	595		
E2X-T2015_08a(20-56)	1.9.2015	200	12	103	60	1	2	20	450			
E2B-14016-2-1-0_T275D-A_Ag	26.10.2015	5.2	4	100	97	1.3	1.8			45	240	600
E2F-XXXX	11.2015	200	12									
S	Feb-16	200	12									
В	Q1 2016 (TBD)	750	12									
В	Q3 2016 (TBD)	750	12									
_	Q1 2016 (TBD)	750	12									
_	Q3 2016 (TBD)	750	12									
		1		1	1	1		1				1

760 m of tape produced (EuCARD2 partner Bruker) and procured (CERN)

We are covered for the small coil program (Feather0)

We still need the large production for the program bulk (estimated at 3 km total)

cables

Name Length Delivery Width Pitch Thickness SC Tapes Cu Tape Tape origin Tape ic Expected cable ic (m) (mm)	Cable sample	es cata	logue - si	perco	nduc	ting											
77 K, s.f. 4.2 K, 20T	Name	Length	Delivery	Width	Pitch	Thickness	SC Tapes	Cu Tape	s T	ape o	rigin	Tape width	Tape thickness	Тар	e ic	Expected	d cable Ic
(mm) (mm) (mm) (mm) (mm) (mm) (mm) (mm) (mm) (m) (m) </th <th></th> <th>77 K, s.f.</th> <th>4.2 K, 20 T</th> <th>77 K, s.f.</th> <th>4.2 K, 20 T</th>														77 K, s.f.	4.2 K, 20 T	77 K, s.f.	4.2 K, 20 T
E25-15/5.5-002 1.6 6.1.1.2014 12 226 0.8 15 0 5P-KIT-20130729 12 0.1 362 1443 E25-15/5.5-002 1.8 6.1.1.2014 12 226 0.8 15 0 SP-KIT-20130729 12 0.1 278 1126 E25-15/5.5-003 5 1.5.2015 12 226 1.12 15 0 T281D 12 0.14 133 1050 886 4 E28-15/5.5-004 2 Sep-15 12 226 1.12 15 0 F281D 12 0.14 133 1050 886 4 E28-15/5.5-004 2 Sep-15 12 226 1.12 15 0 E28-15/5 138 878 4 E28-15/5.5-005 1 Sep-15 12 226 1.12 10 188 878 4 E28-15/5.5 10 Sep-15 12 226 1.12 10 188 878 4 E28-15/5.5 10 Oct-15 E20-15/5.5-001 3 4.4.2014 <td></td> <td>(m)</td> <td></td> <td>(mm)</td> <td>(mm)</td> <td>(mm)</td> <td>(-)</td> <td>(-)</td> <td></td> <td></td> <td></td> <td>(mm)</td> <td>(mm)</td> <td>(A)</td> <td></td> <td>(A)</td> <td></td>		(m)		(mm)	(mm)	(mm)	(-)	(-)				(mm)	(mm)	(A)		(A)	
E25-15/5.5-002 1.8 6.11.2014 12 226 0.8 15 0 9F-NT-12030729 12 0.1 278 1126 E25-15/5.5-002 5 1.5.2015 12 226 1.12 15 0 7E31D 12 0.1 278 1126 E28-15/5.5-003 5 1.5.2015 12 226 1.12 15 0 7E31D 12 0.14 133 1050 896 4 E28-15/5.5-004 2 Sep-15 12 226 1.12 15 0 7E31D 12 0.14 133 1050 896 4 E28-15/5.5-004 2 Sep-15 12 226 1.12 15 0 7E31D 12 0.14 130 188 878 4 E28-15/5.5 10 Sep-15 12 226 15 10 16 12 130 188 878 4 E28-15/5.5 10 Sep-15 12 226 15 10 130 178 Tape Tape Tape <t< td=""><td>E2S-15/5.5-001</td><td>1.6</td><td>6.11.2014</td><td>12</td><td>226</td><td>0.8</td><td>15</td><td></td><td>0 SP-KI</td><td>T-2013</td><td>030</td><td>12</td><td>0.1</td><td>362</td><td></td><td>1443</td><td></td></t<>	E2S-15/5.5-001	1.6	6.11.2014	12	226	0.8	15		0 SP-KI	T-2013	030	12	0.1	362		1443	
E28-15/5.5-003 5 1.5.2015 12 226 1.12 15 0 T270D-1, E28-15- T270D-2, E28-15- T270D-2, E28-15- 12 0.14 133 1050 896 4 E28-15/5.5-004 2 Sep-15 12 226 1.12 15 0 F28-15-T283D 12 0.14 130 1188 878 4 E28-15/5.5-005 1 Sep-15 12 226 1.12 15 0 E28-15-T283D 12 0.14 130 1188 878 4 E28-15/5.5-005 1 Sep-15 12 226 0 12 0.14 130 1188 878 4 E28-15/5.5-006 35 Dec-15 12 226 0 12 0.1 10 10 1188 878 4 10 12 0.1 10 10 10 12 10 11 1188 878 4 12 12 11 1188 878 4 10 12 11 118 118 118 118 118 11 11	E2S-15/5.5-002	1.8	6.11.2014	12	226	0.8	15		0 SP-KI	T-2013	0729	12	0.1	278		1126	
220-15/5-004 2 260-13/5 1.12 13 0 120.10 12 0.14 133 10.50 690 4 220-15/5-5004 2 Sep-15 12 226 1.12 15 0 120.11 130 1188 878 4 220-15/5-5006 35 Dec-15 12 226 1.12 15 0 120.14 130 1188 878 4 E20-15/5.5-006 35 Dec-15 12 226 0.14 130 1188 878 4 E25-15/5.5 10 Sep-15 12 226 0.14 130 1188 878 4 E25-15/5.5 10 Oct-15 10 Cable samples catalogue - dummies Tape origin	F2B-15/5 5-003		1 5 2015	12	226	1 12	15		E2B-1 14-T2 T270 T270	14-T252 255D, E D-1, E2 D-2, E2	2D, E2B- 2B-15- B-15- B-15-	12	0.14	122	1050	806	4252
L2b-15/5.5-004 L2 L1.12 L3 D L2b-15/12350 L2 D L1 L1.12 L3 D L2b-15/12350 L3 D L1.12 L3 D L2b-15/12350 L3 L3 D L3 L3 D L3 <thl3< th=""> L3 <thl3< th=""> <</thl3<></thl3<>	E2B-15/5.5-003	2	1.5.2015	12	220	1.12	15		0 528 1	U 15 T 202	20	12	0.14	133	1050	030	4233
C20-15/5.5-005 Sep-15 12 225 Colle samples catalogue - dummes Image Tape Tape<	228-15/5.5-004	4	5ep-15	12	220	1.12	15		U EZB-J	15-1263	50	12	0.14	150	1100	0/0	4013
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Legent 15,5-006 35 Del's 12 300 Tape Tape Tape Tape E25-15/5.5 10 Sep-15	E2B-15/5.5-005	25	Dec 15	12	220												
Name Length Delivery Width Pitch Thickness SC Tapes Cu Tapes Tape origin width thickness E2X-15/5.5 10 Oct-15 (m) (mm) (mm) <td>EZIVI-15/5.5-000</td> <td>33</td> <td>Dec-15</td> <td>12</td> <td>300</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>Таре</td> <td>Таре</td> <td></td>	EZIVI-15/5.5-000	33	Dec-15	12	300										Таре	Таре	
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C2A-15/5.5 10 OCC+15 (m) (mm)	E23-13/3.3	10	Oct 15														
C2M-13/5.3 0 0ctr13 E2D-15/5.5001 3 4.4.2014 12 226 0.8 15 0 dummy SS 12 0.1 E2F-15/5.5 10 Oct-15 E2D-15/5.5002 3 4.4.2014 12 226 1.5 15 dummy SS 12 0.1 E2F-15/5.5 30 Dec-15 E2D-15/5.5003 20 13.5.2014 12 226 0.8 15 0 dummy SS 12 0.1 E215/5.5 30 Dec-15 E2D-15/5.5003 20 13.5.2014 12 226 0.8 15 0 dummy SS 12 0.1 E215/5.5 30 Dec-15 E2D-15/5.5003 13 1.10.2014 10 426 0.8 15 0 dummy SS 12 0.1 E215/5.5 20 Feb-16 E2D-15/5.5006 32 1.8.2015 12 300 0.8 15 0 dummy SS 12 0.1 E215/5.5 20 Feb-16 E2D-15/5.5-008 32 1.8.2015 12 226 0.8 15 0<	E2X-15/5.5	10	Oct-15				(m)		(mm)	(mm)	(mm)	(-)	(-)		(mm)	(mm)	
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E2D-15/5.5 20 Oct-15						E2D-15/5.5	20	Oct-15	i								-
						E2D-15/5.5	20	Oct-15									1

140 m of dummy cable + 10 m SC cable produced (EuCARD2 partner KIT) and procured (CERN) Additional procurement action for 35 m SC cable to meet milestone MS66 (CERN): first full length !

REBCO tapes specs

- Tape width: 12 mm
- Tape thickness: 0.1 mm (SP, SuperOX, Sunam) ... 0.14 (BHTS) mm
- Electrodeposited copper layer (after punching): 2 x 20 μ m
- Engineering current density (20 T, 4.2 K) > 400 A/mm² (target 600 A/mm²)
- Critical current (20 T, 4.2 K) > 500 A (target 670 A)
- Unit length: minimum 50 m (> 30 m needed for magnet winding)
 - UL for Aligned Blocks: 20 m (1.2 mm thick cable) to 28 m (0.8 mm thick cable)
 - UL for Cos Theta: 17 m (1.2 mm thick cable)

cut tape geometry

• Optimal geometry as defined by KIT



- t = 5.85 ... 5.9 mm
- g = 0.2 mm
- $\alpha = 30^{\circ}$
- p = 300 mm
- R = 10 mm

baseline cable designs

Skinny Roebel (AB) (out of 0.1 mm tapes)

Number of tapes	(-)	15
Width	(mm)	12
Thickness	(mm)	0.9±0.1
Transposition pitch	(mm)	300
Critical current (4.2 K, 20 T perpendicular)	(kA)	≥ 4.8

Fat Roebel (CT+AB) (out of 0.14 mm tapes)

Number of tapes	(-)	13
Width	(mm)	12
Thickness	(mm)	1.1±0.1
Transposition pitch	(mm)	300
Critical current (4.2 K, 20 T perpendicular)	(kA)	≥ 5.8

measured cable thickness



• Measured Roebel cable thickness is about 10 % higher than ideal one

$$t_{measured} \approx 1.12 t_{ideal}$$

 Spread is relatively large, and physical (cross-overs, center vs. edges,...), typically ± 0.1 mm

summary

- Tape production
 - Bruker PLD300 restart planned for end of January 2016, PLD 600 will be used to produce 12 mm tape for the next EuCARD2 delivery (A. Usoskin)
 - CERN procurement feeds magnet R&D in the meantime (A. Ballarino)
- Cable production
 - KIT new tool imminent, production to restart in January with new geometry (W. Goldacker)
- Transverse pressure experiment on Roebel cable
 - KIT, Twente finalizing test geometry and procedure (W. Goldacker, M. Dhalle)
- AC loss measurement and analysis
 - Twente, Southampton, CERN completed first iteration, hysteresis dominates, and collective cable effects are important (M. Dhalle, Y. Yang) – next step ?
- Quench experiment
 - Bruker, KIT provided tape samples (to be Cu-coated), Twente ready to measure (M. Dhalle) – next step ?
- BSCCO cable test
 - CERN HT holder and "vintage" cable at NHMFL, discussions to schedule HT in the OPHT furnace