DI-BSCCO

Advances in Bi-2223 wire for High Field Applications

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Outline

- ✓ **Introduction to DI-BSCCO®**
- ✓ **Updated status of "Type HT-NX"**

  I_c performance and mechanical strength
- ✓ **R&D activities**

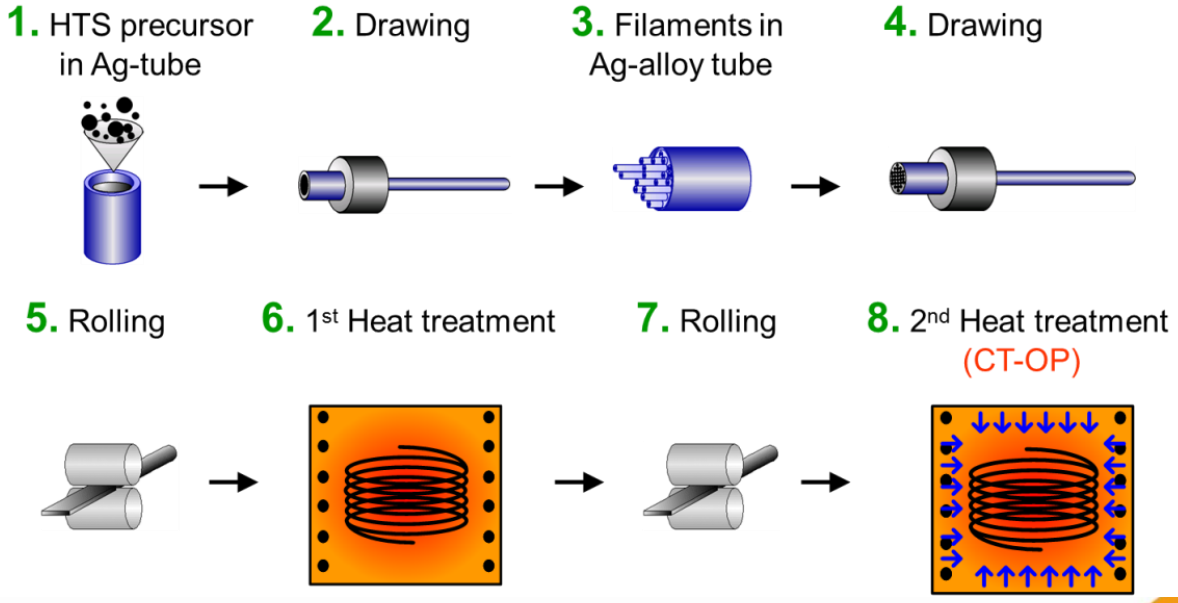
  Improvement of spliced structure with TypeHT-NX
- ✓ **Summary**

Lineup of DI-BSCCO

Specifications (Bare tapes)

	TypeH High Current Density	TypeG Low Thermal Conductance Au-Ag 5.4wt% sheathed,
Average Width	4.3±0.2mm	4.3±0.2mm
Average Thickness	0.23±0.01mm	0.23±0.01mm
Ic (77K, self field)	180~200A	180~200A

PIT process



CT-OP furnace
(Controlled Over Pressure)

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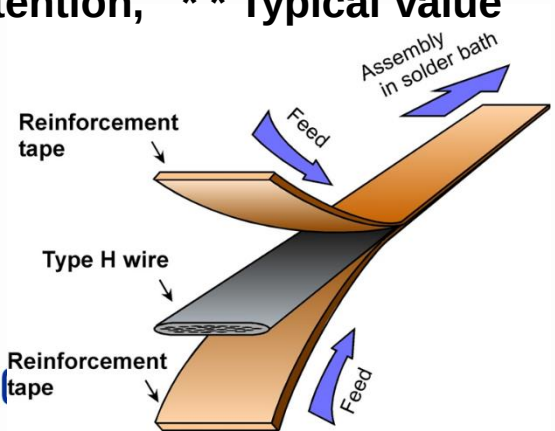
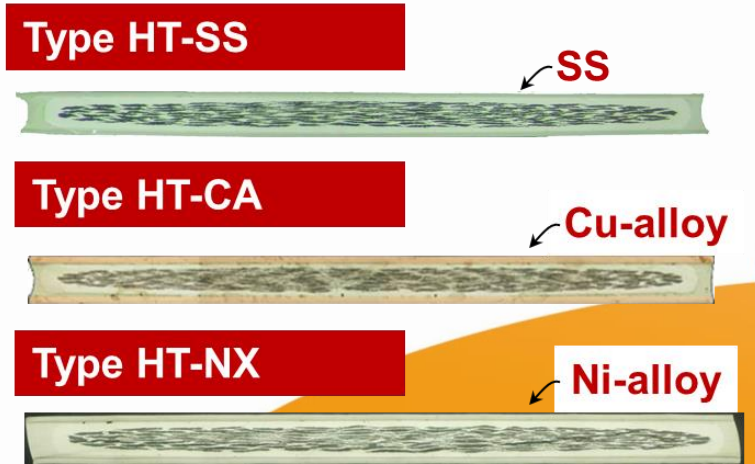
Lineup of Type HT

Sumitomo Electric introduced reinforcement with high strength lamination
Irreversible stress limit at 400 MPa with Ni alloy (Type HT-NX)

	Type HT-SS	Type HT-CA	Type HT-NX
Average Width	4.5+/-0.1mm	4.5+/-0.1mm	4.5+/-0.2mm
Average Thickness	0.29+/-0.02mm	0.34+/-0.02mm	0.31+/-0.03mm
Reinforcement tape	Stainless steel ($0.02mm^t$)	Copper alloy ($0.05mm^t$)	Nickel alloy ($0.03mm^t$)
Critical Wire Tension * (RT)	230N **	280N **	410N **
Critical Tensile Strength * (77K)	270 MPa **	250 MPa **	400 MPa **
Critical Tensile Strain * (77K)	0.4% **	0.3% **	0.5% **
Critical Double Bending Diameter * (RT)	60mm **	60mm **	40mm **

* 95% Ic retention, * * Typical value





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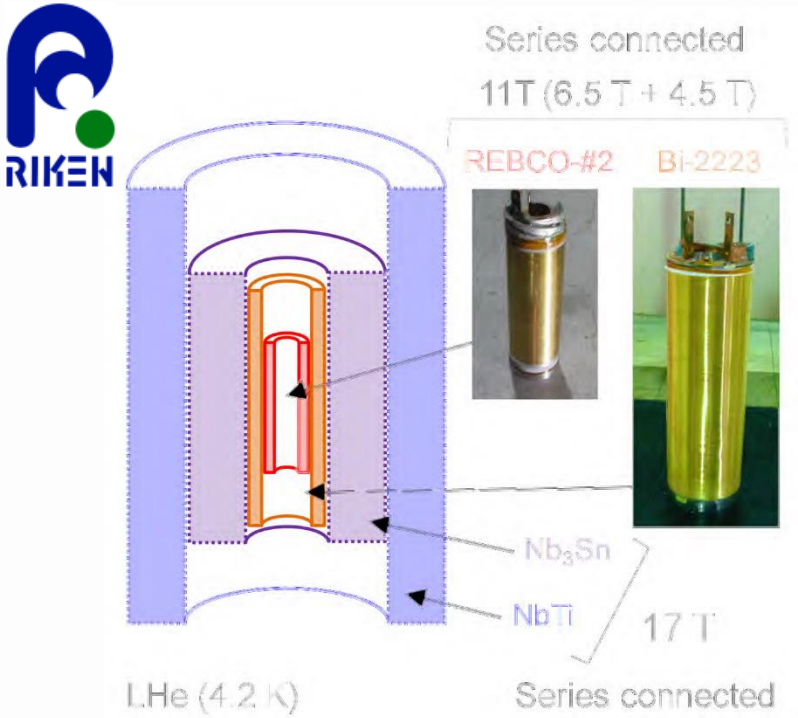
Project Examples using Type HT-NX

The 27.6 T superconducting magnets



Y. Yanagisawa et.al., IEEE/CSC & ESAS SUPERCONDUCTIVITY NEWS FORUM (2016)

The 25 T cryogen-free superconducting magnet

S. Awaji et.al., Supercond. Sci. Technol. 30 (2017) 065001

These magnets showed that TypeHT-NX could be used in magnets generating over 24T.

Collaborative study:
Toyama Univ. Dr. K. Kasaba

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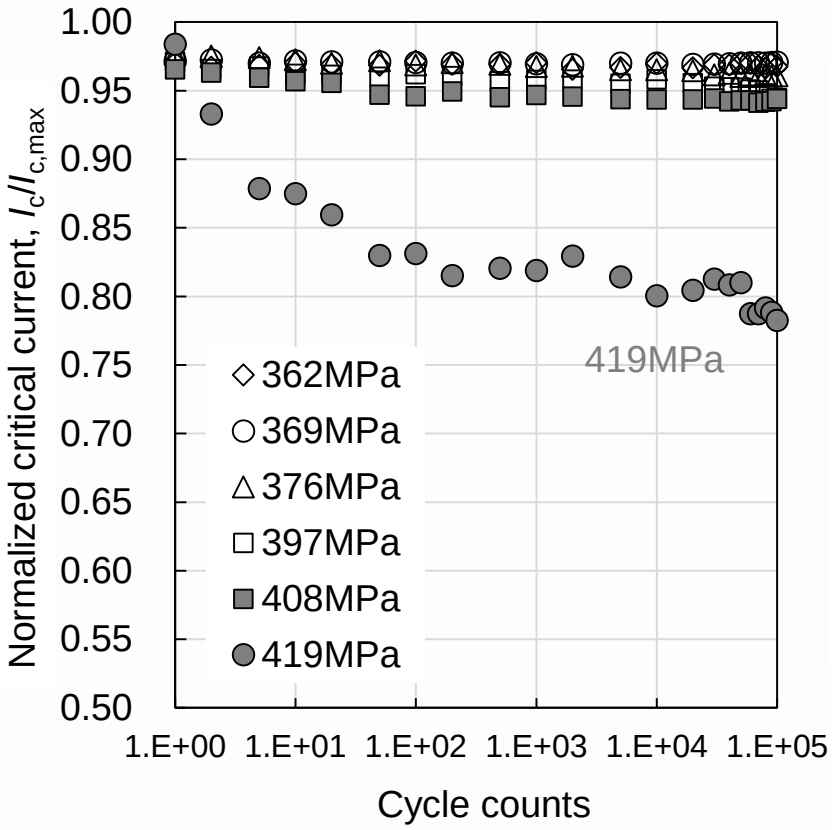
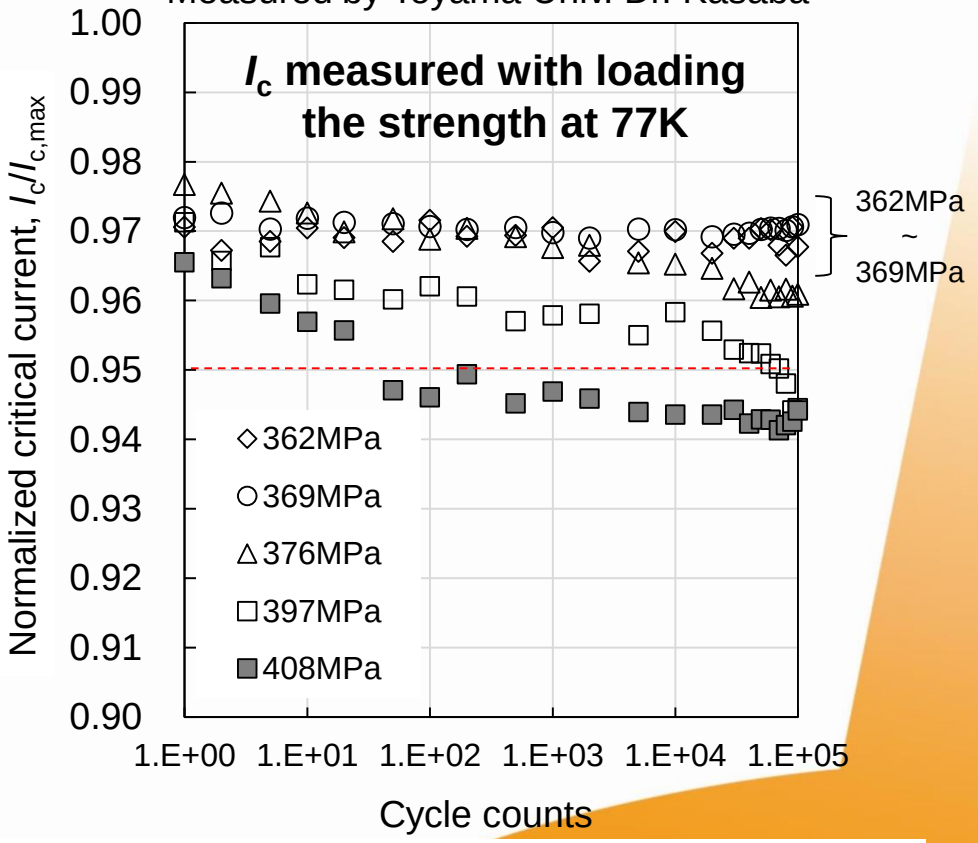
Tensile fatigue test of Type HT-NX at 77K

✓ Test condition

Wire: HT-NX (0.03mm^t, Mass-produced product)
Temperature: 77K Tensile loading: 362 MPa～419MPa (Spec. 400MPa@77K)
Number of Cycles: up to 100,000 cycles



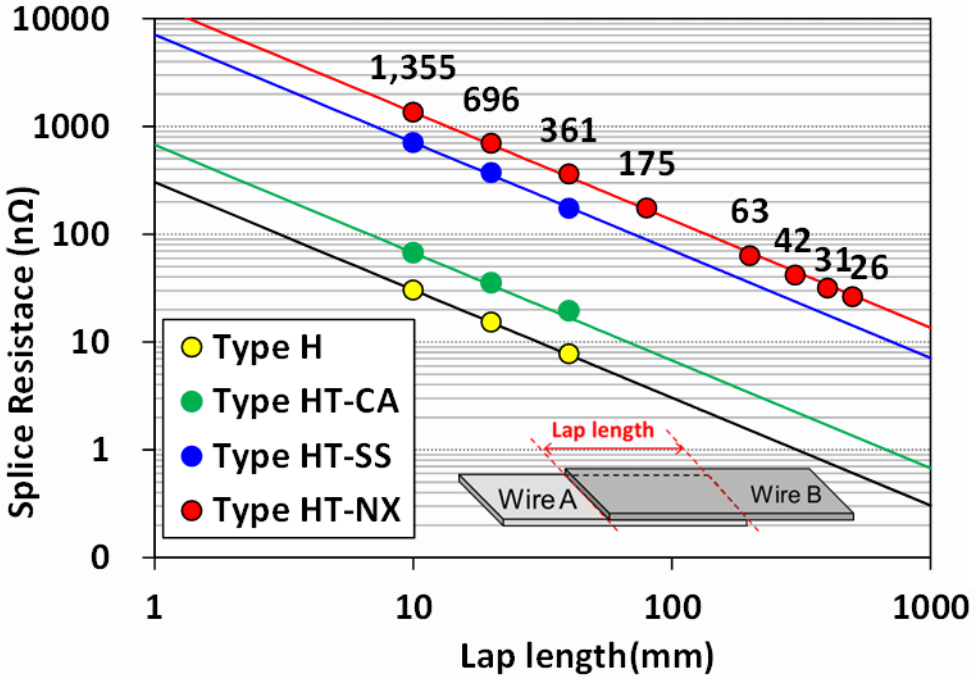
Measured by Toyama Univ. Dr. Kasaba

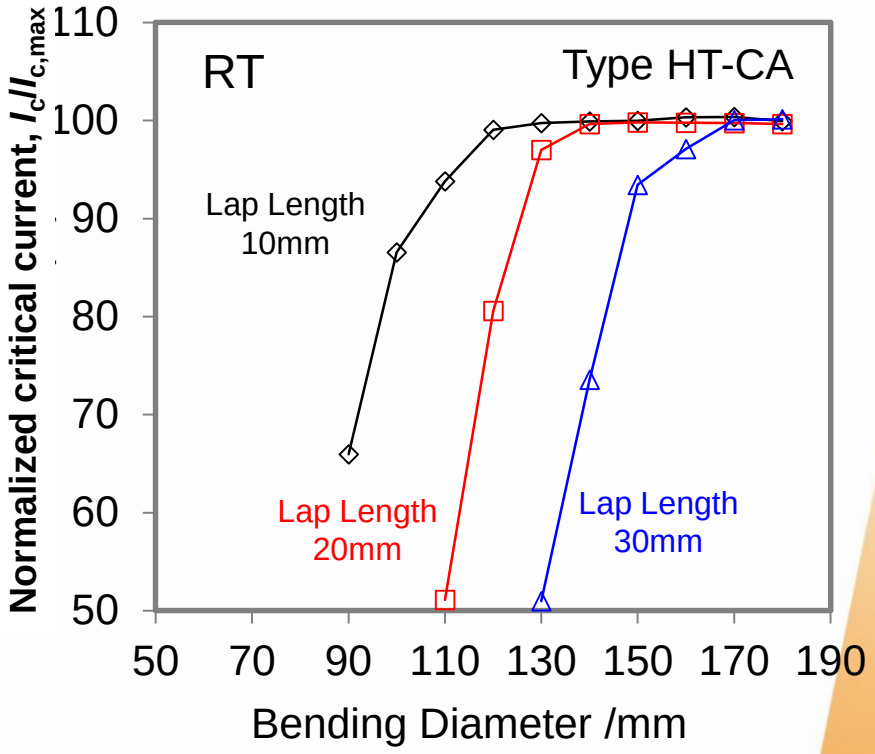


Up to 370MPa (93% of 400MPa), no degradation of I_c until 10^5 cycles

Splice Resistance of Type HT-NX

Splice resistance is inversely proportional to the lap length of the spliced wire





- ✓ **Splice resistance of the Type HT-NX wire is higher than any other Type HT series because the resistivity of the Ni alloy reinforcement material is high.**
- ✓ **Longer lap length reduced the splice resistance but bending property become worse.**

★ **<u>Reducing the splice resistance</u> without the deterioration of mechanical properties of the spliced wire is important.**

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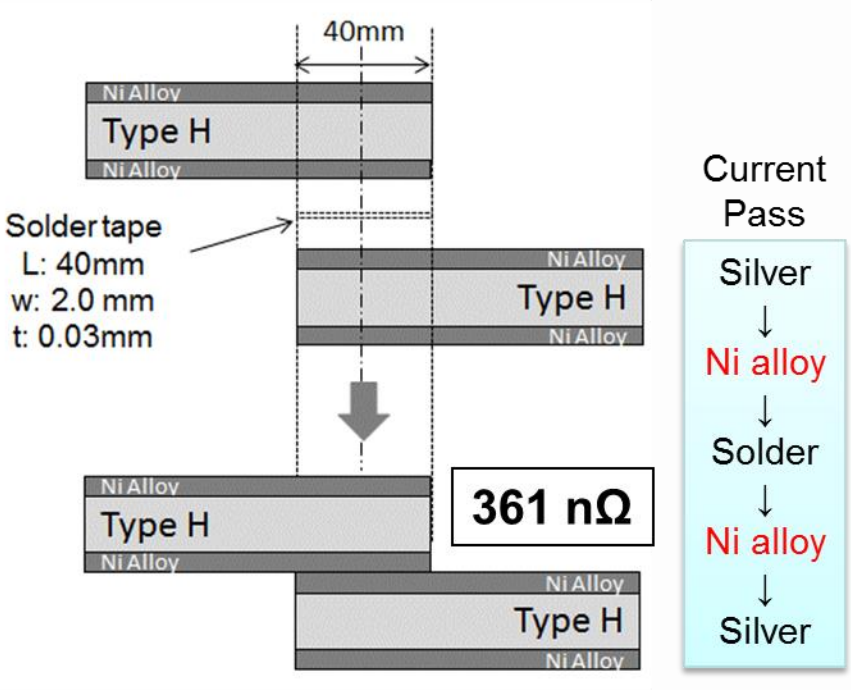
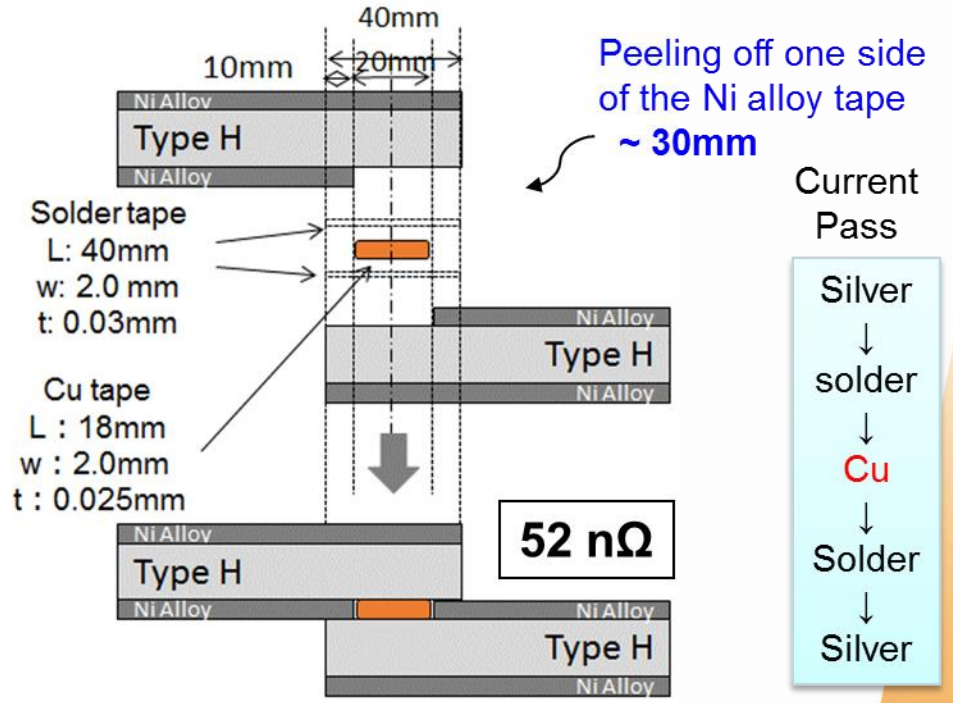
Splice Structure for Type HT-NX

conventional

Overlapped Splice



Peeling Splice

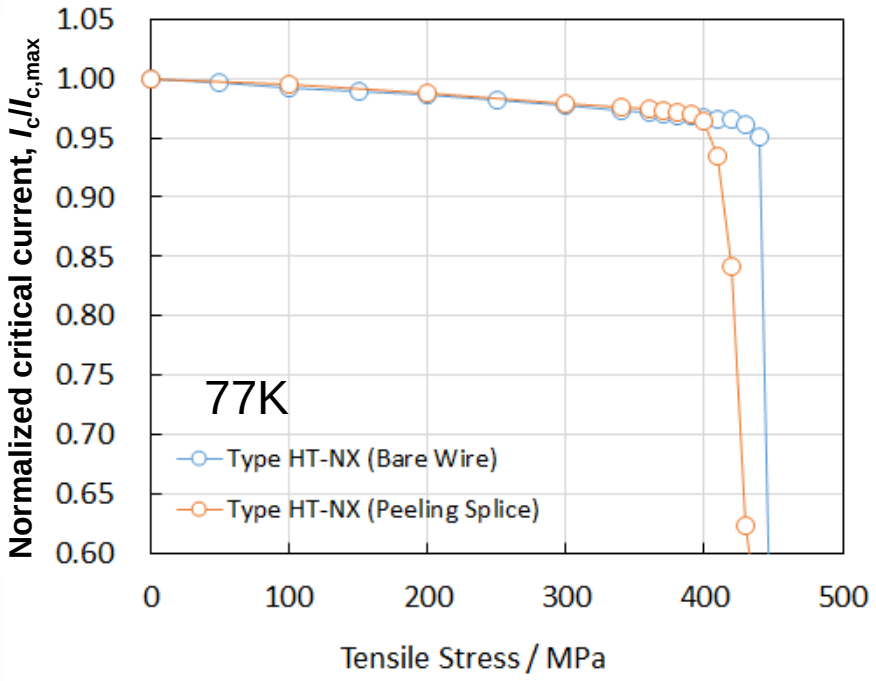


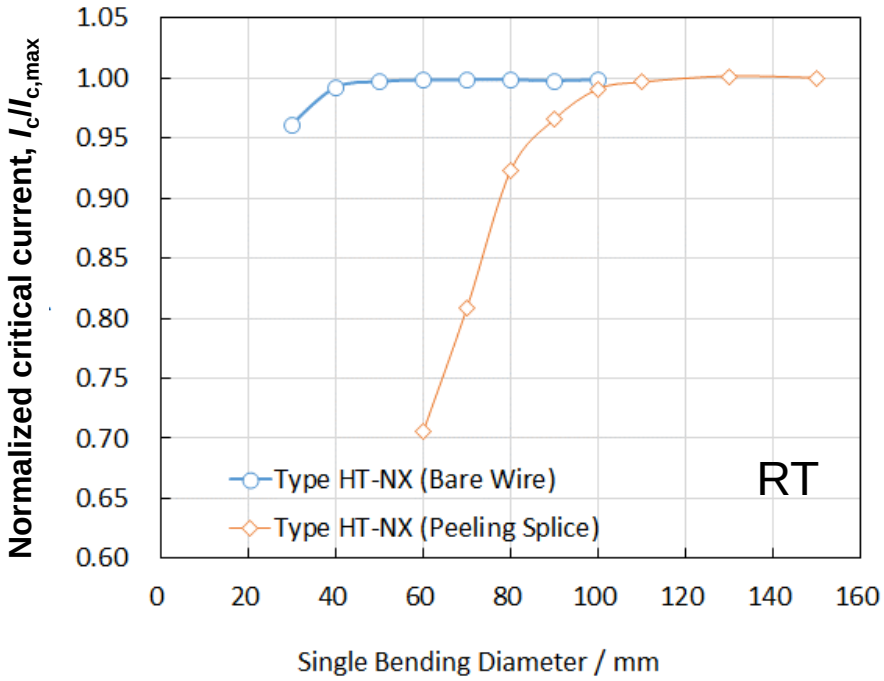
Longitudinal cross-section images of a over-lapping splice structure

★ Splice resistance of the overlapped splice wire is **361nΩ**. Splice resistance of new spliced Type HT-NX (with Cu tape) was **52nΩ** at 77K .

⇒ **Splice resistance reduced 86% to compare with conventional Spliced Type HT-NX**

Strength of the peeling splice Type HT-NX





Critical tensile stress of the Type HT-NX wire itself was **440MPa** at 77K.
Critical tensile stress of peeling splice wire was 405MPa.That is 92% of the original wire.
Critical single bending diameter of peeling splice was 85mm.

New structure has shown remarkably lower resistance without deteriorating the mechanical properties.

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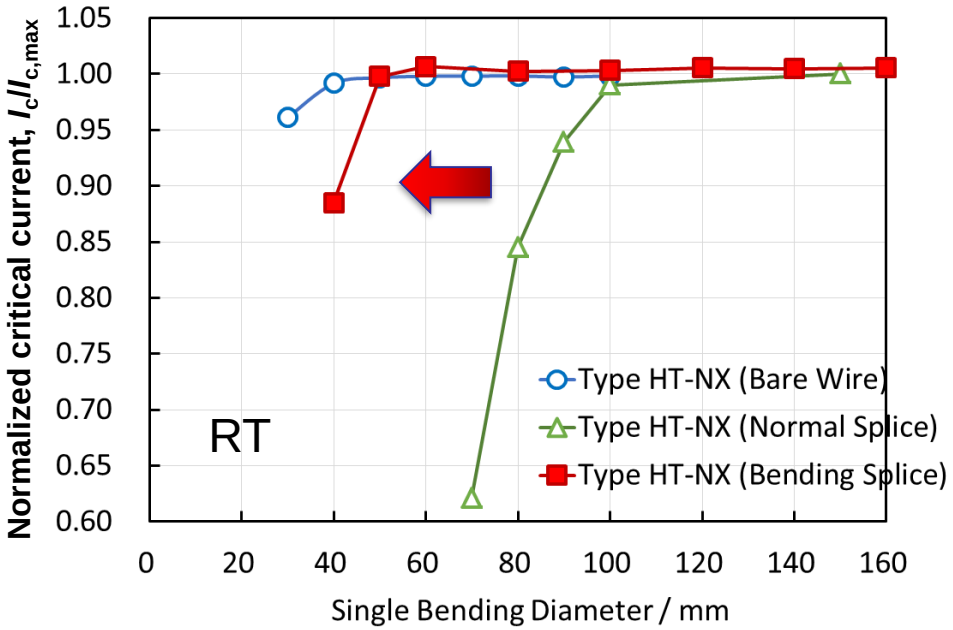
Strength of the bending splice Type HT-NX



- ✓ Critical single bending diameter of a peeling splice wire was **85mm**.
- ✓ Critical single bending diameter of a bending splice wire was 50mm.
  ⇒The smaller splice bending diameter resulted in the better bending property.

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What's new in Portable splicing machine

- Lap length: φ130: 105mm, φ200: 145mm
- Applicable Wire width: ~5.0mm
- Adjustable Pressure: 100~400N
- Adjustable Temperature: 50~ 280℃
- Size: W250 x D650 x H700 mm
- Weight: 53 kg
- Power supply: 200~220V
- Language: English

✓ Spliced Type HT-CA product are already commonly used the cable manufactures.

Summary

	Type H	Type HT-SS	Type HT-CA	Type HT-NX
Average Width	4.3+/-0.2mm	4.5+/-0.1mm	4.5+/-0.1mm	4.5+/-0.2mm
Average Thickness	0.23+/-0.01mm	0.29+/-0.02mm	0.34+/-0.02mm	0.31+/-0.03mm
Reinforcement tape	—	Stainless steel ($0.02mm^t$)	Copper alloy ($0.05mm^t$)	Nickel alloy ($0.03mm^t$)
Ic (77K, Self Field)	170A, 180A, 190A, 200A			
Critical Wire Tension * (RT)	80N **	230N **	280N **	410N **
Critical Tensile Stress * (77K)	130 MPa **	270 MPa **	250 MPa **	400 MPa **
Critical Tensile Strain * (77K)	0.2% **	0.4% **	0.3% **	0.5% **
Critical Double Bending Diameter * (RT)	80mm **	60mm **	60mm **	40mm **

* 95% Ic retention, * * Typical value

- ✓ Type HT-NX was launched in April, 2015.
- ✓ Unit length of Type HT-NX: max. 200m (present)
  max. >500m (in near future)
- ✓ Splice with low resistance (52 nΩ) and high strength (critical tesile stress 405 MPa, critical bending diameter 50 mm) has been developed for Type HT-NX.