

New Types of Organic Resins for Insulation of Warm Magnets (Cyanate ester resin and UV-resin)

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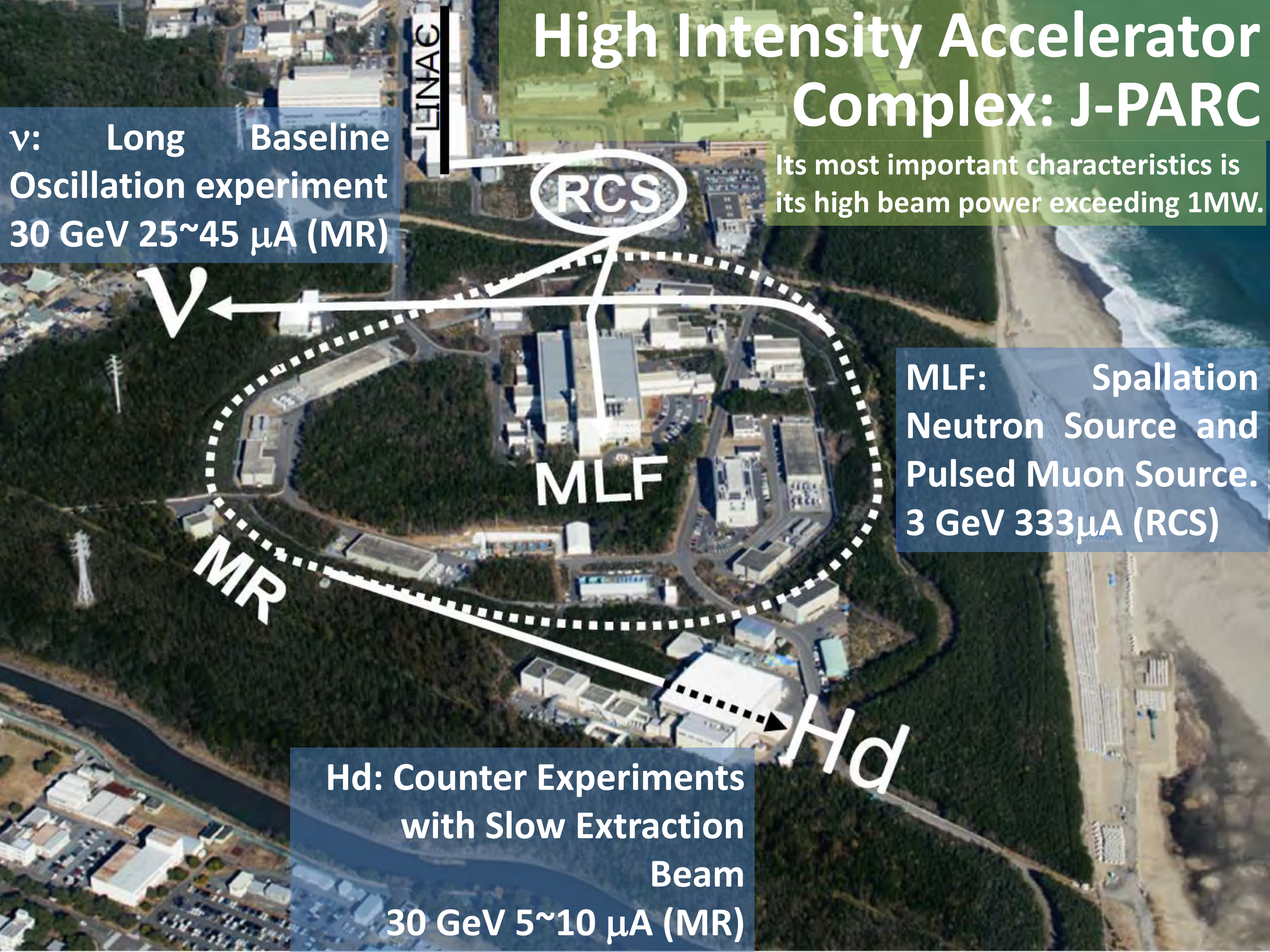
High Intensity Accelerator Complex: J-PARC

ν : Long Baseline Oscillation experiment
30 GeV 25~45 μ A (MR)

Its most important characteristics is its high beam power exceeding 1MW.

MLF: Spallation Neutron Source and Pulsed Muon Source.
3 GeV 333 μ A (RCS)

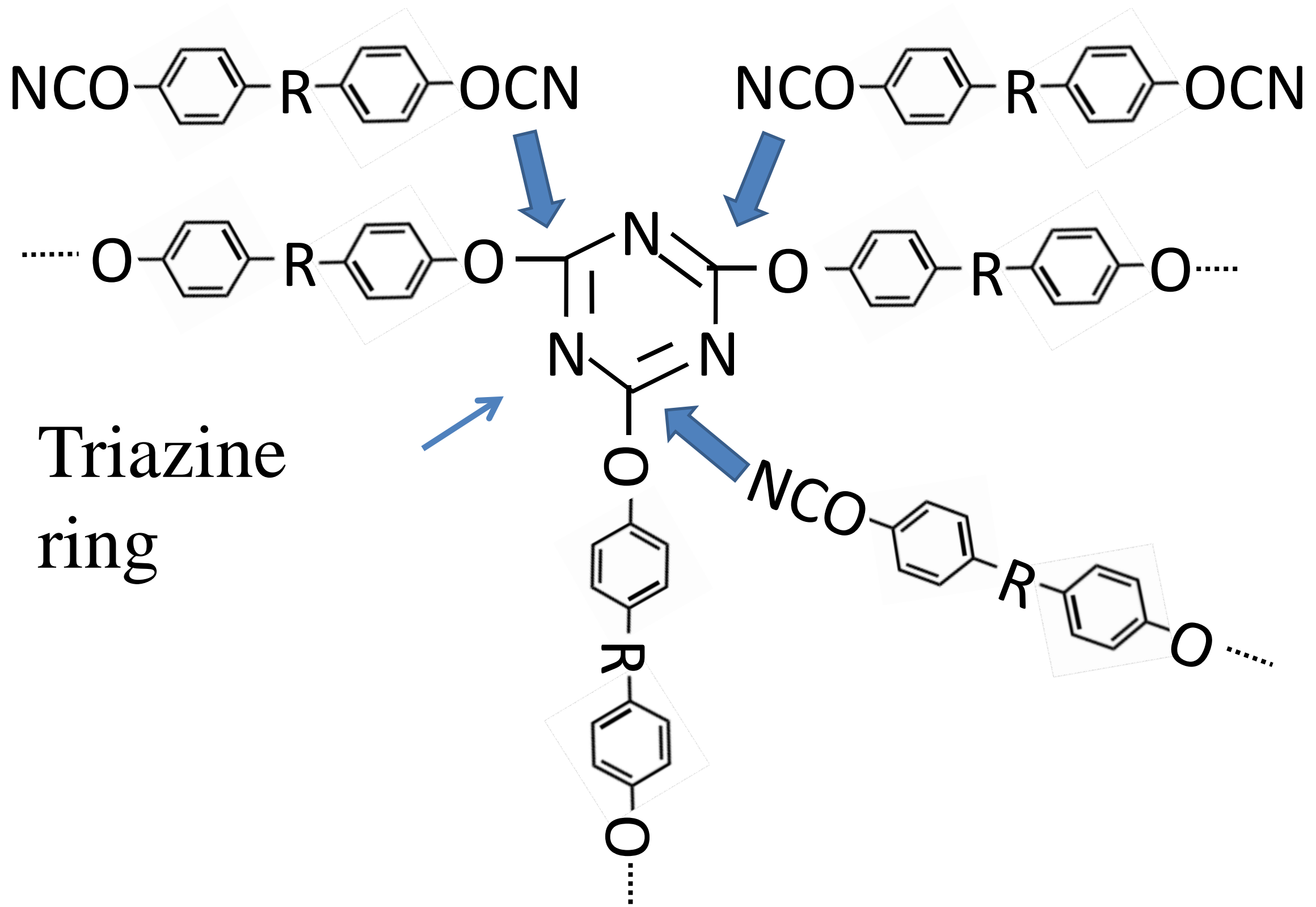
Hd: Counter Experiments with Slow Extraction Beam
30 GeV 5~10 μ A (MR)



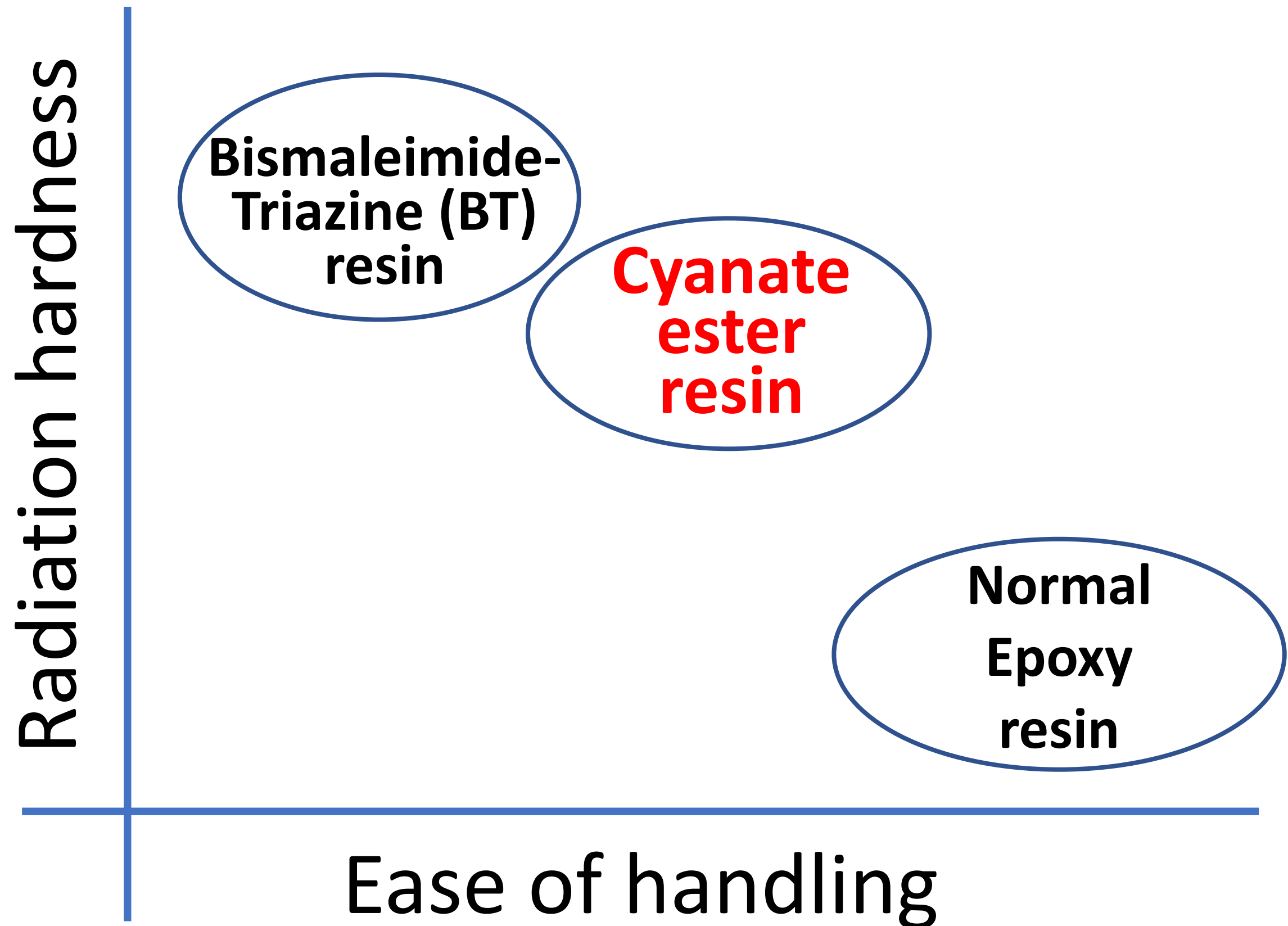
High Intensity Accelerator Complex: J-PARC

- For high intensity accelerators such as Japan Proton Accelerator Research Complex (J-PARC), **organic insulation materials** with **high radiation hardness** are very much important especially for AC operation electromagnets.
 - For DC magnets, **MIC** technology is applicable!
 - For Small Turn Number Magnets: **Ceramics Spray** technology can be applicable!
- For J-PARC, we developed **BT resin**.
 - Some difficulty in its thermal property!
- For future high intensity accelerators, **Cyanate ester resin** is one of candidates.

Formation of Cyanate pre-polymer by three monomers via forming a triazine ring.

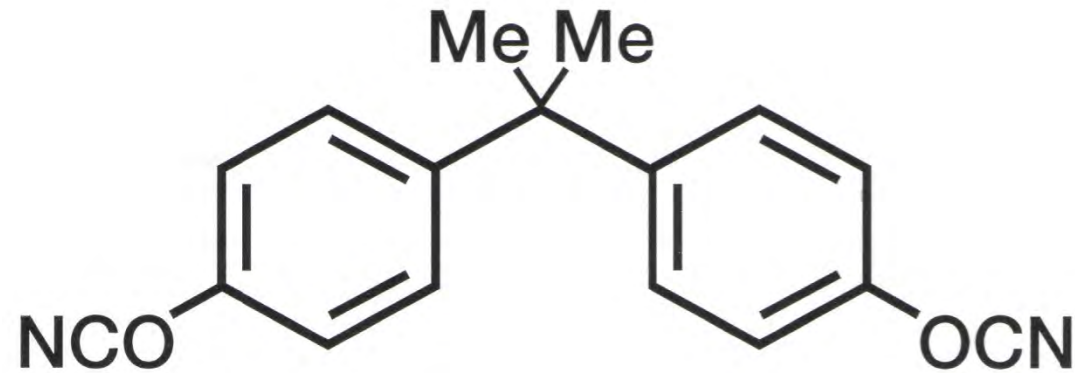


Arbitral comparison of Cyanate ester resin against BT resin and normal Epoxy resin.

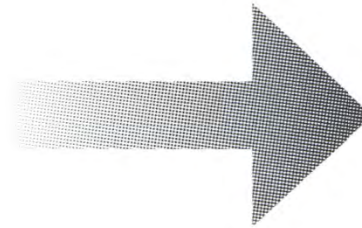


Structure of TA pre-polymer

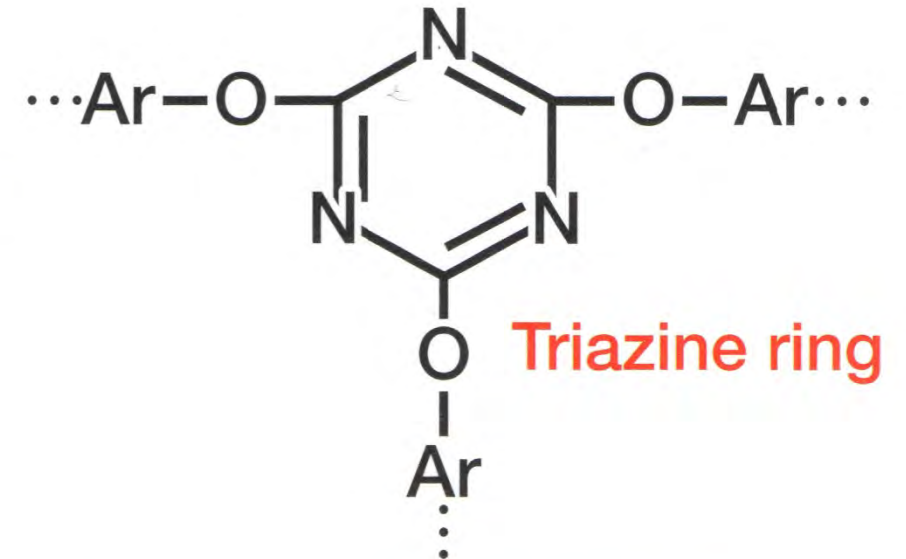
(Mitsubishi Gas Chemical Co. INC.)



TA: Bis-A dicyanate



precuring



TA (monomer):

Melting Point : 80°C

Viscosity at 80°C: 0.013 Pa-s

Room Temp.: White Flake



TA-500:

M. P.: not precisely defined

Viscosity at 80°C: 10 Pa-s

Room Temp.: Liquid



TA-1500:

M. P. : not precisely defined

Viscosity at 80: 70 Pa-s

Room Temp.: Amorphous

Half lap winding



The tape was wound on the Copper hollow conductor with 50% overlap.

Teflon tape winding

Teflon tape was wound on the prepreg tape in order to keep resin inside the glass cloth tape.



**Teflon tape wound over
prepreg tape.**



**Teflon tape acts as a kind of mold
during the curing, i.e.
keeping resin inside
glass cloth tape.**

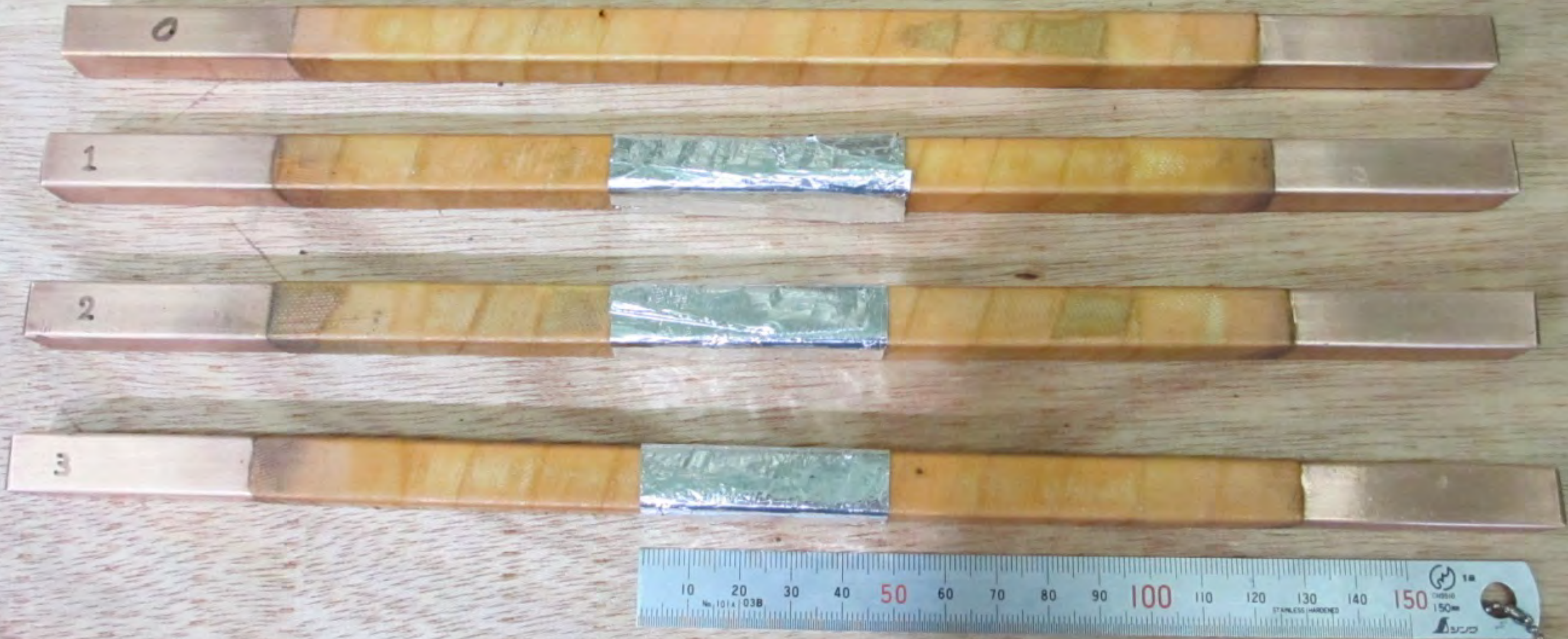
Curing process in the oven



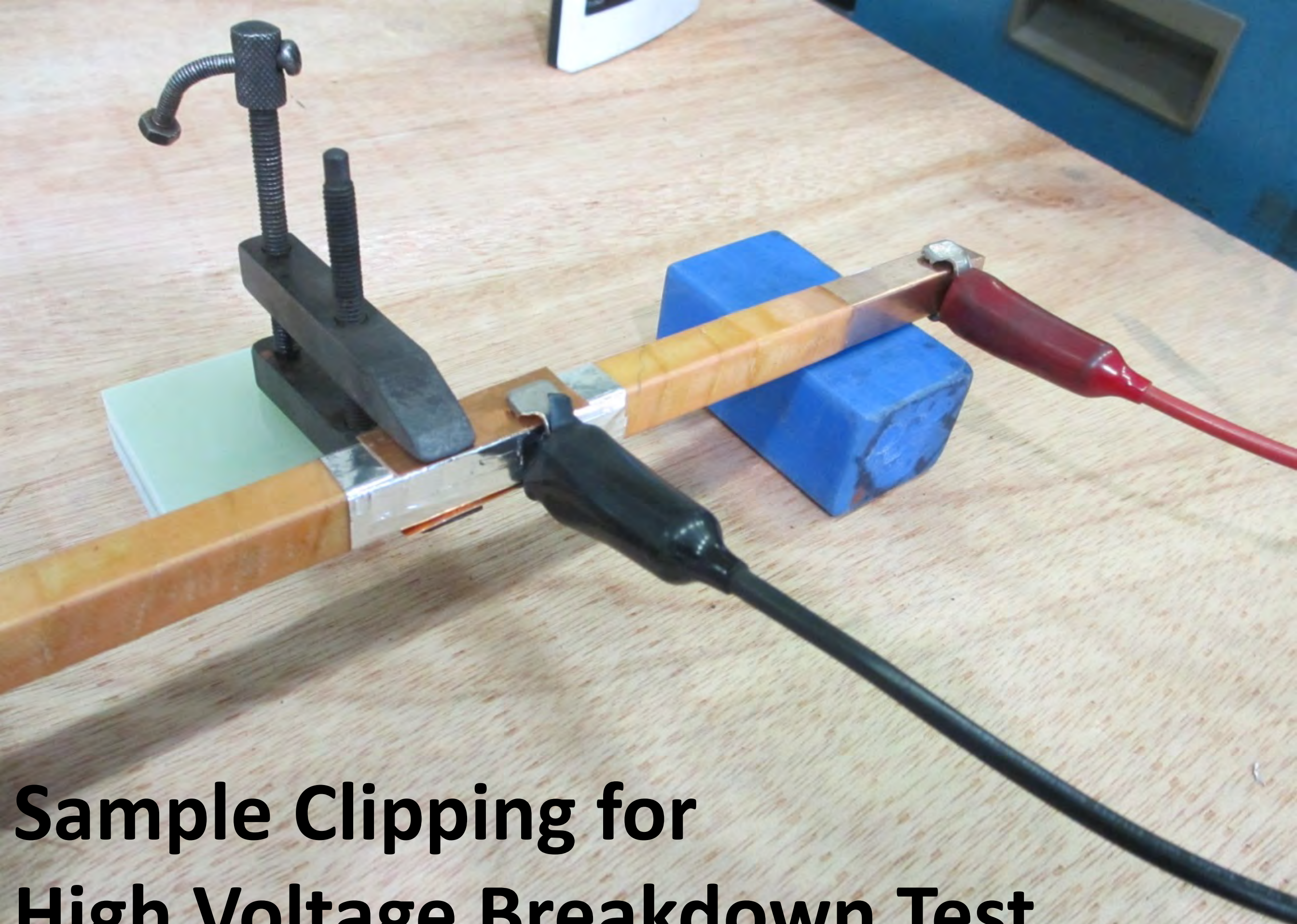
Curing temperature-time was the same as glass fiber cloth sample, i.e. 150°C-1h + 200°C-3h + 230°C-3h.

Prepared hollow conductor samples

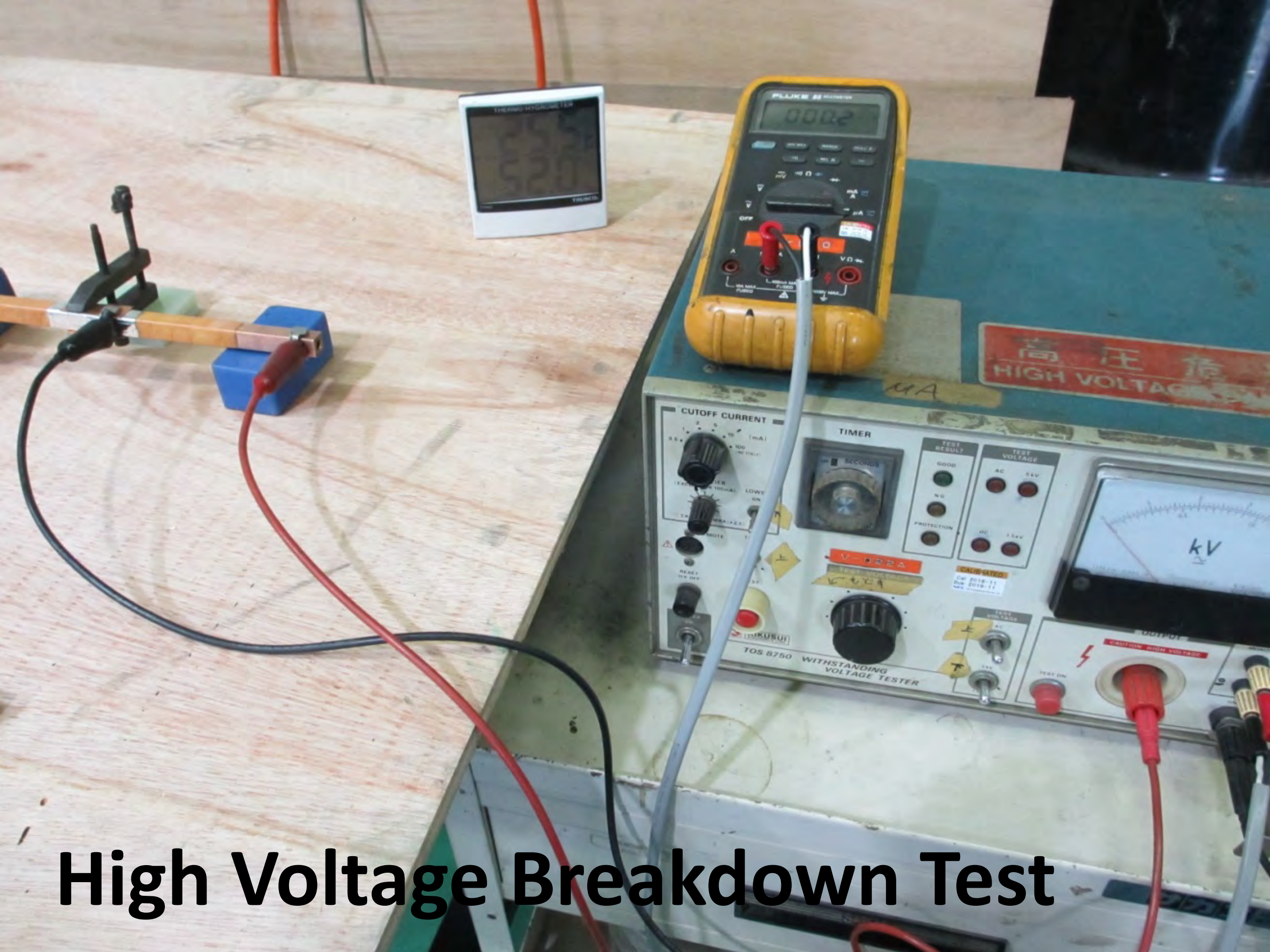
Thin Aluminum foil was wound over the cured prepreg tape for the break down tests.



Four conductor samples were prepared. Size of conductor was 12 x 12 x 300 mm³. After curing, Teflon tape was removed and we inspected cured samples. Then we observed there were no tape peelings or no partial loss of resin.



**Sample Clipping for
High Voltage Breakdown Test**



THERMO-HYGRO-METER
52.5
TRIMMER

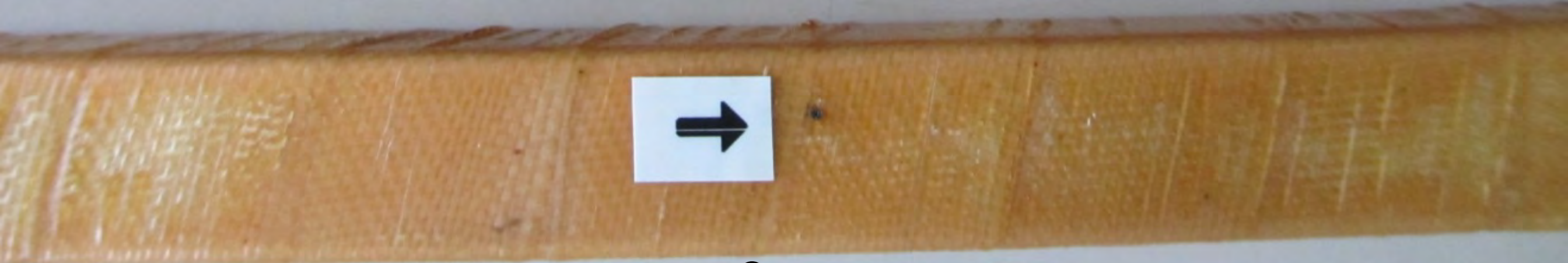
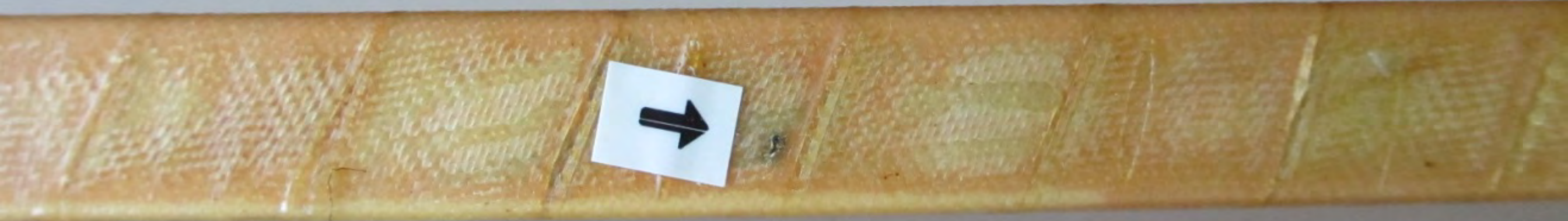
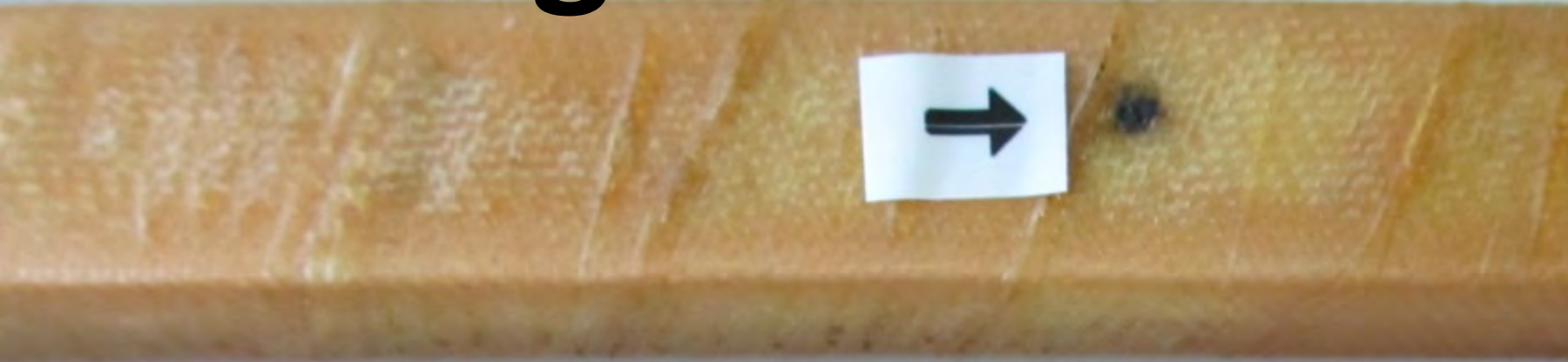
ML1102C
000.2
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高圧危
HIGH VOLTAGE DANGER

CUTOFF CURRENT
1 2 5 10 100 (mA)
TIMER
SECONDS
TEST RESULT
GOOD
NG
PROTECTION
TEST VOLTAGE
AC 5kV
DC 15kV
V-022A
V-02A
CALCULATED
CM 2018-11
DUE 2019-11
TOS 8750 WITHSTANDING VOLTAGE TESTER
CAUTION HIGH VOLTAGE
TEST ON

High Voltage Breakdown Test

Discharge Marks



Sample No.	Breakdown Voltage (AC)
1	4.8 kV
2	4.4 kV
3	3.4 kV

Room Temp.: 25.5 °C, Humidity: 52.0 %

SUMMARY

- R&D status of Cyanate ester resin are briefly summarized.
- The initial test of prepreg tape of Cyanate ester resin showed very good results on the electrical insulation performance.
 - Breakdown voltages were sufficiently high, and were almost two times higher than normal Epoxy and BT resins!
 - The discharge mark left on the insulation layer is only one and circular shape.
 - Location of the mark is almost the center of the flat plane of the conductor surface and not at the edge.
- Cyanate ester resin can form the good electrical insulation layer on the magnet conductor (Copper) from prepreg tape winding.

- Test of **radiation hardness** will be performed in 2020.
- R&D on UV resin is just started.
 - main components of the UV-resin are Acrylate oligomer (pre-polymer) or Acrylate monomer.
 - Because of the wide variety of Acrylate esters, we will be able to find some appropriate UV-resins with **reasonable mechanical strength, electrical insulation performance and radiation hardness.**
 - However, at present, we are using the UV-resin for **rapid maintenance of small defects of insulation layers at the coil surface.**
 - We must eagerly seek and acquire knowledge and experience about the UV resin.

ACKNOWLEDGMENT

- Mitsubishi Gas Chemical Company, INC. for providing the newest information of their Cyanate ester resins.
- Nihon Rika Industries Corp. for their contribution for preparing the prepreg glass cloth sheets and tapes.