# Bruker $Nb_3Sn$ Strands under Bending Strains

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# Motivation

To understand the tolerance of the Bruker strands to bending strain after reaction

# Method

1. React strands on steel cylinders with different radii

2. Transfer reacted strands to ITER barrels, that have an outer radius of ~15 mm

3. Measure $I_C$

# Method

There will be a distribution of bending strain through the thickness of the strand. The largest strain values are given by [1]:

$$\varepsilon_{\mathrm{B}}(R_{\mathrm{HT}}) = \pm\frac{t}{2}\left(\frac{1}{R_{\mathrm{B}}} - \frac{1}{R_{\mathrm{HT}}}\right)$$

| $\varepsilon_{\mathrm{B}}$ | **Heat Treatment Radius** |
|---|---|
| **± 0.1458%** | 16 mm |
| **± 0.2745%** | 17 mm |
| **± 0.3888%** | 18 mm |
| **± 0.4912%** | 19 mm |

$\varepsilon_{\mathrm{B}}$ = bending strain

$t = 0.7$ mm (strand diameter)*

$R_{\mathrm{B}} = 15$ mm (ITER barrel radius)

$R_{\mathrm{HT}}$ = heat treatment cylinder radius

# Current Status

- The stainless steel cylinders for reacting the strands have been ordered. Test schedule to follow.

- Abstract submitted to ASC.

[1] See, e.g., G. Ambrosio *et al.*, *Study of the React and Wind Technique for a Nb3Sn Common Dipole* IEEE TAS **10**:1 (2000)

* Filamentary zone diameter is ~0.45 mm

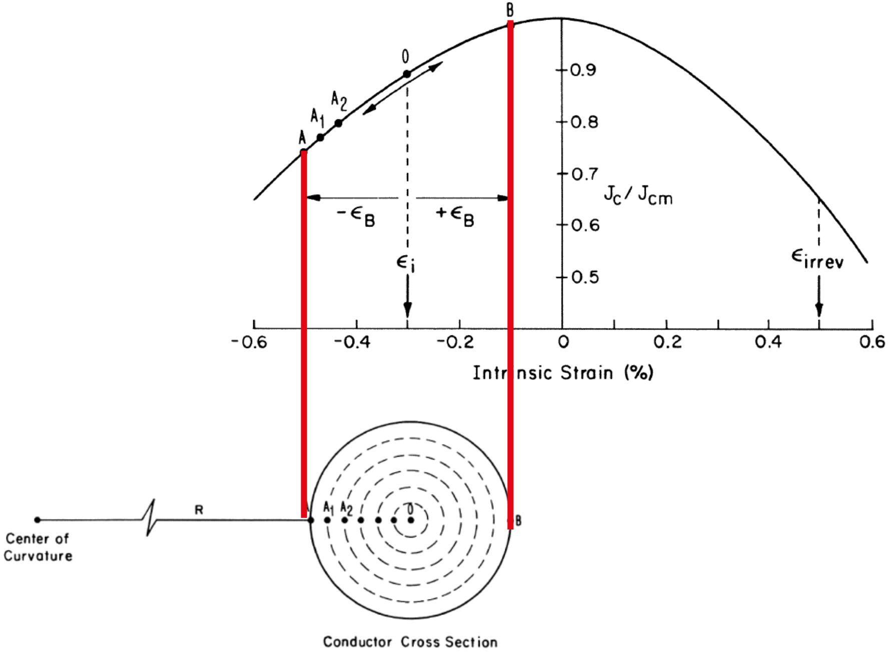
# Extra: Distributions of Bending Strain

From a **physics** perspective:

Distributions of bending strain will lead to distributions of $J_C$ in the strand.

For strands where the interfilamentary current transfer length $L$ is much shorter than the filament twist pitch $l$ (which is *usually* a valid assumption* for $Nb_3Sn$), one can calculate the strand's $I_C$ using**:

$$\frac{I_c}{I_{cm}} = \frac{2}{\pi \varepsilon_B^2} \int_{-\varepsilon_B}^{\varepsilon_B} (\varepsilon_B^2 - x^2)^{1/2} \frac{J_c(\varepsilon_i + x)}{J_{cm}} \, dx$$




*The *assumption* is valid if the Cu matrix RRR is reasonably high
**The *equation* requires knowledge of the axial strain behaviour.

[1] J. W. Ekin, *Strain Scaling Law and the Prediction of Uniaxial and Bending Strain Effects in Multiflimentary Superconductors,* Filamentary A15 Superconductors (Suenaga & Clark) 1980, p187-203