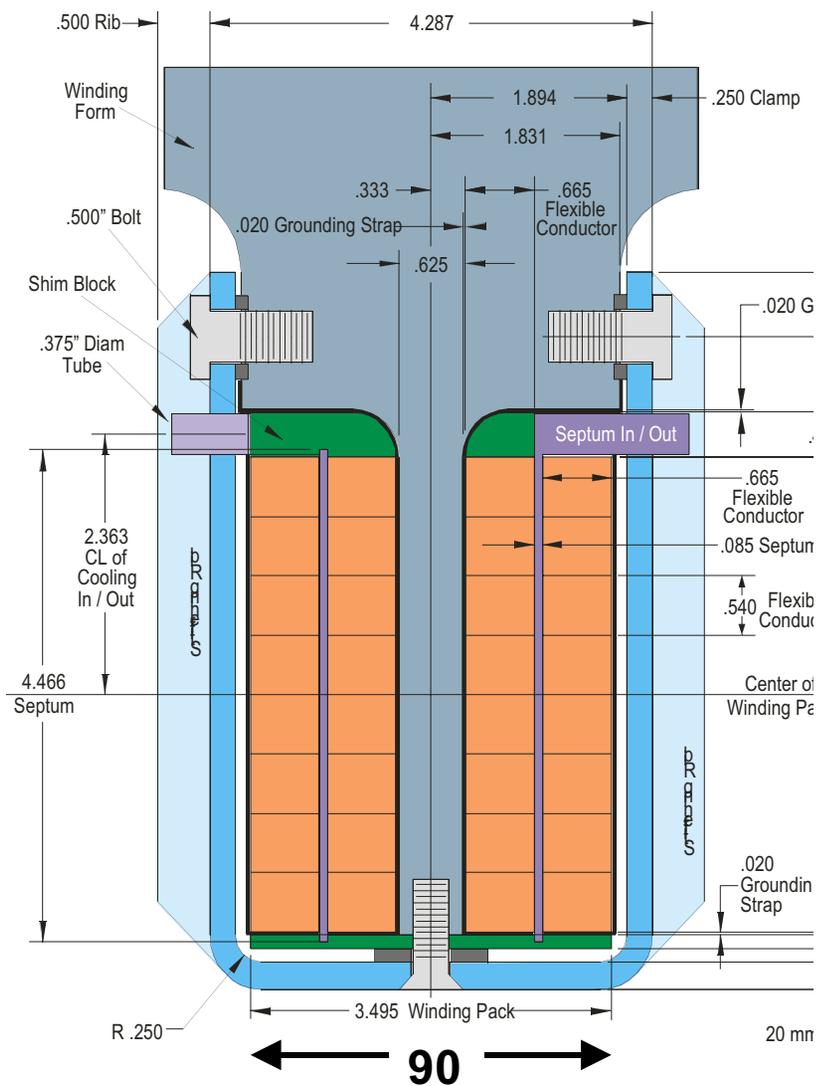


NCSX Modular Coil Conductor Bend Radius

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**NCSX Project Meeting
July 24, 2001**

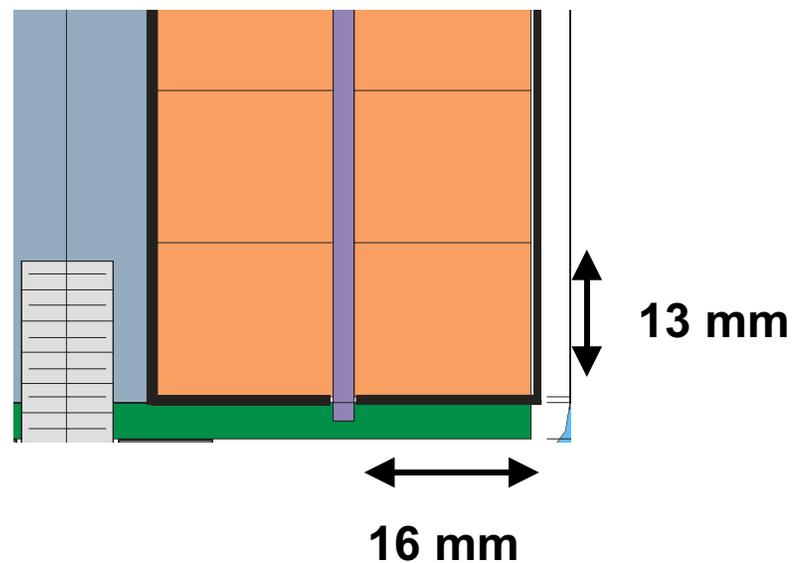
Modular coil cross section



Key dimensions:

- Winding pack: **90 x 110 mm**
- Individual conductor: **13 x 16 mm**

110 mm

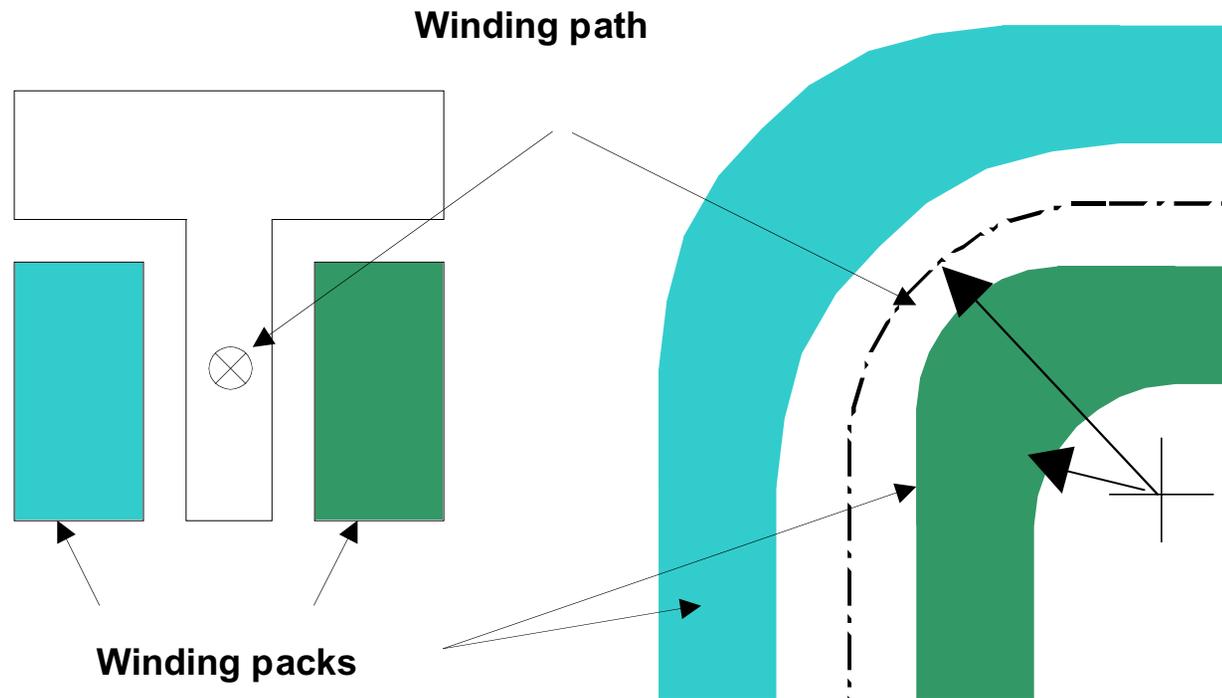


Bend radius - what is limit?

- Bend radius of modular coil winding path is limited by bend radius of individual conductors
 - Conductor criteria: $R_{\text{cond}} > 3 \times W_{\text{cond}}$
 - Winding path criteria: $R_{\text{w. p.}} > 1/2 \text{ width} - W_{\text{cond}}/2 + R_{\text{cond}}$
 - Present design: $W_{\text{cond}} \sim 16 \text{ mm}$, $1/2 \text{ width} \sim 60 \text{ mm}$
 - $R_{\text{lateral}} > (45 - 16/2 + 3 \times 16) > 85 \text{ mm}$
 - $R_{\text{radial}} > (55 - 13/2 + 3 \times 13) > 88 \text{ mm}$
- M12 configuration has bend radii that violate limit, but is the limit too conservative?
- Three hypothetical situations for winding packs going around bends in coil:
 - Normal case
 - “Kinked” case
 - “Mitered corner” case:

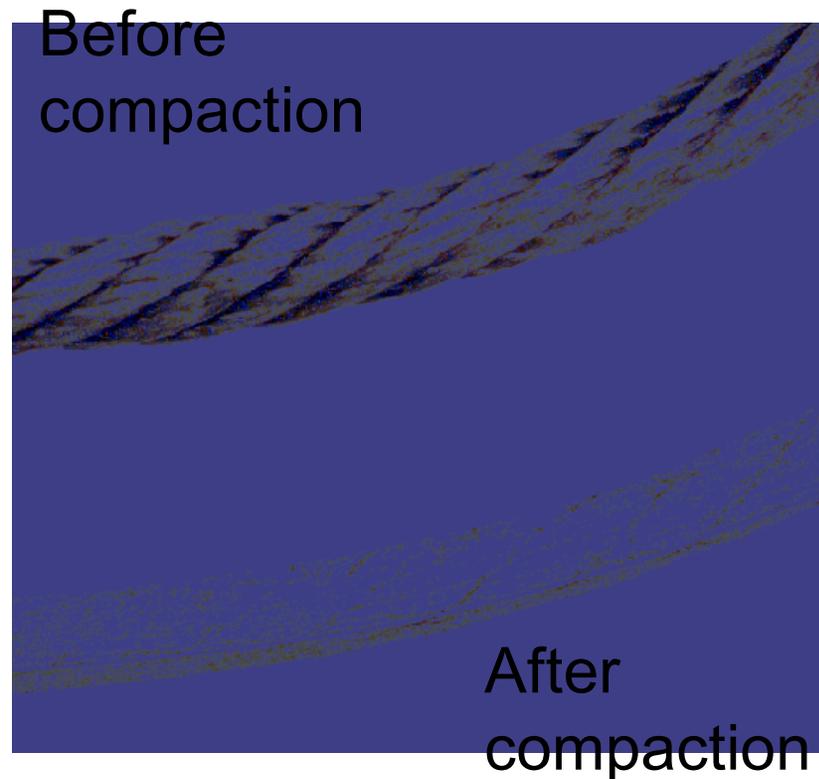
Normal Case

- Bend radius gradual, windings can be concentric with winding path.
- This is the *preferred* situation.



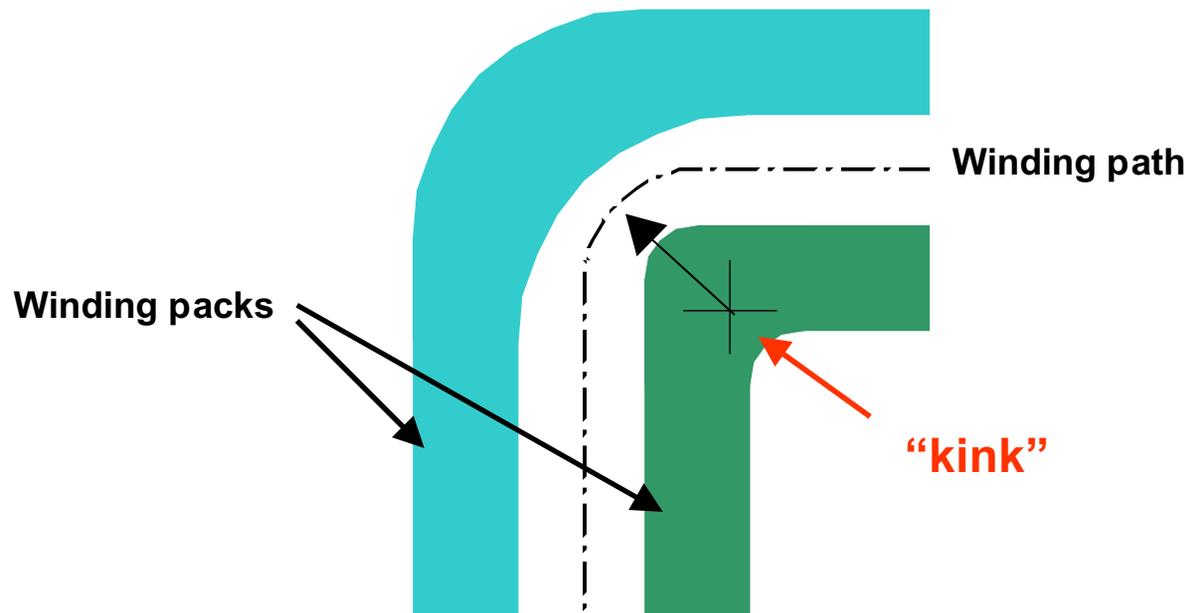
Limit based on small conductor

- Compacted cable produced so far is only 7 mm square, compared to baseline design size of 13 x 16 mm.
- This cable is very flexible, and can be readily wound on a radius of 1.5 times the conductor thickness
- **Bend radius of 3 times the thickness** is recommended to avoid excessive key-stoning and bunching



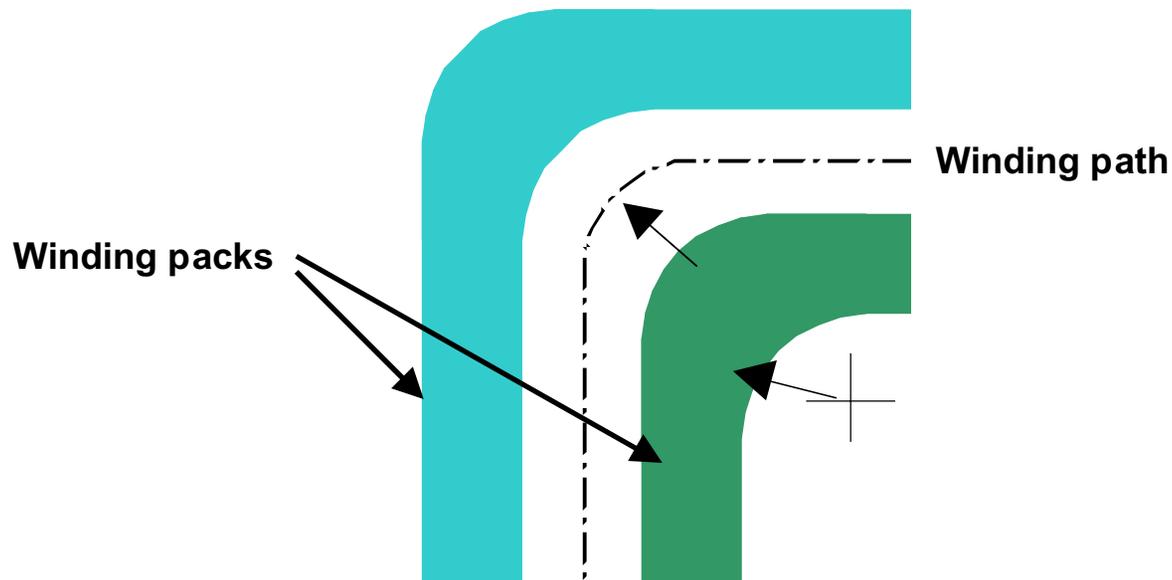
“Kinked” case

- Bend radius is smaller than cross section dimensions, which causes winding to “kink”.
- This situation is *not acceptable* from a fabrication point of view



“mitered” corner case

- Bend radius is small, but windings are not concentric.
- Average path of current has same bend radius as both of the two winding packs.
- This situation is acceptable from a fabrication viewpoint. Is it ok for magnetics?



Bend radii can also be increased locally with manual modifications



Bend radii can also be increased by moving to 18 coil set

- For 0227 (M12) coil set, $R_{min} = 53$ mm
- For 0717 coil set, $R_{min} = 79$ mm
- Algorithm predicts cost savings of 8% in WBS 1 for 0717 compared to PVR (\$23.8 vs \$25.6M)
- If we keep cost constant, size can increase by ~10% (1.4 to 1.54 m)
 - Current density decreases by ~ 10%
 - Access improves for NBI, diagnostics, maintenance
 - Plasma volume increases by 33%

Bend radius issues - Plan

- **Modified coil geometry with larger bend radii will continue to be evaluated by A. Brooks, L. Ku**
- **A. Brooks will evaluate whether “mitered corner” concept would actually help**
- **Full scale cable will be ordered as soon as insulation details are specified (this week), and evaluated to see if conductor bend radius limit can be reduced**