WENDELSTEIN 7-X PROGRESS

Presented by M. Gasparotto on behalf of the W7-X team
Outline

• Introduction- Design parameters
• The W7-X machine concept
• Superconducting coils, mechanical structure, plasma vessel, thermal shields, ECRH
• Assembly
• Conclusions
Introduction

• The WENDELSTEIN 7-X (W7-X) fusion experiment is the next step device in the stellarator line of IPP and is presently under construction at the Greifswald Branch of the Max-Planck-Institut für Plasmaphysik.

• It will be the world‘s largest stellarator-type fusion device.

• W7-X aims at demonstrating the inherent steady state capability of the stellarator at reactor relevant plasma parameters.
# Main design parameters of W7-X

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major plasma radius</td>
<td>5.5 m</td>
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<tr>
<td>Minor average plasma radius</td>
<td>0.53 m</td>
</tr>
<tr>
<td>Plasma volume</td>
<td>30 m³</td>
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<tr>
<td>Machine height</td>
<td>4.5 m</td>
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<tr>
<td>Machine diameter</td>
<td>16 m</td>
</tr>
<tr>
<td>Machine mass</td>
<td>725 t</td>
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<tr>
<td>Cold mass</td>
<td>425 t</td>
</tr>
<tr>
<td>Max. magnetic field on the plasma axis</td>
<td>3 T</td>
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<tr>
<td>Max. magnetic field on coils</td>
<td>6.8 T</td>
</tr>
<tr>
<td>Magnetic energy</td>
<td>600 MJ</td>
</tr>
<tr>
<td>Heating power (1st/ 2nd stage)</td>
<td>15/30 MW</td>
</tr>
<tr>
<td>Plasma pulse length</td>
<td>30 min with 10 MW ECR heating, 10 s with full NBI and ICR heating power</td>
</tr>
</tbody>
</table>
Magnetic Field and Plasma Shape in W7-X

Optimised magnetic configuration to obtain

- good plasma confinement
- Stable plasma equilibrium up to $\beta=5\%$

Field accuracy $\Delta B/ B_0 < 2 \times 10^{-4}$
control coils/correction coils
Divertor and First Wall

Target elements (10 MW/m²): CFC brazed on CuCrZr
Baffles (0.5 MW/m²): graphite tiles
First wall B₄C (0.2 MW/m²)
Plasma Vessel

Volume: 110 m³
Surface: 200 m²
Weight: 35 t
Vacuum: < 10⁻⁸ mbar
Baking: 150° C
Tolerance: <± 2 mm

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Coil Systems

Magnetic field on plasma axis 2.5 T (≤ 3T)
Magnetic field on the coils 6.8 at 17.8 kA

NbTi Superconductor (> 3.4 K)
50 Non Planar Types – 5 Types
20 Planar Coils – 2 Types
Outer Vessel and Ports

Volume: 525 m³
Surface: 480 m²
Weight: 150 t
Vacuum: < 10⁻⁵ mbar
Number of Openings: ~ 1200
Number of Ports: 299
Superconducting Cable

- Strand critical current (4.2 K/6 T) > 150 A
- Conductor void fraction 37%
- Nominal current 17.6 kA

Strand in Nb-Ti

Filaments

Al jacket

243 strands

Jacket produced by co-extrusion

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Superconducting Coils

- winding package
- casing
- embedding
- insulation
- cooling of casing
- reference pin

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Central Support Ring

Central Support

Extension welded on the Central Coil Support Structure

Inconel Bar

Inconel Sleeve

Shoulder

Shim

NPC casing

Coil Support Element

Nut
Narrow Supports

NPC2 casing

Central Pad

NPC3

Pad frame

NS element
Plasma Vessel Sector
Thermal Insulation

Multi-Layer Insulation (aluminised crinkled Kapton foils) supported by actively cooled thermal shields

- Heat flux to the coil: 1.5 W/m²
- With 15 mm MLI thickness, thermal losses limited to 0.62 W/m²

Panel made of pre-impregnated glass layer with 3 embedded copper meshes.
Prototype of W7-X Gyrotron

- 140 GHz - 1 MW
- Two prototypes developed in Europe and USA
- CW tests on progress
Non Planar Coil Assembly Tool
Mounting Stand II

mechanical connection of two half-modules
Conclusions

Assembly phase will start at the end of 2004
Scientific use planned to start in 2010