Fusion for Energy

ITER Diagnostic Pressure Gauges
- design activities -

F4E - EU-ITER Department / Diagnostics group
Disclaimer

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• F4E reserves the right to change any aspect of the information contained in this document.

• This document shall not be binding on F4E.
ITER Diagnostic Pressure Gauges (DPGs)

• DPG’s under the scope of supply of F4E

• DPG’s measures neutral gas pressure in vacuum vessel during operation, under irradiations and high magnetic fields (up to 8T)

• Starting point for the sensor head design available: a modified Bayard Alpert type gauge

• The following key services are required to adapt the existing sensor head concept to the ITER environment
  – R&D including simulation
  – Engineering design, including prototype testing (for e.g. performance, reliability/lifetime and irradiation), up to final or detailed design
  – Project management, QA, configuration management
The DPG system is not only a sensor head: electronic, power supplies, software

- Controllable power supply for filament
- Analog electronic, which provides electrodes potentials and measures currents
- Analog Digital Converters (ADCs)
- Control system with
  - Demodulation of the signal, control and filter
  - Power supply control
  - Communication with CODAC (real-time, data storage & programmable parameters for e.g. calibration and signal interpretation)
- Software design and specifications
Key skills required

- Physics modelling/simulation of ionisation gauge operation (under magnetic field)
- Engineering design including manufacturing engineering
- Electrical and electronics engineering and design (including software)
- CAD design and drawings
- Materials and radiation hardness
- Prototype testing and test engineering
- Engineering analyses (e.g. electromagnetics, neutronics, mechanical, thermal)
- Project management, QA,
- Technical coordination for e.g. management of interfaces

F4E does not regard fusion expertise as needed for the development of this system
Measurement requirements

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Parameter</th>
<th>Range or Coverage</th>
<th>Resolution (Time)</th>
<th>Resolution (spatial)</th>
<th>Accuracy</th>
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</thead>
<tbody>
<tr>
<td>Divertor Operational Parameters</td>
<td>Gas Pressure ($P_{\text{div}}$)</td>
<td>$10^{-2}$ – 20 Pa</td>
<td>50 ms</td>
<td>Several points</td>
<td>20% during pulse</td>
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<td></td>
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<td>$10^{-4}$ – 20 Pa</td>
<td>1 s</td>
<td>Several points</td>
<td>20% between pulses</td>
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<tr>
<td>Gas Pressure and Composition in Main Chamber</td>
<td>Gas Pressure ($P_{\text{main}}$)</td>
<td>$10^{-3}$ – 1 Pa</td>
<td>1 s</td>
<td>Several points</td>
<td>20% during pulse</td>
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<td></td>
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<td>$10^{-4}$ – 1 Pa</td>
<td>1 s</td>
<td>Several points</td>
<td>20% between pulses</td>
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<tr>
<td>Gas Pressure and Gas Composition in Ducts</td>
<td>Gas Pressure ($P_{\text{div}}$)</td>
<td>$10^{-2}$ – 20 Pa</td>
<td>100 ms</td>
<td>Several points</td>
<td>20% during pulse</td>
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<td>$10^{-4}$ – 20 Pa</td>
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Key assumptions
- **Gas composition**: 100% deuterium; calibration curves for the manufactured gauges shall be provided for hydrogen and helium as well.
- **Temperature**: accuracy requirements shall be achieved for 100% deuterium gas, at a temperature of 100° C

Key environmental conditions
- Magnetic fields
- Plasma irradiations
- Dust
- Noise
- Remote electronics and power supplies (long transmission lines)
This upcoming task, in the context of the overall project:

<table>
<thead>
<tr>
<th>Year</th>
<th>Bidding</th>
<th>R&amp;D, System level design, including prototype testing</th>
<th>Preliminary design, including qualification testing</th>
<th>Final design</th>
<th>Software improvements/validation</th>
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<tbody>
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Subject of the upcoming FPA call for proposals:

- **R&D/Design Prototype testing**
  - Bidding
  - R&D, System level design, including prototype testing
  - Preliminary design, including qualification testing
  - Final design
  - Software improvements/validation

- **Manufacturing design**
  - Manufacturing design

- **Sensor Head Assembly**
  - Bidding
  - Manufacture
  - Acceptance test and shipping

  Jan-18
  IPL > Pressure Gauges Sensor Assembly (Head, Box, Baffles, Platforms, Connectors) Delivered to ITER Site

- **Electronics & Power supplies**
  - Bidding
  - Manufacture
  - Acceptance test & shipping

Jun-18
IPL > Electronics Delivered to ITER Site
Contractual tool & procurement approach

• Framework Partnership Agreement (FPA)
  – Sets framework rules for placement of specific contracts with a given unique beneficiary
  – Provides flexibility in further implementation of the various specific contracts

• With only 40% financial contribution from F4E for technical activities (including technical project management)

• Manpower expenses (ppy) are covered
  – Exclusion: Test hardware, for e.g. prototyping, is not to be procured under this FPA, but by third parties, under independent F4E contracts (but support expected from ‘FPA supplier/beneficiary’ in following up of these contracts)

• Additional exclusions:
  – Manufacturing design (manufacturing specifications and drawings, not part of the FPA scope)
  – Cables and feedthroughs design (not part of the FPA scope) – but specifications for the relevant transmission lines fall under the FPA scope
Indicative schedule
see previous dedicated slide

Indicative scope

- System Level Design (SLD) and engineering design, including optimisation of sensor head assembly
  - Review of requirements, environmental constraints and operating conditions
  - Performance assessment by engineering analysis & studies, development and use of simulation/modelling tools, analytic calculations and qualitative expert assessment as appropriate; with a focus on following interdependent phenomena, and their effects on the design performances & reliability: stray capacitance; nuclear and electromagnetic radiations, and their effects on life time degradation and performances; noise level & interferences; filament lifetime; electronics/power supplies architecture design
  - Engineering design & design optimisation (including interfaces) of gauge head and electronics/power supplies, including RAMI analysis
  - Specifications of a detailed R&D/Design validation test program, with full justification for test needs and detailed cost, schedule and risk assessments, including test hardware manufacturing specifications and drawings as appropriate; test facility requirements and specifications (including market survey); and test procedures

- Qualification/validation testing (to be confirmed by design activities above)
  - Thermal & mechanical cycling of filament
  - Performance testing over of P range, B range and field direction angle variations
  - Proofing of calibration approach
  - Irradiation testing (neutrons & gamma)
  - Power supplies/electronic testing

- Engineering design up to final design of the complete system
  - Gauge head, electronics/power supplies, and software
  - at a level enabling immediate subsequent production of manufacturing specifications and drawings for the complete system (except transmission lines, cf. previous slide)

Indicative budget
Substantial engineering and design work to be done, within mainly the next 4 years, in various eng./scientific fields including as well testing, reporting, design configuration management, project management, QA...
Conclusions

• F4E would like to ensure that there are interested parties, ready to undertake such task, and that are thus ready to respond to the upcoming call for proposals

• As such, F4E would like to receive feedback from the ‘market’ on who would be interested in developing the current design scheme, to the level describe therein

• F4E does not regard fusion expertise as needed for the development of this system

• At the same time, this subject forms an excellent opportunity to contribute to ITER, its diagnostic suite, and the European Fusion programme