The ITER Project
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- The ITER Project aims to demonstrate the scientific and technological feasibility of fusion power for peaceful purposes.
- Iter project is an international cooperation between countries which represent more than 50% of the world’s population.
Fusion: the fundamental principle

Einstein’s famous equation:
\[ E = mc^2 \]
Energy = mass \times (speed of light)^2

Mass loss of 4 milligram in 1 gram
\[ \Rightarrow 1 \text{ gram of fusion fuel} \sim 2000 \text{ gallons of oil} \]
Fusion: the fundamental principle

- In the core of the sun the temperature is about 10 million degrees.

- In fusion machines the temperature is above 100 million degrees to maximize the reaction rate.

- A way to confine the plasma is to use strong magnetic fields that create a “cage” preventing the particles to touch the walls of the “container”.

- To avoid the losses at the end of the “container” a closed, toroidal configuration is used.
**Why Fusion?**

- **Fuel:** abundant, world-wide distributed:
  - sufficient deuterium in seawater for millions of years
  - tritium is produced from lithium
    - conservative lithium ore recovery estimates indicate sufficient supplies for thousands of years
    - sufficient lithium in seawater for millions of years

- **Safety:** no risk of major accidents:
  - reactor contains fuel for only a few seconds burn

- **Waste:** no long-term burden:
  - low radio-toxicity after < 100 years
Why Iter?

- Long pulse plasma have yet been tested but with more energy than the output power while net gain of energy has been tested but during very short periods.

- The goal of the ITER fusion program is to produce a long net gain of energy and set the stage for the demonstration fusion power plant to come.

- ITER has been designed to produce 500 MW of output power for 50 MW of input power. The expected duration of each plasma pulse during ITER operation is 1000 second.

- Temperature combines with density in our Sun's core to create the conditions necessary for the fusion reaction to occur. The gravitational forces can not be recreated on Earth, and much higher temperatures are necessary to compensate. In the ITER Tokamak, temperatures will reach 150 million°C.
GENERAL PRESENTATION OF THE PROJECT
ITER Organization (IO):

- The ITER Organization was formally established on 24 October 2007.
- The purpose of the ITER Organization is to finalize the design, construct, exploit and de-activate the ITER Facilities.
- Iter Organization is an international Organization with an international status, like United Nations, with specific legislation and rules of tendering.
- IO is the Nuclear Operator.

Domestic Agencies:

- The seven Members have all created Domestic Agencies to manage their “in-kind” contribution to ITER. The EU Domestic Agency is referred to as Fusion for Energy (F4E) and is based in Barcelona, Spain.
France, CEA and AIF:
- France is referred to as the *Host State*.
- CEA is referred to as the *Host Organization* and has set up a specific agency to manage a range of issues related to the hosting of ITER. This agency is called *Agence ITER France*.

Financial contributions
- EU contributes 46% of construction costs.
- Each of the other 6 members contribute 9% each.
- In the operational phase EU contributes 34% of costs with other members 10 to 13%.
Procurement Arrangement Status

- The IO and DAs have signed more than 100 PA,

- These PA organize the in-kind contribution of each DA representing approximately 90% of the total procurement value for the construction of ITER

- Each DA negotiates contracts with local contractor in accordance with the scope of the signed PA: 1800 industrial contracts have yet been signed
The ITER Tokamak

- **Weight ~23000 t**

**Cryostat**
24 m high x 28 m dia

**Toroidal Field Coil**
$\text{Nb}_3\text{Sn}, 18, \text{ wedged}$

**Vacuum Vessel**
9 sectors

**Poloidal Field Coil**
$\text{Nb-Ti}, 6$

**Port Plug**
heating/current drive, test blankets
limiters/RH diagnostics

**Central Solenoid**
$\text{Nb}_3\text{Sn}, 6 \text{ modules}$
Current Forecast Schedule: Phase I

1st Plasma

Assembly and testing

Buildings and Infrastructure
Present global view of the construction site
Building Construction main contracts

Civil Works: Contract value: €300M – Vinci / Ferrovial / Razel
HVAC & Electricity: Contract value: €500M – Axima / Endel / Ineo / M+W Germany
Contract TB 0: seismic isolation

Year 2012
Building Construction up to date situation

Beginning of the pouring of Tokamak central slab

June 2014
Building Construction up to date situation

Pouring of the Tokamak complex slab

July 2014
ASSEMBLY STRATEGY

Work Sites 001 to 006
MAGNETS

Toroidal Field System
MAGNETS

Poloidal Field System
MAGNETS

Poloidal Field System : Specific building on site
Vacuum Vessel and Port Structures

- Double walled, all-welded structure
- SS 316L(N) - IG
- 9 x 420 tonne 40° sectors
- 18 upper, 17 equatorial, 9 divertor port structures
- RCC-MR 2007
- all welded assembly
- assembly tolerance mid mm
THERMAL SHIELD

Cryostat Thermal Shield
- SS 304L (main structure)
- sub-divided for pre- and final assembly
- silver plated panels
- cooling tubes doubled for redundancy
- ASME (TBD)
- bolted assembly
- assembly tolerance high mm
CRYOSTAT

- Single walled, all-welded structure
- SS 304 L
- ASME VIII, Div 2
- site fabricated from 40° or 60° sectors
- in-situ assembly from 6 sections
- assembly tolerance high mm

central lid, Dia 10.7 x 3.7 (110 t)
main lid, Dia 29.0 x 4.1, 558 t (6 or 9 sectors for transport)
upper cyl, Dia 28.6 x 9.1, 583 t (6 or 9 sectors for transport)
lower cyl, Dia 28.6 x 9.9, 523 t (6 or 9 sectors for transport)
base, Dia 29.0 x 6.0, 1105 t
base plug, Dia 4.3 x .06 (6.8 t)
The cryoplant provides the cooling power required by the main users at three main nominal temperature levels, namely: 4 K, 50 K and 80 K.
COOLING SYSTEM
HEATING SYSTEMS

Neutral Beam Injection

Total weight > 900 tons

- Absolute valve
- Fast shutter
- Bellows
- Calorimeter
- RID
- Neutralizer
- Ion source and accelerator
HEATING SYSTEMS

Ion Cyclotron Resonance Heating

Electron Cyclotron Resonance Heating

Antenna
Operation

- ITER will be operated 365 days/year 24 h/day.
- 11 consecutive days plasma operation followed by 3-days break
- ITER operations will be performed in 3*8 h shifts
- Cryogenics shall have an inherent availability larger than 96%
Prototypicality: NBTF Test Facility

- Total involved area: 17.500 m²
- Trampling surface: 9.170 m²
- Covered surface: 7.050 m²
- Max building height: 26.40 m

1MV insulated high voltage deck (MITICA power supplies)

Main aux plant systems, SPIDER power supplies, local control rooms

MITICA Megavolt ITER Injector & Concept Advancement

SPIDER Source for Production of Ion of Deuterium Extracted from Rf plasma
Prototypicality: NBTF Test Facility

SPIDER Vessel

MITICA Test Bed
Prototypicality: NBTF Test Facility

Building costs: 20 M€ - Equipment cost: 165 M€
Prototypicality: TF Coils case prototype

Case prototype being manufactured in SIMIC premises (Italy) under F4E contract

Case prototype being manufactured in CNIM premises (France) under F4E contract
Thanks for attention
PLAN

- Risk Engineering from ZURICH Global Corporate
- EAR-CAR Insurance programme
ITER CEAR – Risk Engineering Protocol

• 3 Risk Engineers involved

• Annual schedule between Zurich Risk Engineering and ITER representatives

• Quarterly Progress Information

• Visit on-site twice a year including following chronology:
  - On day per visit today and several days adapted to the activity of erection when begun
  - Presence of main co-insurers on the Site visit
  - Review of progress, the overall risk situation, quality and risk management
  - Discussion of losses, non conformities, incidents and main issues
  - Visit of the site
  - Wrap-up meeting
  - Recommendations to improve risk quality
  - Report sent to all panel of co-insurers

• Specific claims visit for all major losses

• Advices concerning design and installation of all means of fire protection
ITER CEAR – Project Management Information

2 co-underwriters

- **IO:**
  Nuclear operator in charge of the project supervision, the ITER equipment assembly and installation.

- **FE4:**
  European Domestic Agency in charge of the construction program, management, organization and supervision assisted by:
  - ENGAGE: Engineering Construction Design, Construction Supervision Management and SPC
  - APAVE: HSPC Missions and Technical Supervisor
  - IRSN: Nuclear controller

**Specificity:**

“in-Kind procurements” : parts of the project and equipment are supplied and installed directly from countries which participate financially to the project
ITER CEAR – Risk Improvement and Advices

- Protection of temporary electrical installations
- Fire prevention plan
- Storage prevention plan
- Smoking policy, Housekeeping, littering
- Regular cleaning of drainage systems
- Fixation of temporary guardrails
- Unprotected ends of rebar
- Quality of structures
- Slope stability of open trenches for drainage systems
- Cranes management / interfaces management tower cranes
INSURANCE PROGRAM

• **Duration**
  - From october 2010 to april 2020 + extensions
  - Review Clause L/P

• **3 sections of covers**
  - **Section I:**
    EAR - CAR cover
  - **Section II:**
    Building in USE
  - **Section III:**
    TPL
INSURANCE PROGRAM

• EAR- CAR cover
  - Material Damage during works of buildings and its facilities
  - Full damage cover outside Core Zone
  - LEG 2 + Extended Maintenance cover in Core Zone

• Building in USE
  - Cover for Owner only
  - Operational risk during erection/manufacturing of process equipment
  - Material Damage after taking over buildings
  - Cover of use of utilities needed for tests in Core Zone
  - Exclusion of Core Zone

• TPL during construction/erection except contamination
  - Accidental bodily injury
  - Accidental Material Damage