GENERAL INFORMATION

NAME OF THE FACILITY: Vulcan Experimental Nuclear Study-Fast
ACRONYM: VENUS-F
COOLANT(S) OF THE FACILITY: Air (Zero power facility) with metal coolants simulated
LOCATION (address): SCK•CEN, Boeretang 200, 2400 Mol, Belgium
OPERATOR: SCK•CEN
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STATUS OF THE FACILITY: In operation
Start of operation (date): Choose an item.

MAIN RESEARCH FIELD(S):
☒ Zero power facility for V&V and licensing purposes
☐ Design Basis Accidents (DBA) and Design Extended Conditions (DEC)
☐ Thermal-hydraulics
☐ Coolant chemistry
☐ Materials
☐ Systems and components
☒ Instrumentation & ISI&R

TECHNICAL DESCRIPTION

Description of the facility
VENUS-F is a zero power fast spectrum facility currently operating in support of the MYRRHA R&D programme. It is used for research related to design and licensing for MYRRHA
and for the Lead Fast Reactor. Specific research examples are the validation of the methodology for online reactivity monitoring of an ADS, the validation of nuclear data and neutronic codes and experimental characterization of representative fast critical and subcritical cores. Because of the varied research needs the design was made flexible so that different core designs can be tested. Venus-F was created by converting the VENUS water moderated thermal spectrum zero power facility. The latter operated from 1964 till 2007 and was controlled via the level of the moderator. Main modifications included the installation of control and safety rods, construction of fuel assemblies and reinforcement of the support structures.

In the VENUS vessel a useful cylindric volume of 1550 mm diameter and 1590 mm height is available. In the vessel, the reactor core and instrumentation are installed. The core is built up in a 12x12 square lattice. These can be filled with fuel assemblies that contain both the fuel and the coolant simulator or with reflector material. Around the core, more reflector material can be placed. Each fuel assembly is a 5x5 square lattice. How these assemblies are filled up depends on the type of core that is being studied in VENUS-F. For example till summer 2014, 9 positions in the fuel assembly contained metallic U rodlets with a 30% enrichment. The diameter of each of these is 0,5 inch. The other 16 positions were taken up by lead, which was simulated the coolant. These can be other materials as well, for example Pb, Bi of LBE to model the HLM coolant or Al₂O₃ to modify the oxygen content in the core or even other materials for example in order to test the presence of irradiation devices in the core. Each assembly surrounded by additional Pb slabs. Finally, a protective a stainless steel wrapper bring the side of the square assembly up to 8 cm. The height of the active part of the core is 600 mm.

In subcritical mode, the four central positions is the grid are used to house the vertical beam line and tritium based neutron source generating 14 MeV neutrons via a tr(d,n)α reaction. Deuterons needed for the reaction are generated by the GENEPI-3C (GEnerator of NEutrons Pulsed & Intense – 3rd generation with Continuous beam) accelerator. The device can both operate in a continuous wave mode as well as pulsed mode with a repetition rate of up to 100Hz and a beam trip duration between 20µs up to 10 ms. The maximum neutron flux is about 5x10¹⁰ n/s. By coupling the accelerator to VENUS-F with a subcritical core, the device operates as an accelerator driven system and is used for research for MYRRHA.

Acceptance of radioactive material
Yes
VENUS-F is a zero power reactor and has the capability to accept radioactive materials. However, in practice this will be limited to fuel for research purposes under well controlled circumstances. VENUS-F is not an irradiation facility.
Figure 1. Venus-F coupling with GENEPI-3C
Figure 2 Variant of VENIUS-F sub-critical core coupled with GENEPI-3C.
SR- safety rod, CR- control rod, O – positions for detectors.

### Parameters table

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coolant inventory</td>
<td>Pb and Bi in solid state simulated</td>
</tr>
<tr>
<td>Power</td>
<td>0-100 W</td>
</tr>
<tr>
<td>Test sections</td>
<td></td>
</tr>
<tr>
<td><strong>TS #1</strong></td>
<td></td>
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<tr>
<td>Characteristic dimensions</td>
<td>Vessel diameter 1550 mm, core dimensions : 445 mm radius by 600 mm height (flexible)</td>
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<tr>
<td>Static/dynamic experiment</td>
<td></td>
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<tr>
<td>Zero power reactor/ADS experiment</td>
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<tr>
<td>Temperature range in the test section</td>
<td>(Delta T)</td>
</tr>
<tr>
<td>Ambient</td>
<td></td>
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<tr>
<td>Operating pressure and design pressure</td>
<td></td>
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<tr>
<td>Ambient</td>
<td></td>
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<tr>
<td>Flow range (mass, velocity, etc.)</td>
<td></td>
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<tr>
<td>N/A</td>
<td></td>
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<tr>
<td>Coolant chemistry measurement and control (active or not, measured parameters)</td>
<td>N/A (Solid HM)</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>Fission chambers, ionisation chambers, temperature monitoring</td>
</tr>
</tbody>
</table>
COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

VENUS-F has been used to do experiments on different core configurations. Various methods are used to obtain an optimal core characterisation. Tests included the control rod calibration (required for the core certificate), maximal flux and power measurements by a calibrated Fission Chamber, rod drop tests and safety rod worth measurements by the MSM method. The core is further characterized via axial traverses by U-235, Pu-239, Np-237 and U-238 fission chambers and radial traverses using U235 and U238 foils. In addition, spectrum indexes (including capture on U238/Fission of U235) and minor actinides fission rates ratio were determined employing fission chambers and foils. As a first step a standard critical and subcritical cores were investigated. Secondly, different methods for sub-criticality monitoring using 12 fission chambers as detectors for neutron power variations were studied.

PLANNED EXPERIMENTS (including time schedule)

Further measurements of zero power cores with a composition closer to the realistic MYRRHA core (2015-2016) : These additional experiments are done because of the MYRRHA core design evolutions. In addition, specific questions from the safety authorities during the licensing of the new MYRRHA facility are expected. These experiments will include reactivity worth measurements of different core configurations, e.g. In-pile sections, Mo production irradiation devices, etc. Also safety related measurements, e.g. determination of coolant void reactivity effects in different core configurations will be performed.

Characterisation of references cores : as before in each measurement campaign it is essential to obtain a proper characterisation of the reference core. The same characterisation methods as mentioned above will be used.

Study of the influence of the choice of the detector deposit and the position relative to the core influence on sub-criticality monitoring. The precise set-up influences the ease with which monitoring is performed. However, in a realistic reactor not all positions will be available due to design constraints meaning that also sub-optimal positions were investigated.

TRAINING ACTIVITIES

Training activities are in principle possible by prior arrangement, subject to availability and under supervision of qualified SCK•CEN personnel.

REFERENCES (specification of availability and language)

