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***Link to IAEA Research Reactors Data Base**:*TAPIRO

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1. General information and technical data of TAPIRO research reactor

The TAPIRO nuclear research reactor (Fig. 1), is a fast neutrons source. The reactor name comes from the Italian acronym **TA**ratura **P**Ila **R**apida Potenza Zer**O** (Fast Pile Calibration at 0 Power). It was built to support an experimental program on fast reactors and it is in operation since 1971.

In the frame of an agreement between ENEA and SCK/CEN Mol (Belgium), an extensive neutronic characterization of the TAPIRO source reactor was carried-out (1980-1986). It was found that TAPIRO is able to provide a family of neutron spectra of extremely variable hardness (about pure fission spectrum near the core center). This remarkable feature makes the TAPIRO most suitable to many metrology applications, also taking into account that a good spherical symmetry of the neutron flux shape was evidenced by the joint ENEA-SCK/CEN experimental campaign.

Fig. 1 - TAPIRO reactor room.

It can be used in many areas for: validation of calculation codes for generation IV reactors design; fast neutrons damage; benchmark for nuclear data testing, evaluation of fast neutron damage induced on electronic components; qualification of chains of innovative detectors, hands-on experience in nuclear engineering courses.

It can operate at the maximum power of 5 kW, and the neutron flux at the center of the core at full power is about $4 \times 10^{12}\ n \cdot cm^{-2} \cdot s^{-1}$.

In Tab. 1 are provided some characteristics of the reactor.

CORE	Cylindrical: diameter about 120 mm Diameter/height: about 1
FUEL	Uranium-molybdenum alloy (weight 98.5% U – 1.5% Mo) Density: 18.5 g cm^{-3} Enrichment: 93.5% ^{235}U
CLADDING	Stainless steel: thick 0.5 mm
REFLECTOR	Cylindrical Inner Reflector: diameter 348 mm Outer Reflector: diameter 800 mm Overall Height: 700 mm Material: Copper Weight: 2600 kg
COOLING SYSTEM	Forced He: 100 g/sec @ 7.5 ata Heat Exchanger + Cooling Inlet core temp: 25° C - Outlet 35° C
BIOLOGICAL SHIELD	Shape: near spherical Thickness: 1.75 m Material: high density borate concrete Density: 3.7 g cm^{-3}
IRRADIATION CHANNELS	3 channels at the reactor mid-plane 1 tangential (to the top edge of the core)
CONTROL RODS (Tab. 2)	2 Shim Rods + 2 Safety Rods +1 Regulating Rod

Tab. 1 – Characteristics of the TAPIRO reactor.

The reactor core is a cylinder made of highly enriched metallic uranium (weight 98,5% U; 1,5% Mo). The experimental channels which is fitted to the reactor, allow the installation of devices and experiences in areas of high flow (Figs.2-3).

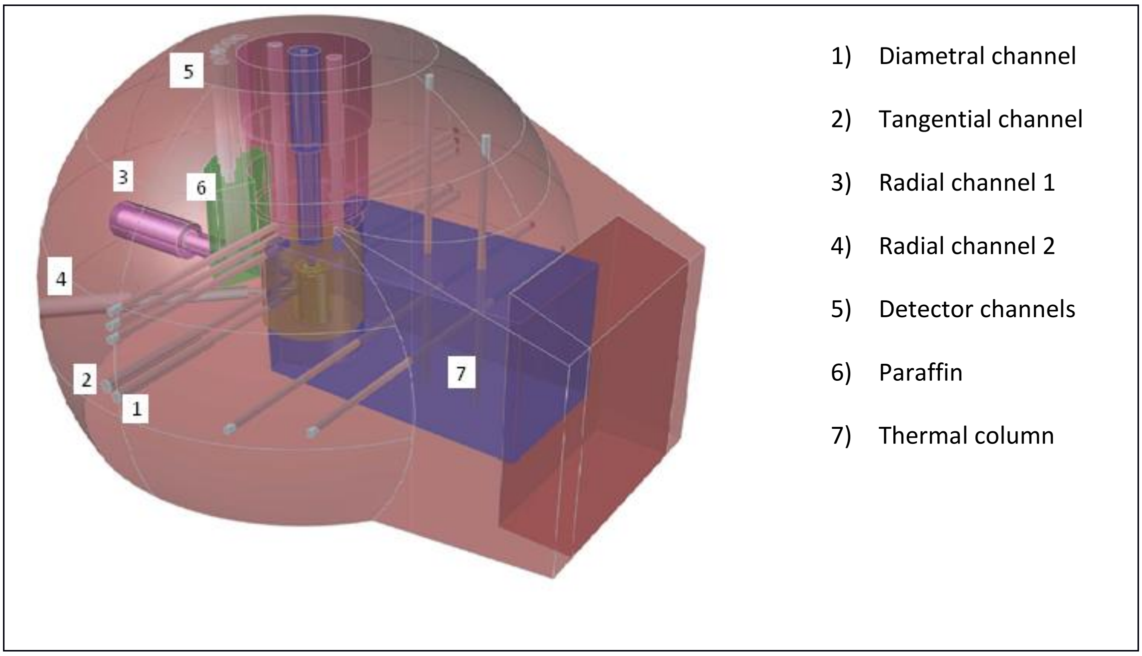
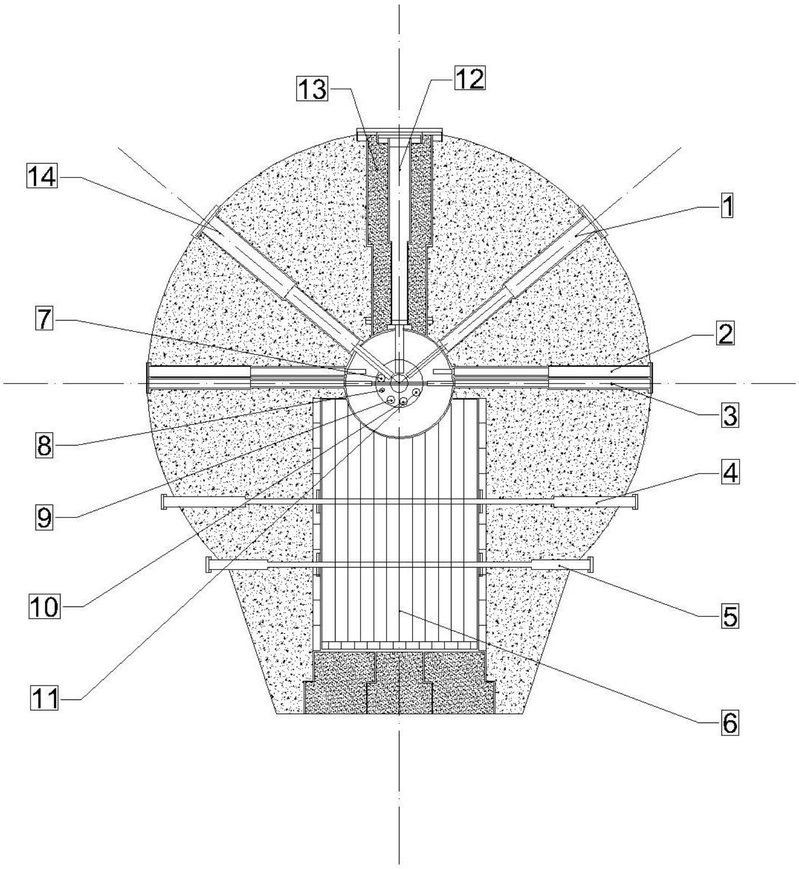


Fig. 2 - Irradiation facilities.



LEGENDA	
1	Canale Sorgente
2	Canale Tangenziale
3	Canale Diametrale
4	Canale Orizzontale colonna termica n°1
5	Canale Orizzontale colonna termica n°2
6	Colonna termica
7	Barra di Sicurezza n°1
8	Barra di Regolazione
9	Barra di Calibrazione n°1
10	Barra di Calibrazione n°2
11	Barra di Sicurezza n°2
12	Canale Radiale n°1
13	Grande Canale Orizzontale
14	Canale Radiale n°2

Fig. 3 - Section of the reactor parallel to the floor of the reactor room at 1 m height

Each channel consists of a metallic cylindrical jacket and a plug for shielding purposes. The channels have a gradually reducing section to lower the gamma streaming effect. Each channel plug is essentially constituted by a casing filled with shielding material for the entire section, and it is provided with a copper extension occupying the area of penetration in the reflector. This extension may be modified for hosting the sample container. The plugs are provided with three holes available for remote control or power cables eventually needed by the experiments.

The experimental equipment is complemented by a thermal-column. The purpose of the thermal column is to provide an epithermal neutron flux, allowing at the same time the assembling of large experimental equipment.

The characteristics of the experimental channels are summarized in Tab. 2

Name	Position	Penetration	Useful diameter
Diametral channel (D.C.)	Piercing. Horizontal. Diametral in the core.	Inner and outer fixed reflector. Core.	10 mm in core
Tangential channel	Piercing. Horizontal. 50 mm above core mid-plane. Parallel to D.C. 106 mm from core axis.	Inner and outer fixed reflector.	30 mm in reflector
Radial channel 1 (R.C.1)	Radial. Horizontal on core mid-plane, at 90° with respect to D.C.	Inner and outer fixed reflector, up to 93 mm from core axis.	56 mm in reflector
Radial channel 2	Radial. Horizontal on core mid-plane, at 50° with respect to R.C.1.	Outer fixed reflector, up to 228 mm from core axis.	80 mm in reflector
Grand Horizontal Channel (G.H.C.)	Radial. Concentric with R.C.1.	Up to reflector outer surface	400 mm near reflector
Grand Vertical Channel (G.V.C.)	Above core, on the same axis.	Outer fixed reflector, up to 100 mm from upper core base.	800÷900 mm in reflector
Thermal column	Horizontal.	Shield, up to outer reflector	110x116x160 cm^3
Irradiation cavity	On safety plug upper base.	7.4 mm	33 mm

Tab. 2 - TAPIRO experimental locations main characteristics.

2. TAPIRO in the field of the applied research

2.1 Irradiation experiments for studies of neutron damage

TAPIRO has several experimental channels to perform experiments about neutron induced damage on different types of materials.

Some of the experiences carried out are:

- Neutron radiation damage on avalanche photo-diodes APD used in the ATLAS (A Toroidal LHC ApparatuS) experiment of LHC (Large Hadron Collider) at CERN;
- Neutron radiation damage on Monitored Drift Tubes (MDT) and Avalanche Photo-diodes (APD) of the electromagnetic calorimeter CSM of LHC;
- Fast neutron effects on electromechanical devices (piezo-motor) to be used in the nuclear fusion prototype of ITER project;
- Test of self-powered neutron detectors for their usability in ITER nuclear fusion prototype;
- Fast neutron damage of electronic components for aerospace application.

2.2 *Medical applications*

Neutron radiation effects on cells and small animals for micro-dosimetry and tumor cell treatment with neutron beams with 0.4 eV to 10 keV of energy.

2.3 *Applications in FNAA (Fast Neutron Activation Analysis)*

Gamma spectrometry measurements are performed by mean of HPGe detectors supplied from Canberra and ORTEC, equipped with adequate instrumentation and software. The laboratory is also equipped with an anti-coincidence measurement system utilizing a NaI 12×12 inches annular single crystal Bicron detector characterized by a relevant spectral background reduction. Another useful detector is constituted by a HPGe planar detector with high efficiency in measuring x and γ rays of energy < 100 keV and for XRF counting.

By exploiting the instrumental analysis (INAA) potentials it is possible to study analytically and determine, either by thermal, epithermal, or fast neutrons, or by the radiochemical separation, the majority of the macro constituents, minor constituents, trace, and ultra-trace elements in a very wide set of matrices and materials. The samples that may be analyzed and the applications of the INAA range from alloys to soils; from sediments and suspended matter to the atmospheric particulate matter; from archaeological materials to detectors materials used in the field of elementary particles; from radiotracers to the execution of forensic studies.

2.4 *Radiological characterization*

During the last years the activities carried out at the TAPIRO Reactor by Nuclear Materials Characterization Laboratory’s personnel has been aimed to the radiological characterization of drums containing wastes produced in the routine activities of the Plant.

The characterization was carried out using mobile equipment:

> **ISOCS (In Situ Object Counting System):** radiological characterization system for assaying objects of any shape and nature containing ϒ-emitting radionuclides; the measurement system operates with a Germanium detector, whose response to a series of point sources or distributed in predefined arrays was characterized using Monte Carlo codes.
>
> **Portable Multi-Channel,** equipped with neutron probe and gamma radiation detector. This instrument is characterized by high accuracy and speed in response and was used for preliminary inspections of the drums.

2.5 *Codes validation*

Experiences for the validation of codes applied to the analysis of nuclear plants characterized by high degree of heterogeneity, as in the case of HTGR systems (High Temperature Gas-cooled Reactor).

3. Design and manufacturing of experimental devices and measurement systems

TAPIRO facility has a section devoted to design and manufacture experimental devices (mechanicals, hydraulics and electronics). Some examples of this capability are:

- Neutron collimators;
- Irradiation devices;
- Ancillary systems for experiments;
- Electronic control panels;
- Devices for neutron activation analyses.

4. Use of the reactor in the field of education and personnel training

- Teaching for University students:
    - Introduction to calculation tools for reactor analysis (with Monte Carlo and Deterministic codes);
    - Introduction to experimental measurements;
- Personnel training:
    - Training of plant personnel for the attainment of the certificates for the plant operation;
    - Permanent training for operation and maintenance of the plant;
    - Training of operators active in the nuclear field (Qualified experts, Firefighters, Soldiers etc…).