NEUTRON FLUX MEASUREMENT AND THERMAL POWER CALIBRATION OF THE IAN-R1 TRIGA REACTOR

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IAN-R1 TRIGA Reactor

- The IAN-R1 TRIGA reactor in Colombia was initially fueled with MTR-HEU enriched to 93% U-235, operated since 1965 at 10 kW, and was upgraded to 30 kW in 1980.
- General Atomics achieved in 1997 the conversion of HEU fuel to LEU fuel TRIGA type, and upgraded the reactor power to 100kW .
- After the core conversion, the reactor was brought into an extended shutdown condition in 1998 until 2005. So, since 2005, it has been necessary the development of several activities in order to get a good performance of the IAN-R1 TRIGA reactor.

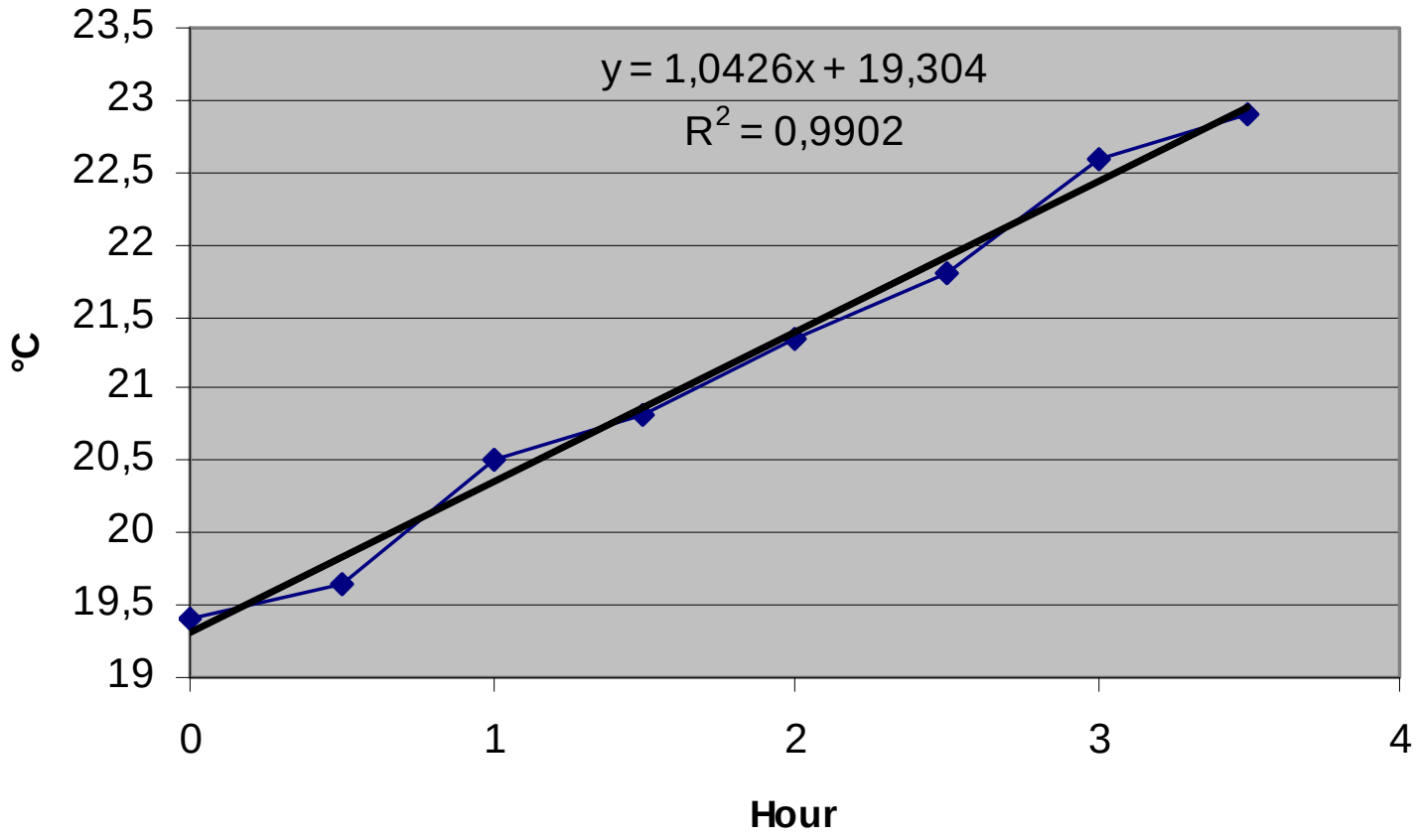
Thermal power calibration and flux measurements

- Since the IAN-R1 TRIGA reactor was in an extended shutdown during seven years, it was necessary to repeat some results of the commissioning test conducted in 1997.
- Initially a thermal power calibration was carried out using calorimetric method. As a preliminary step, the power channels stayed to approximate at the same levels according to last measurements achieved by a OIEA`s expert mission in 2005.
- As neutron flux measurements were not achieved as part of initial startup during the calibration activities in 1997, flux measurements have recently been carried out in-core irradiation position. In this way, it has actually been completed all other commissioning activities.

Thermal Power Calibration

- The thermal power calibration was carried out using the calorimetric method. The reactor was operated approximately at 20kW during 3.5 hours, with manual power corrections since the automatic control system failed and with the forced refrigeration off. During the calorimetric experiment, the pool temperature was measured with a RTD which is installed near to the core. The dates were collected in intervals of 30 minutes.
- For establishing thermal power reactor, the water temperature versus the running were registered. For a calculated tank volume of 16 m3, the tank constant calculated for the IAN-R1 TRIGA reactor is 0.0539 C/kW-hr. The reactor power determined was 19 kW.

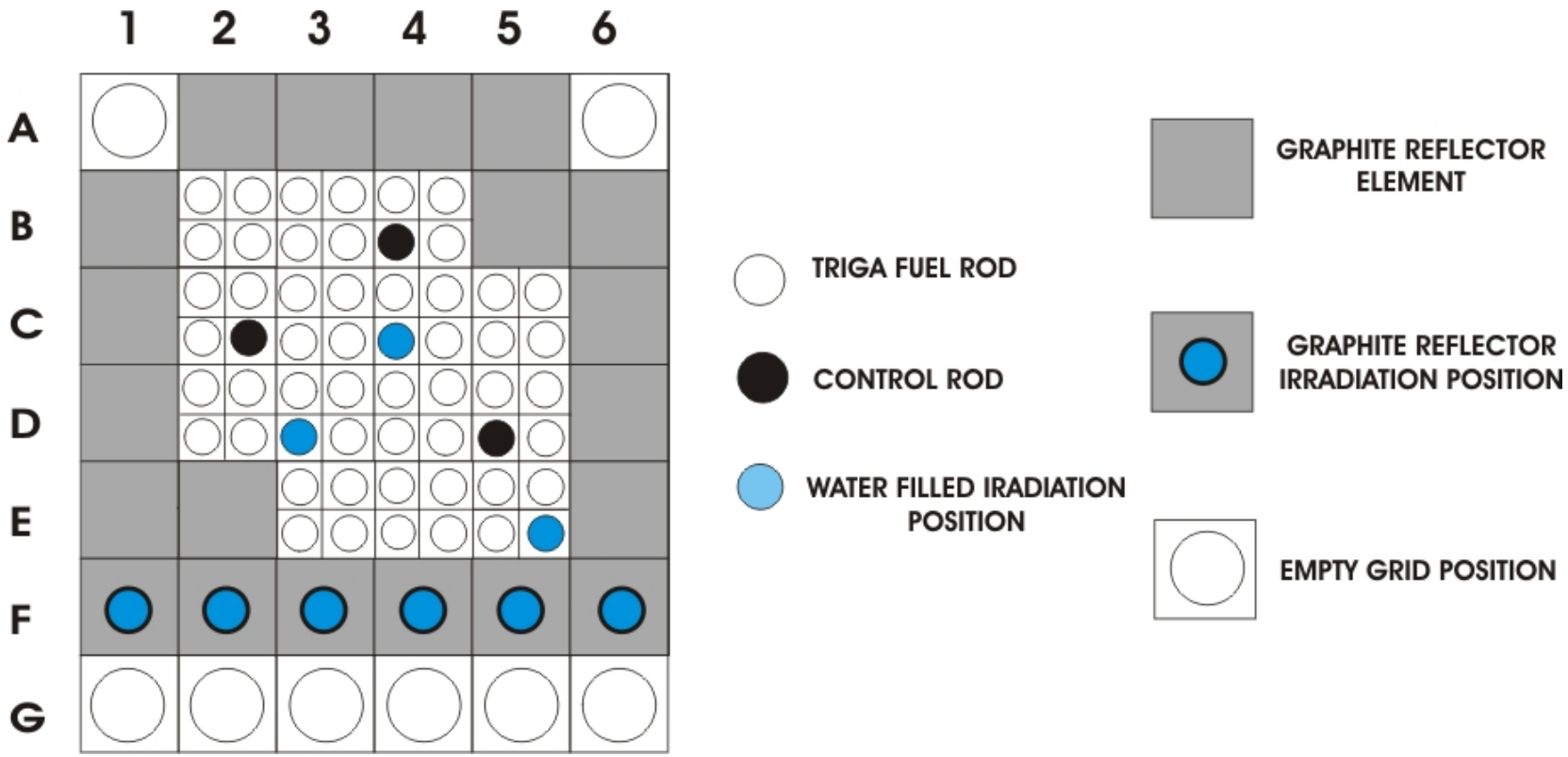
Water Temperature versus Time



TRIGA Core

- The core configuration is a rectangular grid plate that holds a combination of 4-rod and 3-rod clusters.
- 3-rod clusters provide a fourth cluster space to be used for control rods , and others 3-rod clusters have a fourth cluster space to be used for in-core irradiation.
- The core contains 50 fuel rods with LEU fuel TRIGA (UZr H1.6) type enriched to 19.7%. Each fuel rod is 34.9 mm in diameter and 765 mm long with a fueled length of 381 mm.
- The radial reflector consists of twenty graphite elements six of which are used for isotope production. The top an bottom reflectors are the cylindrical graphite end reflectors which are installed above and below of the active fuel section in each fuel rod.

Top View of the IAN-R1 TRIGA Core



Neutron Flux Measurement

- The spatial dependence of thermal *neutron flux* was measured axially in the 3-rod clusters 4C, 3D, 5E and in the 4F graphite element. The spatial distribution of the thermal neutron was determined using a self-powered detector and the absolute value of thermal neutron flux was determined by a gold activation detector.
- The (n, b-) reaction is applied to determine the relative spatial distribution of thermal neutron flux with rhodium like target. The values of such detectors are proportional to the thermal neutron flux and, therefore, the values during the measurements can be directly used to calculate the spatial distribution of thermal neutron flux.

- Aluminium-covered and cadmium-covered gold foils were employed to determine the absolute value of thermal neutron flux throughout the reactor core. The neutron flux was determined by measurement of the activity of the samples irradiated.
- In the irradiation channels in core position 4C, and 3D, two gold foils, one in aluminium cover while the other in cadmium cover were irradiated. The foils in polyethylene sample holder were forwarded to the operating reactor by means of the pneumatic rabbit system joining the irradiation channels 4C, 3D.
- The gold foils were irradiated during 1.5 hours to 20 kW power level. The sample intensities were taken by a NaI Canberra counter.

Al and Cd capsules for covering the gold foils

- **Gold foil**
- *A* mass number 196.66 g
- Thickness: 0.0127mm
- Abundance isotope: 99.5 %
- Microscopic activation cross section of 197Au: 98.65 m2
- Decay constant of 19 8Au . 64,8 h
- **Aluminium cover**
- Thickness: 0.4 mm
- Diameter: 11.3 mm
- **Cadmium cover**
- Thickness: 1.15 mm
- Diameter: 13.0 mm

Gamma Counter

NaI Detector (802-4W)

- Resolution 1.9keV (FWHM) Co60 1332 keV
- Preamplifier 2007P
- Amplifier 4001C
- Efficiency *198Au (411,8 KeV) del 11,8263 %.*

Results

Foil with	Mass (g)	Irradiation position	Decay time (h)	Activity (Bq)
Al	0,0021	C4	6.43	45630.05
Cd	0.0037	C4	69.12	37677.51
Al	0.0020	D3	5.85	37783.74
Cd	0.0022	D3	68.44	18879.57

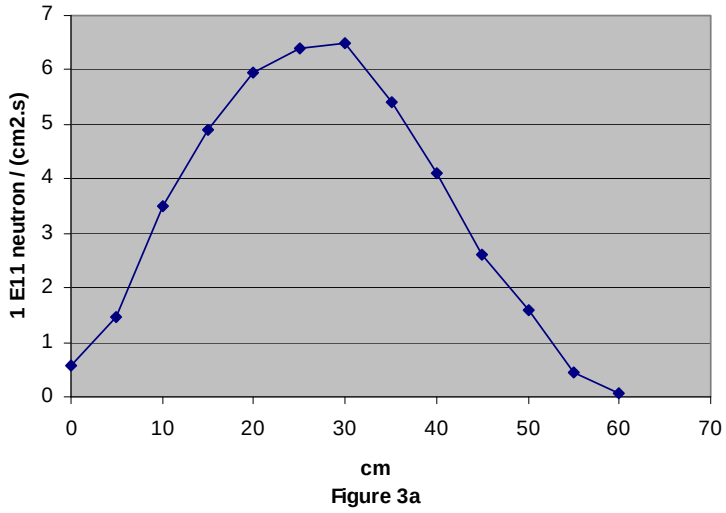


Figure 3a

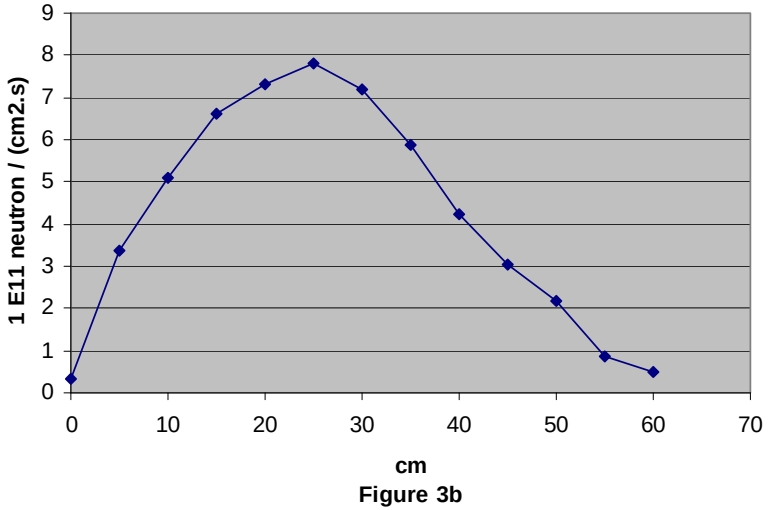


Figure 3b

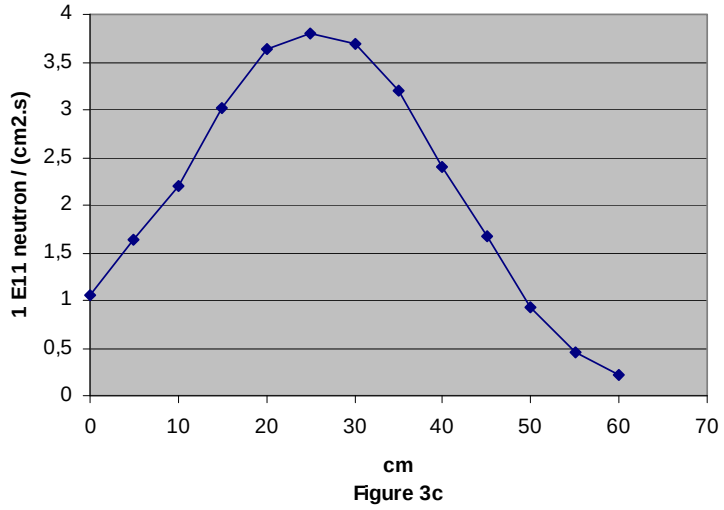


Figure 3c

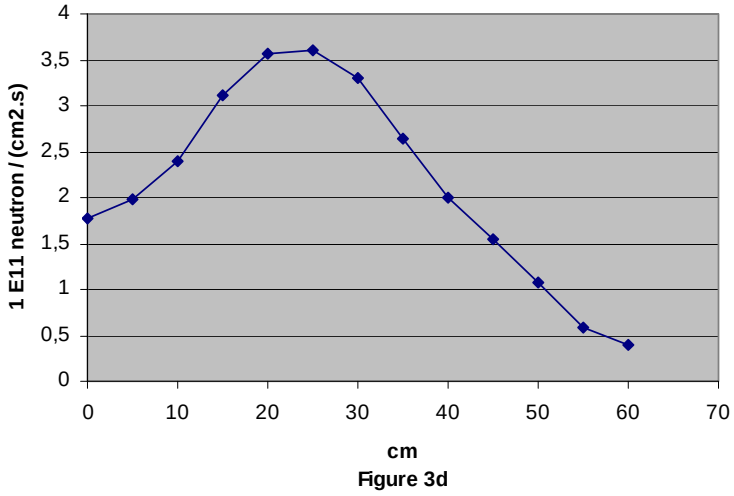


Figure 3d

Conclusion

- The calorimetric experiment used in this work for establishing the thermal reactor power it is a quick and precise method for being implemented as a calibration method for IAN-R1 TRIGA reactor.
- The experimental procedures using a self-powered detector together with the measurement of the activity irradiated foils, enable determination of thermal neutron flux throughout the reactor core of the IAN-R1 TRIGA reactor

Acknowledgment

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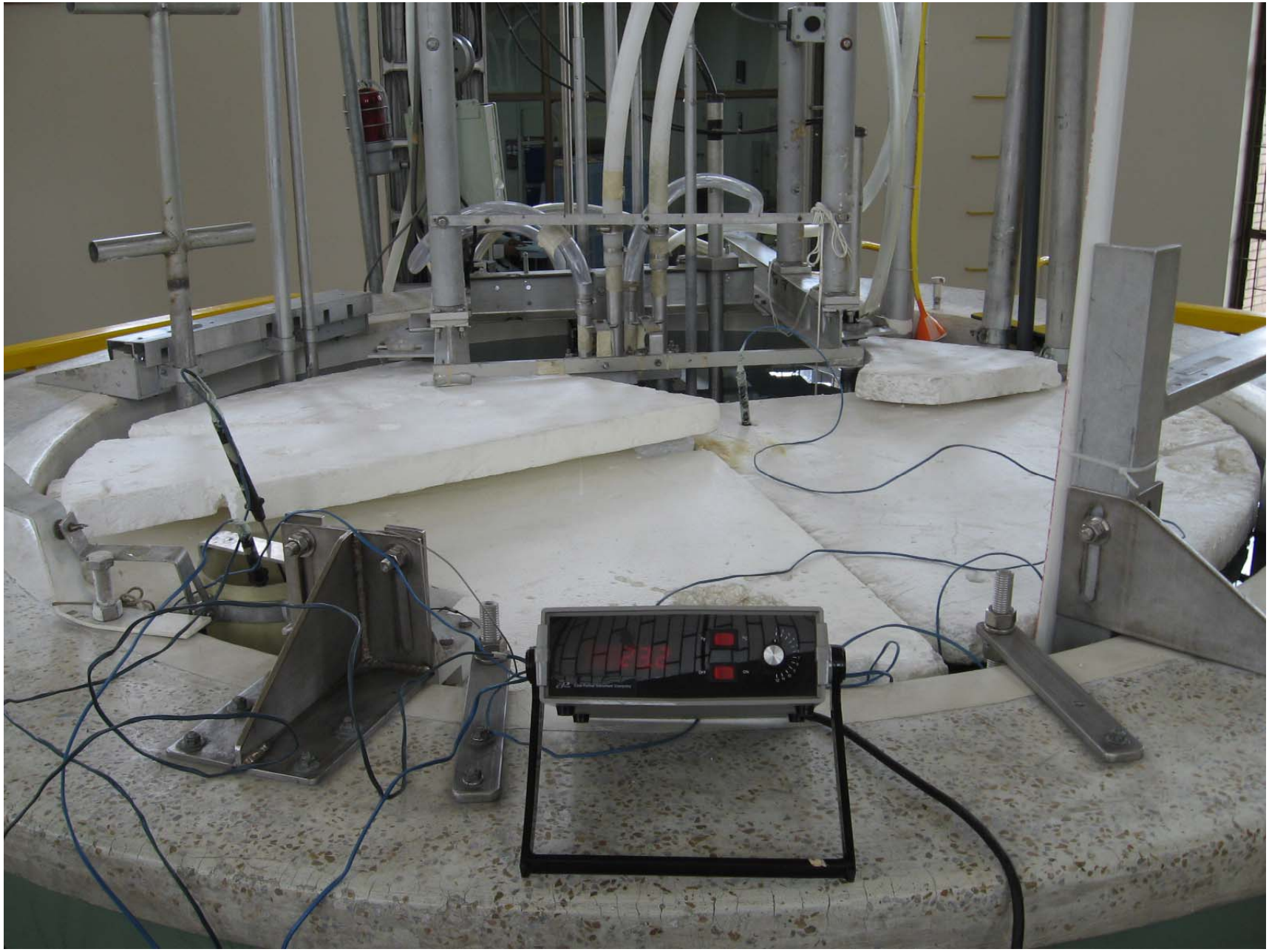

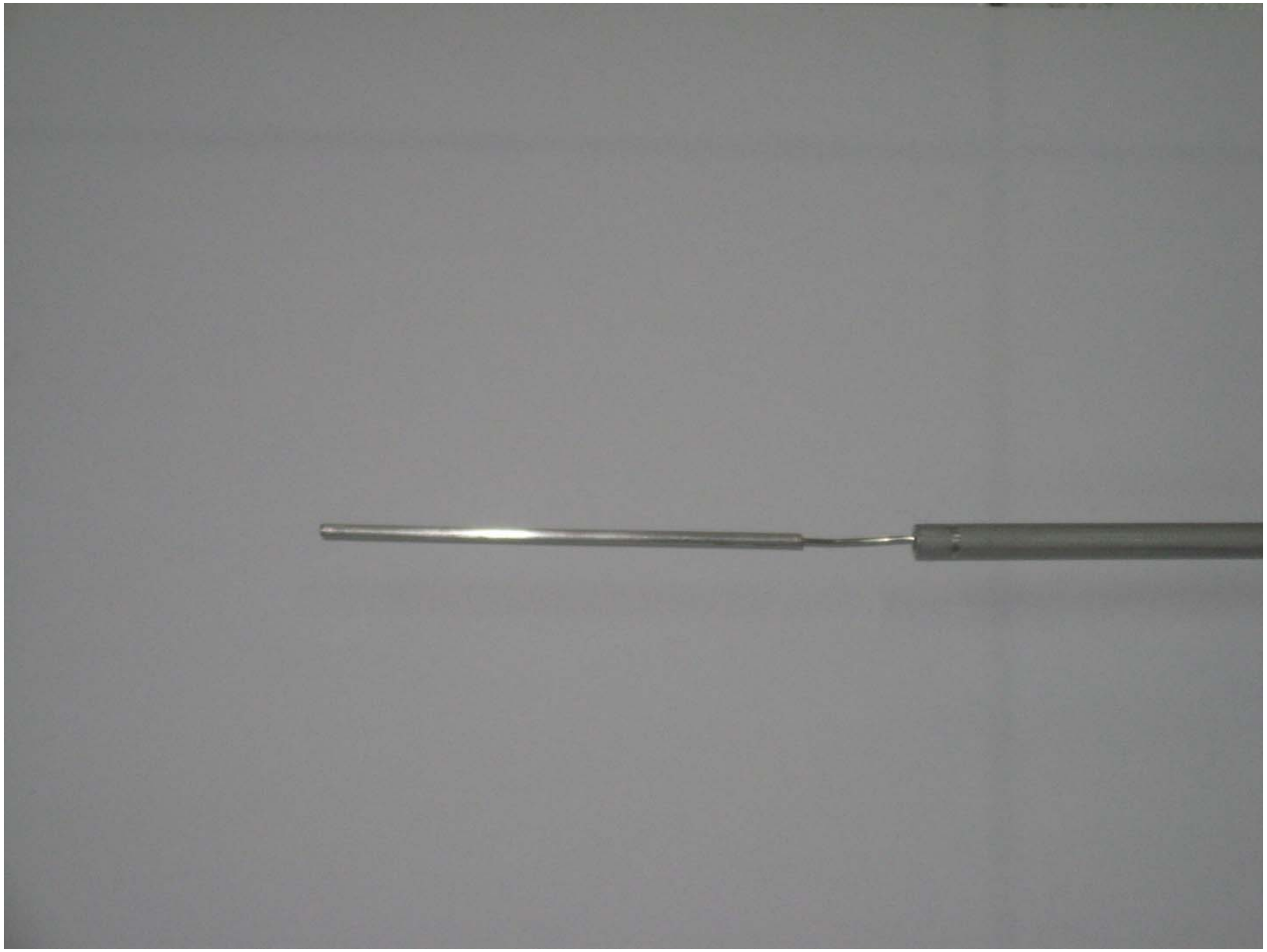


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