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Experimental evaluation, for radiation protection purpose, of photon and neutron radiation field during the public presentation of the prototype called "Energy Amplifier"

PREFACE

On 14/01/11 at the GM System plant of Via dell'Elettricista 16 in Bologna, I performed radiation field measurements for radiation protection purposes as per your request of 09/11/10.

This report is therefore about the evaluation of the photon and neutron radiation field near the prototype called "Energy Amplifier" during its public presentation.

The process, the geometry and the materials used for the production of energy inside the "Energy Amplifier" are unknowns that I'm not aware of. Environmental monitoring is defined temporally before, during and after the test in question

The field evaluation can not relate to criteria of functionality of the system and can not be used for comparison in systems different from this one, in the process, in the geometry or in the construction materials used.

TIME DESCRIPTION OF THE TEST

The test has been conducted without interruptions in the measures presented below, which therefore represent, to all intents and purposes, a continuous monitoring of the photon field and of the neutron field samples as summarized in table:

| ID | Phase | Start time | End time |
|-----------|-----------------------------------|-------------------|-----------------|
| 0 | External environmental background | 13:10 | 13:20 |
| 1 | Before ignition | 15:45 | 16:22 |
| 2 | Ignition | 16:22 | 16:45 |
| 3 | Stability | 16:45 | 17:25 |
| 4 | Switching off | 17:25 | 17:55 |
| 5 | After switching off | 17:55 | 19:00 |

Table 1: Time phases of the present measures during the presentation of the "Energy Amplifier".

REPRESENTATION OF THE MEASURE GEOMETRY

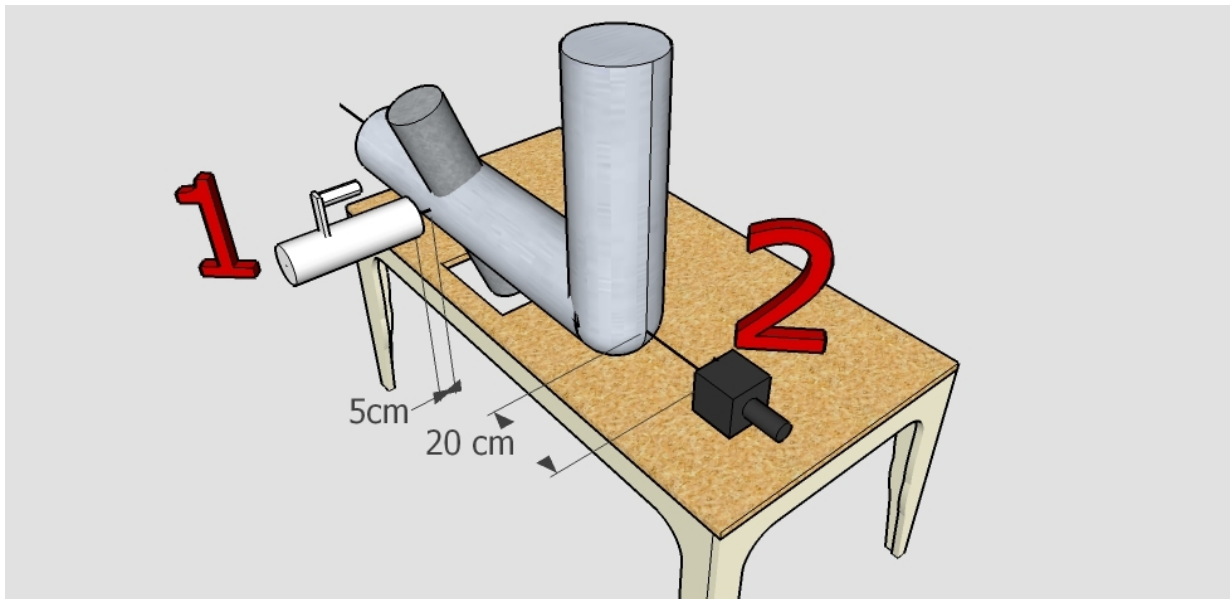


Figure1: This is the prospective representation of the relative position between probes and the “Energy Amplifier”. This figure can be used to represent the environment in which the instruments were used. Probe”1”’: as describe in Table 2. Probe”2”’: as describe in Table 4

EVALUATION OF THE X e γ FIELD

This measure has the purpose of detecting, only for radiation protection purposes, the X e γ radiation around the “Energy amplifier” during it's using.

This measure does not take into account in any way the internal attenuation of the photons produced by the apparatus and can not in any way be traced back to the production or otherwise of the photons due to the same apparatus.

METHOD

Has been defined a measurement protocol structured as follows:

- In agreement with the ICRU definitions (*International Commission on Radiation Units and Measurements; rif. Report 57-1998*), we have chosen to evaluate the ambient dose equivalent $H^*(10)$ as a dosimetric indicator of the X and γ field;
- The ambient dose equivalent measurements have been performed in dose rate mode;
- The measurement position is not fixed but is variable around the “Energy amplifier” at a minimum distance of measurement from the outer structure equal to $d=(5\pm 2)$ cm. This choice has the purpose of monitoring the possible anisotropic radiation through the mapping of the radiation solid angle around the system;
- The measurements have been repeated at a frequency such that the average of the values is magnitude representative of the dosimetric values distribution;
- The average values are both temporal (time phase) and spatial (different positions of measurement);
- The analysis of the data is based on the comparison with the environmental background measured in an independent temporal phase (phase 0) and in an environment reasonably far from the “Energy amplifier” ($d>50m$).

MATERIALS

The measurements were performed with the following instrumentation:

| |
|---|
| • AUTOMESS 6150 AD-b (s/n 93883); |
| • Last calibration certificate SIT 065/R n. 9521/S/12/10 del 20.12.2010); |
| • Probe: zinc sulfide (ZnS scintillator) size 3” \times 3”; |
| • Measuring range 23 keV – 7 MeV; |
| • Resolution declared of 1 nSv/h; |
| • Measuring range of 50 nSv/h – 99.99 μ Sv/h. |

Table 2: Specification data of the used instrument for the present measure.

RESULTS

The measured values are shown in the following table:

| Temporal Phase | H*(10) [nSv/h] |
|----------------|----------------|
| 0 | 118 ± 10% |
| 1 | 107 ± 10% |
| 2 | 111 ± 10% |
| 3 | 115 ± 10% |
| 4 | 116 ± 10% |
| 5 | 123 ± 10% |

Table 3: Ambient dose equivalent for each test phase as described in Table 1 (Please note that Phase 0 correspond to the background value)

The uncertainty on the measure is estimated in accordance with the methods described in ICRU Report 76 *Measurement Quality Assurance for Ionizing Radiation Dosimetry (2006)*.

CONCLUSIONS

From the measures it is shown that there are no evidence of meaningful differences of H*(10) compared to the background environmental radiation.

Furthermore the dosimetric measures are not dissimilar from the environmental background measurement both as average and as maximum peak values.

EVALUATION OF THE NEUTRON FIELD

This measure has the purpose of detecting, only for radiation protection purposes, the neutron radiation around the “Energy amplifier” during its using.

The measure does not take into account in any way the attenuation and the thermalization of neutrons maybe produced or present inside the apparatus and can not be in any way be traced back to the production or otherwise of neutrons due to the same apparatus.

MATERIALS

For the measurement we used a direct reading electronic detector described by the following technical summary:

| | |
|--|---|
| <i>Manufacturer:</i> | LUDLUM |
| <i>Electrometer:</i> | LUDLUM 2221 Scaler/Ratemeter SCA |
| <i>Probe:</i> | Prescila 42-41 Neutron Radiation Detector (neutron recoil scintillator) |
| <i>Sensitivity declared by the manufacturer:</i> | 350 cpm per mrem/h; |
| <i>Angular dependance:</i> | 15 % in all the measure range |

Table 4: Specification data of the used instrument for the present measure.

The instrument has been periodically calibrated by an accredited ENEA center that has provided the following calibration factors:

- On 17/03/2010 (N°1N10) with AmBe source ($E_{\text{neutrons}} = 4.4 \text{ MeV}$) equal to 36CPM per $\mu\text{Sv/h}$
- On 28/01/08 with di Pu-Li source ($E_{\text{neutrons}} = 0.54 \text{ MeV}$) equal to 15 cpm per $\mu\text{Sv/h}$

METHOD

Has been defined a measurement protocol structured in the following way:

- The evaluation of the neutron field is based on the rate measurement of the counts per minutes (cpm) so as they are provided by the instrument, by integrating the registered counts in 60 seconds;
- The measurement position is fixed with respect to the “Energy amplifier” at measurement distance from the external structure equal to $d = (20 \pm 5) \text{ cm}$. This choice has the purpose to monitoring the neutron radiation in the room in the chosen angular direction. The choice of the position is due the instrument available space;
- The values provided are the average of the values collected in the temporal interval;
- The measurements have been repeated at a frequency such that the average of the values is representative of the distribution of dosimetric values;

- The analysis of the data is based on the comparison with the background measured in an independent temporal phase (phase 0) and in an environment reasonably far from the “Energy amplifier” (d>50m).

RESULTS

The results are presented in temporal rate of counts per minutes type (counts per minutes) in the same way as what is provided directly by the instrument (average values for each time interval in question):

| PHASE | CPM (counts per minutes) |
|--------------|---------------------------------|
| 0 | 16 ± 2 |
| 1 | 15 ± 2 |
| 2 | 16 ± 2 |
| 3 | 15 ± 2 |
| 4 | 14 ± 2 |
| 5 | 16 ± 2 |

Table 5: Count per minute values for each test phase as described in Table 1 (Please note that Phase 0 correspond to the background value)

CONCLUSIONS

From the measures it is shown that there are no evidence, within the bounds of the instruments presented before, of meaningful differences in the measured values compared to the background environmental radiation.

Further:

- The absence of neutron field observable from the measured background does not allow the dosimetric analysis for a comparison with the calibration values associated with the instrument.
- The measure results are not dissimilar from the environmental background both as average and as maximum values.

In faith
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