GUIDELINES FOR THE USE OF
ACTIVE PERSONAL DOSEMETERS IN INTERVENTIONAL
RADIOLOGY/CARDIOLOGY- ORAMED PROJECT

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General problematic and main goals

This work has been done in the WP3 of ORAMED dealing with the optimization of the use of the Active Personal Dosemeters in interventional radiology/cardiology

- **In interventional radiology and cardiology (IR/IC)**
  The possibility to assess the dose equivalent in real time is particularly interesting since medical staff can receive relatively high doses while standing close to the primary radiation field.

- **Active Personal Dosemeters APDs**
  Operational dosimetry, which provides information in real time with electronic devices, allows the application of the ALARA principle. Possible alarm at a pre-set dose equivalent and/or dose equivalent rate level when the personnel is accidentally exposed to the primary beam is very attractive.

- **Personal dose equivalent \(Hp(10)\)** is measured to estimate the effective dose \(E\).

- **Guidance to select an appropriate APD electronic device for the radiology and cardiology specific workplaces**

- **Guidance to use APD correctly in radiology and cardiology pulsed beams**
### Interventional Radiology and Cardiology specificities

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>High voltage</td>
<td>60-120 kVp</td>
</tr>
<tr>
<td>Intensity</td>
<td>5-1000 mA</td>
</tr>
<tr>
<td>Inherent filtration</td>
<td>3 - 6 mm Al_{eq} (typically 4.5 mmAl_{eq})</td>
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<tr>
<td>Additional filtration</td>
<td>0.2 - 0.9 mmCu</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>1 - 20 ms (typically 10-20 ms)</td>
</tr>
<tr>
<td>Pulse frequency</td>
<td>1 - 30 pps (typically 15 pps)</td>
</tr>
<tr>
<td>Dose equivalent rate in the direct beam (table)</td>
<td>2 to 360 Sv.h^{-1}</td>
</tr>
<tr>
<td>Dose equivalent rate in the scattered beam (operator - above the lead apron)</td>
<td>5.10^{-3} to 10 Sv.h^{-1}</td>
</tr>
<tr>
<td>Energy range of scattered spectra</td>
<td>20 keV - 100 keV</td>
</tr>
</tbody>
</table>
Beam characteristics

Typical HV waveform in multi-pulse mode 70 kV 10 pps

Pulse frequency: number of pulses per second = pps
Pulse width: Dt
Direct beam: beam directly delivered by the X-ray tube
Scattered beam: scattered beam by patient and equipment
APDs characteristics and previous studies

- Only a few devices can detect low energy fields (20-100 keV). The threshold in energy is generally higher than 20 keV.

- None of them are specially designed for working in pulsed radiation fields.

This problem was clearly highlighted during two international comparisons:

1- Inter comparison of personal dose equivalent measurements by active personal dosimeters organised by EURADOS and IAEA. (2007). *IAEA Report IAEA-TECDOC-1564 (Vienna: IAEA)*

2- Inter comparison performed in the framework of the CONRAD project, supported by the EC within its 6th Framework Program. *Inter comparison of active personal dosemeters in interventional radiology. Clairand et al. Radiat. Prot. Dosim. 129 (1-3), pp. 340-345*

*Continuous and mono-pulse beams In primary beam*  
*Continuous beam and mono-pulse beams In the scattered beam of the patient phantom*
ORAMED STUDY

- 8 APDs suitable for IR/IC were tested in terms of:
  - energy response
  - angular response,
  - dose equivalent response
  - dose equivalent rate response
- In different conditions
  - Laboratory continuous beam
  - laboratory multi-pulsed beam
    - pulse width (Dt)
    - Pulse frequency (pps)
  Pulsed X-rays for interventional radiology:
  Tests on Active Personal Dosemeters
  Denozière M, Daures J, Lecerf N, Bordy JM.
  CEA-R-6233 report, (APD)
- Hospital real conditions
Specific ORAMED recommendations when selecting an APD in IR/IC (1/3)

- The APD has to fulfill the requirements of the IEC 61526 standard “Radiation protection instrumentation – Measurement of personal dose equivalents Hp(10) and Hp(0,07) for X, gamma, neutron and beta radiations – Direct reading personal dose equivalent meters »

  - Energy response: correct (-29% +67%) in the energy range 20 keV – 100 keV
  - Angular response: correct (-29% +67%) from 0° to 60° from the reference direction within the energy range 20 keV – 100 keV.
  - Dose equivalent rate range: The maximum dose equivalent rate value required by IEC is 1 Sv/h. But in IR/IC, APD can stand higher dose equivalent rates, it has to be able to give at least an alarm for dose equivalent rates higher than 1 Sv/h.
Specific ORAMED recommendations when selecting an APD in IR/IC (2/3)

- As pulsed radiation fields are not taken into account in existing standards, some information in the APD characteristics in pulsed fields are needed (effect of pulse frequency and pulse width response)

  - Results of the tests eventually performed by the manufacturer
Specific ORAMED recommendations when selecting an APD in IR/IC (3/3)

- Perform tests using the following configuration
  - Place one ISO slab phantom on the table to simulate the scattered field created by the patient
  - Place one ISO slab phantom at a representative position of the operator
  - Place the APD and a passive dosemeter side by side on the operator phantom (without lead apron)
  - Use a usual configuration of your facility (kV, mAs, and integrate at least 300 µSv
  - A factor of 2 between the doses given by the active and passive dosemeters can be considered as acceptable.
Specific ORAMED recommendations when using an APD in IR/IC

- The APD has to be periodically (according to local regulation) calibrated in terms of $Hp(10)$ preferably with X-ray beams in a calibration laboratory traceable to the primary standard, the conditions of calibration have to be as close as possible as those of use.

- The APD is considered, for this application in IR/IC, as a tool to optimize and reduce the exposure (ALARA principle), we then recommend to wear it the over the lead apron.

- We do not recommend to use APD for the legal dose record in case of IR/IC, the reference $Hp(10)$ has still to be taken from the passive dosemeter results.

- The alarm should be switched ON (only visual alarm) in order to warn the operator when he/she is too close to the direct beam.
Thank you for your attention