



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

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# General problematic and main goals

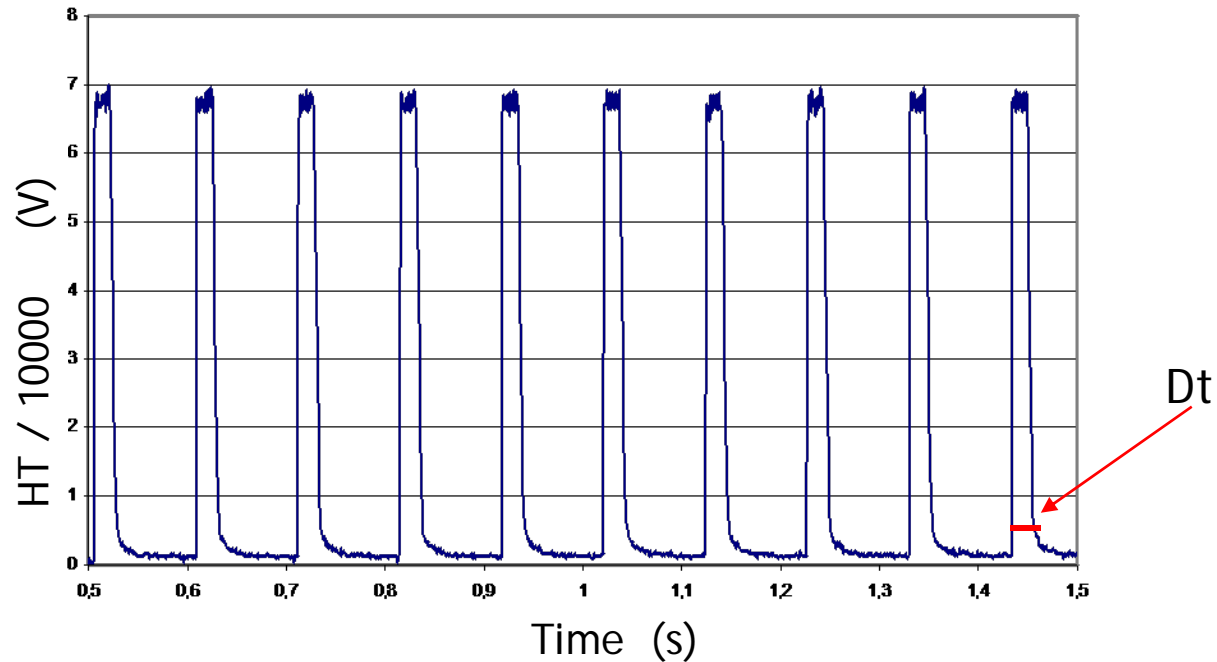
This work has been done in the WP3 of ORAMED dealing with the optimization of the use of the Active Personal Dosemeters in interventional radiology/cardiology

- **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  $H_p(10)$**  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

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

# 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)*

*Continuous and mono-pulse beams  
In primary beam*

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 doseimeters in interventional radiology. Clairand et al. Radiat. Prot. Dosim. 129 (1-3), pp. 340-345*

*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 Dosimeters  
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  $H_p(10)$  and  $H_p(0,07)$  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 performed within the ORAMED project (Clairand I. et al “Active personal dosimeters in interventional radiology: tests in laboratory conditions and in hospital. Rad. Prot. Dosim. (doi:10,1093/rpd/ncp556, 2010, pp 1-6)
  - 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 dosimeter side by side on the operator phantom (without lead apron)
  - Use a usual configuration of your facility (kV,mAs, and integrate at least 300  $\mu$ Sv)
  - A factor of 2 between the doses given by the active and passive dosimeters 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  $H_p(10)$  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  $H_p(10)$  has still to be taken from the passive dosimeter 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**