

## 7. MEASUREMENT OF INTENSITIES

Table 7.3.3.1. Commonly used detection processes

	1st conversion (neutron captures)	2nd conversion	3rd conversion	Sensor
	Capture/solid $\rightarrow e^-$ $n + {}^{157}\text{Gd}$			Film
Gas ionization	Capture/gas $n + {}^3\text{He} \rightarrow p + t$	Gas ionization $\rightarrow e^-$ ( ${}^3\text{He} + \text{add. gas}$ )		Electronics
	Capture/solid $n + {}^{10}\text{B}, {}^6\text{Li}, {}^{235}\text{U}$ fission products	Gas ionization $\rightarrow e^-$ (e.g. Ar + CO <sub>2</sub> )		Electronics
Scintillation	Capture/solid:	Fluorescence/solid:		
	<u>LiF</u> + ZnS(Ag) $n + {}^6\text{Li} \rightarrow \alpha + t$	<u>LiF</u> + ZnS(Ag) $\rightarrow \nu$		Film
	<u>LiF</u> + ZnS(Ag) $n + {}^6\text{Li} \rightarrow \alpha + t$	<u>LiF</u> + ZnS(Ag) $\rightarrow \nu$	Photoelectric effect $\rightarrow e^-$	Electronics
	Ce <sup>3+</sup> enriched <u>Li</u> glass $n + {}^6\text{Li} \rightarrow \alpha + t$	<u>Ce<sup>3+</sup></u> enriched Li glass $\rightarrow \nu$	Photoelectric effect $\rightarrow e^-$	Electronics

 $\nu$  = photon.

Table 7.3.3.2. A few examples of gas-detector characteristics

Detection gas	Additional gas	Gas pressure (atm)	Useful detection volume (mm × mm)	Mounting	Capture efficiency	
					$\lambda = 1 \text{ \AA}$	$\lambda = 2 \text{ \AA}$
<sup>10</sup> BF <sub>3</sub>		1	$L = 200, \varnothing = 50$	Axial Radial*	65.5% 23.4%	88.1% 41.3%
<sup>3</sup> He		5	$L = 100, \varnothing = 50$	Axial Radial*	97.5% 84.4%	99.9% 97.5%
<sup>3</sup> He		8	$L = 250, \varnothing = 10$	Radial*	44.7%	69.5%
<sup>3</sup> He (monitor)	C <sub>3</sub> H <sub>8</sub>	2	100 × 40 × 40		$10^{-5}$ to $10^{-3}$	

\* Value calculated for the diameter.

In order to maximize the light collected by the photomultiplier [Fig. 7.3.3.3(b)], a light reflector is added in front of the scintillator, and a light coupler adapts the dimensions of the scintillator to that of the photomultiplier (PM). The area of the scintillator might be very large (up to 1 m<sup>2</sup>). The optimum thickness of a glass scintillator is about 1 to 2 mm, corresponding to a neutron detection efficiency of 40 to 97% for  $\lambda = 1.8 \text{ \AA}$ , depending on the <sup>6</sup>Li concentration (Strauss, Brenner, Chou, Schultz & Roche, 1983). In a Ce-doped Li silicate glass, the number of photons emitted per captured neutron is about 9000, giving finally about 1500 electrons at the photocathode in the optimum light-coupling configuration. The number of photons emitted per captured neutron, the number of those reaching the photocathode, and the scintillator decay time are parameters that might differ by an order of magnitude, depending on the scintillator material. However, the glass scintillator remains for

the time being the best choice, since the possible gains given by other materials, in decay time or in the number of photons emitted, are always very severely offset by poor light output (e.g. the plastic scintillator). It is very important to maximize the number of photons per neutron reaching the photocathode, since this will help to discriminate between neutrons and  $\gamma$  rays [see Fig. 7.3.4.2(e)]. The optical coupling between the different parts of the detection system must be of very good quality.

## 7.3.3.4. Films

Films are classed as position-sensitive detectors. Two types of neutron converter are used in neutron film-detection processes. In the case of the scintillation film system, a light-sensitive film is pressed close to one or between two plastic <sup>6</sup>LiF/ZnS(Ag) scintillator screens (Thomas, 1972). In the case of the Gd-foil