

Film Dosimetry

Films have been used for radiation detection since the discovery of radioactivity and x-rays. Photographic film consists of a radiation-sensitive emulsion coated on a transparent polyester base. The emulsion consists of silver halide crystals (typically 95% silver bromide and 5% silver iodide) embedded in gelatin. The exact composition of emulsions covered with a thin layer of gelatin to protect from mechanical damage varies with manufacturers and is closely guarded industrial secret. When the emulsion is exposed to radiation, excitation and ionization take place in the silver halide that leads to the formation of a latent image. Film development is a chemical process which amplifies the latent image by a factor of millions. Electron micrographs of some commonly used films in dosimetry reveal vast difference in grain size and uniformity between the different types of films.

Film dosimetry relies on optical density (OD) defined as $\log(1/T)$ where T is transmission. If α is area of single developed grain of silver and n is number of grains/cm², OD is nearly equal to $0.4343\alpha n$. The OD versus $\log(\text{exposure})$ curve is uniquely defined for each film and is known as characteristic curve or H&D curve, stands for its inventors Hurter and Driffield in 1890. H&D curve has sigmoidal shape divided into toe, slope, and shoulder regions. The slope is important factor that decides the quality of the film. In dosimetry, OD versus dose is known as sensitometric curve that should be linear with dose and independent of the dose rate and energy. The OD of film also depends on the type of radiation, film processing and reading conditions, which will be discussed.

Even though there are several types of film in market, Kodak films account for 95% of the films used for dosimetry in the USA. Two most commonly used films are XTL and XV films stands for therapy localizing and verification respectively as fast and slow film. These films are individually wrapped in light tight envelopes. These wrapping creates significant problems in dosimetry, which has been described in literature. Some of these problems have been resolved in CEA films. Due to high Z composition (Ag, Br, I), films have strong energy dependence. This causes serious problem in dosimetry in kilovoltage beam but lesser degree in megavoltage beam. In megavoltage, film could have strong spectral dependence in beam and in penumbra region. Some of these difficulties will be addressed in the context of dosimetry related to machine QA, soft wedges (virtual, universal, and dynamic), HD270, IMRT, total skin electron, total body, surface dose, HDR and other applications. Some of the dosimetric difficulties with photographic films are eliminated in new type of low Z film called Radiochromic or Gafchromic film. The radiochromic films use organic based dye that changes color due to polymerization when exposed to radiation. These films provide advantages over photographic in various applications that will be discussed.

In summary, this talk will be based on historical background, photographic theory, applications, advantages and disadvantages of various types of films for radiation dosimetry.