SECTION 6. RADIOGRAPHY (X-RAY) INSPECTION

5-73. GENERAL. Radiography (x-ray) is an NDI method used to inspect material and components, using the concept of differential adsorption of penetrating radiation. Each specimen under evaluation will have differences in density, thickness, shapes, sizes, or absorption characteristics, thus absorbing different amounts of radiation. The unabsorbed radiation that passes through the part is recorded on film, fluorescent screens, or other radiation monitors. Indications of internal and external conditions will appear as variants of black/white/gray contrasts on exposed film, or variants of color on fluorescent screens. (See figure 5-14.)

5-74. LIMITATIONS. Compared to other nondestructive methods of inspection, radiography is expensive. Relatively large costs and space allocations are required for a radiographic laboratory. Costs can be reduced considerably when portable x-ray or gamma-ray sources are used in film radiography and space is required only for film processing and interpretation. Operating costs can be high because sometimes as much as 60 percent of the total inspection time is spent in setting up for radiography. With real-time radiography, operating costs are usually much lower, because setup times are shorter and there are no extra costs for processing or interpretation of film.

5-75. FILM OR PAPER RADIOGRAPHY. In film or paper radiography, a two-dimensional latent image from the projected radiation is produced on a sheet of film or paper that has been exposed to the unabsorbed radiation passing through the test piece. This technique requires subsequent development of the exposed film or paper so that the latent image becomes visible for viewing.

5-76. REAL-TIME RADIOGRAPHY. A two-dimensional image that can be immediately displayed on a viewing screen or television monitor. This technique converts unabsorbed radiation into an optical or electronic signal which can be viewed immediately or can be processed with electronic or video equipment.

5-77. ADVANTAGE OF REAL-TIME RADIOGRAPHY OVER FILM RADIOGRAPHY. The principal advantage of real-time radiography over film radiography is the opportunity to manipulate the test piece during radiographic inspection. This capability allows the inspection of internal mechanisms and enhances the detection of cracks and planar defects by allowing manipulation of the part to achieve the best orientation for flaw detection. Part manipulation during inspection also simplifies three-dimensional dynamic imaging for the determination of flaw location and size. In film radiography, depth parallel to the radiation beam is not recorded. Consequently, the position of a flaw within the volume of a test piece cannot be determined exactly with a single radiograph. To determine flaw location and size more exactly with film radiography, other film techniques; such as stereo-radiography, triangulation, or simply making two or more film exposures with the radiation beam being directed at the test piece from a different angle for each exposure, must be used.

5-78. COMPUTED TOMOGRAPHY (CT). CT is another important radiological technique with enhanced flaw detection and location capabilities. Unlike film and real-time radiography, CT involves the generation of cross-sectional views instead of a planar

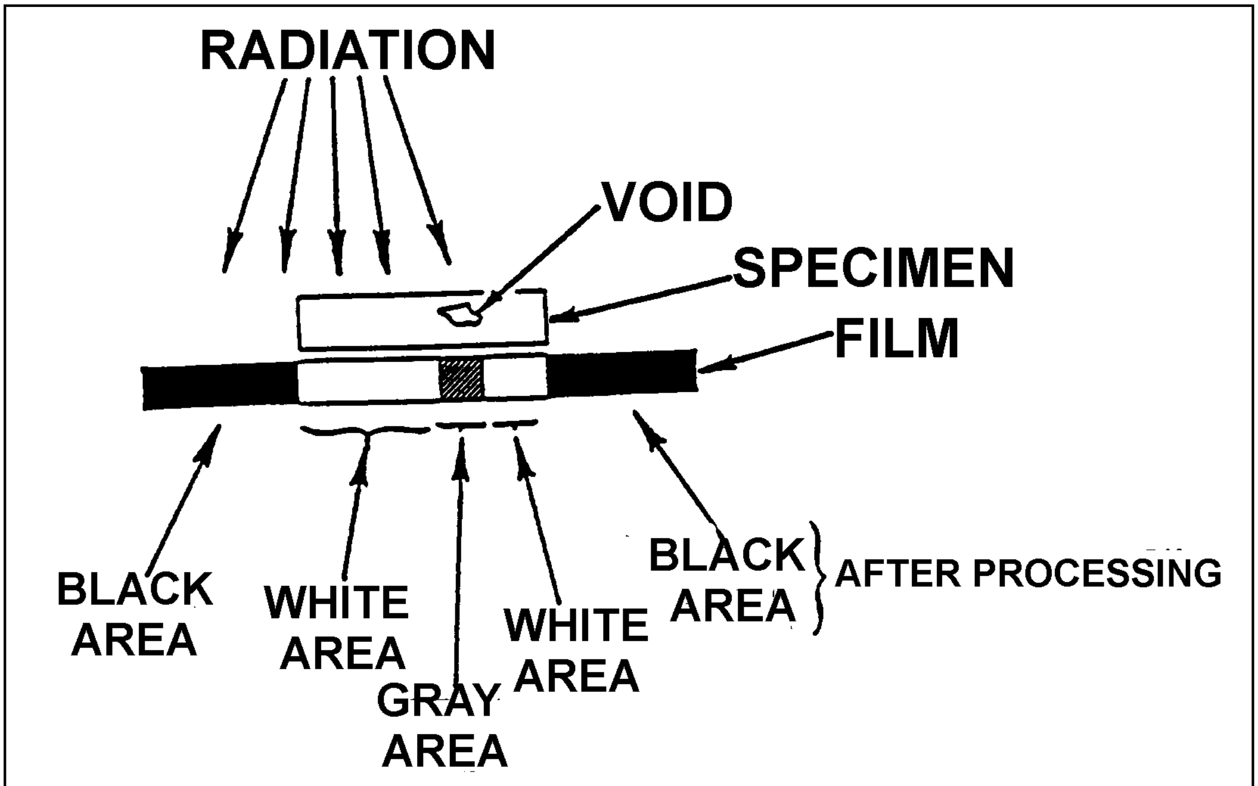

FIGURE 5-14. Radiography.

projection. The CT image is comparable to that obtained by making a radiograph of a physically sectioned thin planar slab from an object. This cross-sectional image is not obscured by overlying and underlying structures and is highly sensitive to small differences in relative density. Computed tomography images are also easier to interpret than radiographs.

5-79. USES OF RADIOGRAPHY. Radiography is used to detect the features of a component or assembly that exhibit a difference in thickness or density as compared to surrounding material. Large differences are more easily detected than small ones. In general, radiography can detect only those features that have an appreciable thickness in a direction along the axis of the radiation beam. Therefore, the ability of radiography to detect planar discontinuities, such as cracks, depends on proper orientation of the test piece during inspection. Discontinuities which have measurable thickness in all directions, such as voids and inclusions, can be detected as long as they are not too small in relation to section thickness. In general, features that exhibit a 2 percent or more difference in radiation adsorption compared to the surrounding material can be detected.

5-80. COMPARISON WITH OTHER NDI METHODS. Radiography and ultrasonic are the two generally-used, nondestructive inspection methods that can satisfactorily detect flaws that are completely internal and located well below the surface of the test part. Neither method is limited to the detection of specific types of internal flaws. However, radiography is more effective when the flaws are not planar, while ultrasonic is more effective when flaws are planar. In comparison to other generally-used NDI methods (e.g., magnetic particle, liquid penetrant, and eddy current inspection), radiography has the following advantages.

a. The ability to inspect for both internal and external flaws.

b. The ability to inspect covered or hidden parts or structures.

c. The ability to detect significant variations in composition.

d. Provides a permanent recording of raw inspection data.

5-81. FLAWS. Certain types of flaws are difficult to detect by radiography. Cracks cannot be detected unless they are essentially along the axis of the radiation beam. Tight cracks in thick sections may not be detected at all, even when properly oriented. Minute discontinuities such as: inclusions in wrought material, flakes, microporosity, and microfissures may not be detected unless they are sufficiently segregated to yield a detectable gross effect. Delaminations are nearly impossible to detect with radiography. Because of their unfavorable orientation, delaminations do not yield differences in adsorption that enable laminated areas to be distinguished from delaminated areas.

5-82. FIELD INSPECTION. The field inspection of thick sections can be a time-consuming process, because the effective radiation output of portable sources may require long exposure times of the radiographic film. This limits field usage to sources of lower activity that can be transported. The output of portable x-ray sources may also limit field inspection of thick sections, particularly if a portable x-ray tube is used. Portable x-ray tubes emit relatively low-energy (300 kev) radiation and are limited in the radiation output. Both of these characteristics of portable x-ray tubes combine to limit their application to the inspection of sections having the adsorption equivalent of 75 mm (3 inches) of steel maximum. Portable linear accelerators and betatrons that provide high-energy (> 1 MeV) x-rays can be used for the radiographic field inspection of thicker sections.

5-83. SAFETY. Radiographic safety requirements can be obtained from; the OEM's manual, FAA requirements, cognizant FAA ACO engineers, and radiation safety organizations such as the Nuclear Regulatory Commission (NRC). Information in radiation safety publications can be used as a guide to ensure that radiation exposure of personnel involved in radiographic operations is limited to safe levels, and to afford protection for the general public.

5-84.—5-88. [RESERVED.]