



American National Standard

ANSI/HPS N43.2-2021

Radiation Safety for X-ray Diffraction and Fluorescence Analysis Equipment

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American National Standards Institute, Inc.



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Foreword (This foreword is not part of American National Standard N43.2)

The problem of radiation hazards connected with the operation of x-ray diffraction and fluorescence analysis equipment has been a continuing one since the advent of such equipment. Since the last release of this standard many new technologies have emerged and have been incorporated into systems design without sufficient consideration and little or no guidance by standards. In addition, new uses have been found in areas like hand-held x-ray fluorescence spectrometers and new x-ray production technologies have found their way from the large accelerator facility to the table top, like laser produced x-rays. This revision is meant to modernize the past recommendations (many of which are still valid, however) and to provide guidance for x-ray use in new technologies. Also, this standard will include consideration of safety provisions according to the level of use, distinguishing “routine use” from alignment or service operations. The old standard would allow open or closed beam configuration to be applied at all times as would be needed for whichever operation required maximum access or flexibility. This version will encourage a split mode configuration; providing the maximum protection of an enclosed beam configuration for most use conditions and allow the option of a controlled access to an open beam mode for those few situations that are incompatible with enclosed beam.

Historically, the American Standards Association (ASA), Sectional Committee Z54, in 1946 issued American War Standard Z54.1 “Safety Code for the Industrial Use of X-rays” which included a section on x-ray diffraction. In 1967, the ASA was superseded by the USA Standard Institute, and Sectional Committee Z54 was replaced by Committee N43 under the sponsorship of the National Bureau of Standards (NBS, now known as the National Institute of Standards and Technology).

Responsibility for the development of the original standard was assigned to Subcommittee N43-1. American National Standard N43.2-1971 “Radiation Safety for X-ray Diffraction and Fluorescence Analysis Equipment” was approved on October 6, 1971, published as NBS Handbook 111, and then reaffirmed with minor revisions in 1976. In 1985, the Health Physics Society replaced the National Bureau of Standards as the Secretariat for the N43 Committee.

In 1988 Subcommittee N43.2 reformed to begin the updating process and had the standard reaffirmed in March 1989. Revision work was completed in December 1998 and the draft received N43 Committee approval July 31, 2001. This document was reaffirmed on January 4, 2010.

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to HPS Standards Program Director, Health Physics Society, 950 Herndon Blvd., Suite 450, Herndon, VA 22170 USA.

Key words: diffraction, fluorescence, x-ray

1 Purpose and Scope

1.1 Purpose

This standard concerns safe operation of analytical x-ray diffraction and fluorescence analysis equipment, establishes equipment design criteria, and sets up requirements for approved operating procedures. This standard also references reviews of the types of injuries resulting from accidental exposure to ionizing radiation, and recommends the establishment of health surveillance, and personnel monitoring programs. The circumstances under which operation of equipment must be limited to specially designated areas equipped with radiation barriers and warning signs are provided. Dose limits recommended by the National Council on Radiation Protection and Measurements are provided for reference. A list of references to selected articles on various aspects of radiation safety is given, and notes on the detection and measurement of radiation from x-ray diffraction and fluorescence analysis equipment are included in appendix A.

1.2 Scope

This standard provides guidelines specific to the radiation safety aspects of the design and operation of electrically powered/energized x-ray diffraction and fluorescence analysis equipment. This standard includes use of hand-held equipment using x-ray fluorescence to detect and identify contraband such as explosives and narcotics, in addition to other types of materials. It does not include electrical safety guidelines or other safety considerations outside the realm of radiation safety. Equipment employing x-rays from radioactive sealed sources is not within the scope of this standard.

2 Normative References

These are documents to which reference is made in the standard in such a way as to make it indispensable for the application of the standard.

- 1.) Howley, J.R. and Robbins, C., Radiation hazards from x-ray diffraction equipment. Radiological Health Data and

Reports vol. 8, no. 5, (May 1967), pp. 245-249.

- 2.) A Summary of Industrial Accidents in USAEC Facilities, 1965-1966. United States Atomic Energy Commission, Division of Technical Information, Oak Ridge, TN 37830, (TID-5360-Supplement 6), pp. 4 and 6.

- 3.) Merriam, G.R. and Focht, E.F., Clinical study of radiation cataracts and relationship to dose. The American Journal of Roentgenology, Radium Therapy and Nuclear Medicine, vol. 77, May 1957, pp. 759-785.

- 4.) American National Standard for General Radiation Safety - Installations Using Non- Medical X-ray and Sealed Gamma-Ray Sources, Energies Up To 10 MeV, American National Standard N43.3-2008.

- 5.) Kaelble, E.F. (Editor), Handbook of X-rays. New York: McGraw-Hill Book Co., (1967).

- 6.) Conference on Detection and Measurements of X-Radiation from Color Television Receivers. United States Department of Health, Education and Welfare; and Electronic Industries Association; Bureau of Radiological Health, Washington, D.C. 20850, March 28-29, 1968 (Technical Papers).

- 7.) American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments, IEEE/ANSI standard N323AB-2013.

- 8.) Clark, G.L. (Editor), The Encyclopedia of X- rays and Gamma Rays. New York: Reinhold Publishing Corporation, 1963.

3 Definitions

The definitions and terms contained in this standard, or in other American National Standards

referred to in this document, are not intended to embrace all legitimate meanings of the terms. They are applicable only to the subject treated in this standard.

ALARA. As Low As Reasonably Achievable - making every reasonable effort to maintain exposures to radiation as far below the dose limits as practical, taking into account the state of the technology, the economics of the improvements in relation to the benefits, and other societal or socioeconomic considerations.

Analytical X-ray Equipment. Laboratory equipment utilizing x-ray radiation to analyze or obtain information about material properties (e.g. surface characteristics, elemental composition, material structure, etc.) by means of diffraction or fluorescence techniques.

Area Monitor. An area monitor is an active stationary x-ray radiation detector mounted in the area of the x-ray machine to provide warning of unusual x-ray fields. It can be set as close to background radiation as is reasonably achievable and shall be of sufficient energy and exposure sensitivity as to provide a meaningful alert.

Controlled Area. Any area in which the dose equivalent received by individuals may exceed 1 mSv (100 mrem) in any year, but does not exceed the levels that would require it to be designated a radiation area (see section 5.2), shall be designated a controlled area. Access to controlled areas shall be managed in order to protect personnel from occupational radiation exposure.

Dose, Absorbed. The energy imparted to matter in a volume element by ionizing radiation divided by the mass of irradiated material in that volume element. The unit is the Gray (Gy) and replaces the previous unit of absorbed dose, the rad. One Gy = 1 J/kg and one rad equals 100 ergs per gram. (1 Gy = 100 rad.)

Dose Equivalent (H). The product of absorbed dose, radiation weighting factor, and other modifying factors necessary to express on a common scale, for all ionizing radiation, the dose incurred by exposed persons. The

unit is the Sievert (Sv) and replaces the previous unit of dose equivalent, the rem. (1 Sv = 100 rem.)

Dose Rate, Absorbed. The absorbed dose per unit time.

Exposure. A measure of the ionization produced in air by x- or gamma-radiation. It is the sum of the electrical charges on all of the ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in the air, divided by the mass of the air in the volume element. The unit of exposure is coulomb per kilogram (C/kg) and replaces the previous unit of exposure, the roentgen (R). (1 R = 2.58×10^{-4} C/kg)

Exposure Rate. The exposure per unit time.

Fail-safe Design. A design in which the failure of any single component results in a condition in which personnel are safe from exposure to radiation. For example: if a light indicating "X-RAY ON" fails, the production of x-rays shall be prevented, or if a shutter status indicator fails, the shutter shall close. In many cases, especially indicators, redundant components may meet the failsafe single component failure criteria.

High Radiation Area. Any area accessible to individuals, in which radiation could result in an individual receiving a deep dose equivalent in excess of 1 mSv (100 mrem) in any one hour at 30 cm (1 foot) from the source or from any surface that the radiation penetrates. Note: other definitions of high radiation area may exist, see Section 8.1.

Installation. A room or other space with defined boundaries where analytical x-ray equipment is located.

Installation Enclosure. That portion of an installation which clearly defines the transition from an uncontrolled to a controlled area, and provides such shielding as may be required to limit the dose rate in the uncontrolled area during normal operation. For example, the walls of a room containing an x-ray unit may be the installation enclosure.