

**CIRMS Measurements for Diagnostic Radiology Applications** (Tuesday July 27 4:00 PM)

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## Presenting Authors:

M. O'Brien, National Institutes of Standards and Technology, "Establishment of Molybdenum and Rhodium Anode x-ray beams"

F. Cerra, Center for Devices and Radiological Health, "Application of Mammography beams at the FDA"

L. A. DeWerd, University of Wisconsin, "The response of ionization chambers to Molybdenum anode x-ray beams"

P. Lamperti, National Institutes of Standards and Technology, "Establishment of Diagnostic x-ray beams at NIST"

Educational objective: An understanding of equipment and methodology involved in the establishment of standards for Diagnostic Radiological Applications.

**DESCRIPTION OF CIRMS**

The Council on Ionizing Radiation Measurements and Standards (CIRMS), incorporated in January 1993, is a non-profit and action-oriented society organized for educational and scientific purposes. The main objectives of CIRMS are advancement and dissemination of the physical measurements and standards needed for safe and effective applications of ionizing radiation. In particular, CIRMS represents users of ionizing radiation and radioactive sources engaged in medical radiation. CIRMS provides a forum for discussing ionizing radiation issues; identifying, defining and prioritizing needed standards; disseminating information on standards; and organizing workshops and meetings to advance ionizing radiation technology. CIRMS has been effective in coordinating the activities of federal, (e.g. NIST and FDA), state, (e.g. radiation control programs), and private sector, (e.g. hospitals), organizations concerned with applications of ionizing radiation and the related programs of physical measurements and standards laboratories. The National Institute of Standards and Technology (NIST) is heavily involved with this organization and considers its directives as statements of work to be completed. To accomplish its purposes, the Council functions through an annual meeting, through activities of committees and subcommittees, and through sponsorship of seminars and workshops. In addition, two NEEDS reports for standards, which outline the areas in which measurements and standards are apparently lacking, have been prepared by the Science and Technology Committee of CIRMS. The first report was published in January 1995 and the second in 1999. In the 1999 report, 25 Measurement Program Descriptions (MPDs) have been identified that require concerted efforts from industry, government and the academic community. Each MPD describes a measurement-related need, a possible solution, and the impact of that solution. Details are provided regarding the technical nature of the solution, relationship to existing programs, technical opportunities, challenges and goals. Resources available and those needed to accomplish the programs are also indicated. The first CIRMS National Needs Report in 1995 proved the effectiveness in coordination of a national effort. One of the top needs identified in the 1995 report was the need for x-ray standards for mammography. This work was accomplished in a collaborative effort between the FDA, NIST and the University of Wisconsin.

This example was used by the NIST in a presentation to the House Science and Technology Subcommittee in 1995. The standards for mammography x-ray beams MPD is included as an appendix in the 1999 report.

## OUTLINE OF THE SYMPOSIUM

A presentation of the research and measurements made for standards for Medical Diagnostic Radiology Applications will be summarized addressing two major topics: Molybdenum (Mo) and Rhodium (Rh) anode beams for mammographic chamber calibrations and the establishment of medium filtration x-ray beams for other diagnostic radiographic applications. Each of these standards is described in Measurement Program Descriptions (MPD), which are statements of requirements and the reasons for the measurements. The titles of the appropriate MPDs are A.1 (Appendix A) National Air-kerma Standards for Mammography and A.5 Air-kerma Standards for Diagnostic X-ray Beams.

## DIAGNOSTIC IONIZING RADIATION HISTORICAL STANDARDS

One of the oldest applications of ionizing radiation is in medical diagnostic applications. Shortly after his discovery of x-rays, Roentgen was the first to take a radiograph of a hand. As the medical use of x rays developed, x-ray tubes had to be designed to handle the high instantaneous energy input from small focal spot tubes. The design of anodes became more specialized and the use of appropriate energies for body parts was determined. Finally this progression came to the use of specialized machines for mammography. The characteristic lines of molybdenum and rhodium anodes were of benefit to making the mammographic image.

Historically the Diagnostic x-ray beams were based on the National Bureau of Standards (now National Institute of Standards and Technology [NIST]) beam qualities developed for radiation therapy treatments. These beams are based on measurements with free air chambers. Free air chambers with different dimensions were developed to cover the energy range from 10 keV to 300 keV. The development of x-ray beams specifically for diagnostic applications is the subject matter of this symposium.

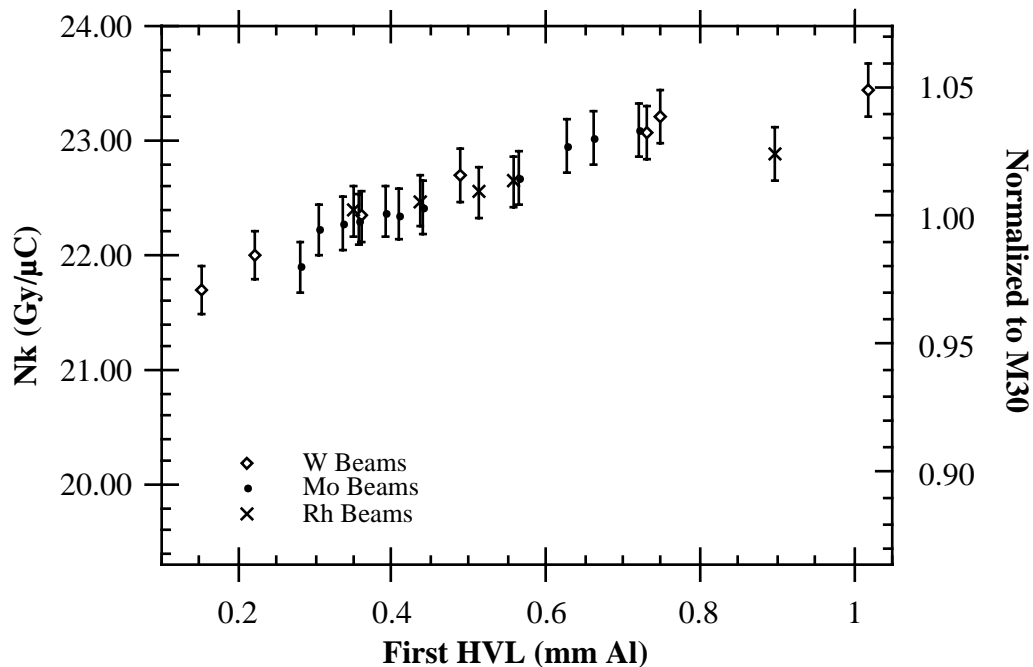
## STANDARDS FOR MAMMOGRAPHIC X-RAY BEAMS

The national attention to health care and the goal of universal coverage have highlighted the need for cost effectiveness and quality assurance in the care provided to every U.S. resident. Breast cancer is the second leading cause of cancer deaths in women. During their lifetime, one in nine women will develop breast cancer. The Center for Disease Control estimates that breast cancer mortality could be reduced by 30 percent if all women were screened regularly. The best way to prevent deaths from breast cancer is early detection. The best methods of early detection are self-examinations coupled with periodic mammograms. The goal of the Mammography Quality Standards Act (MQSA) was to provide high quality mammograms with the least radiation exposure. When MQSA was passed in 1992 there were no national standards for x-ray tubes commonly found in mammography units. The need for developing mammography air kerma standards was evident. CIRMS and the AAPM communities developed the equipment and procedures for these type of beams. As a result, national standards are now available for air

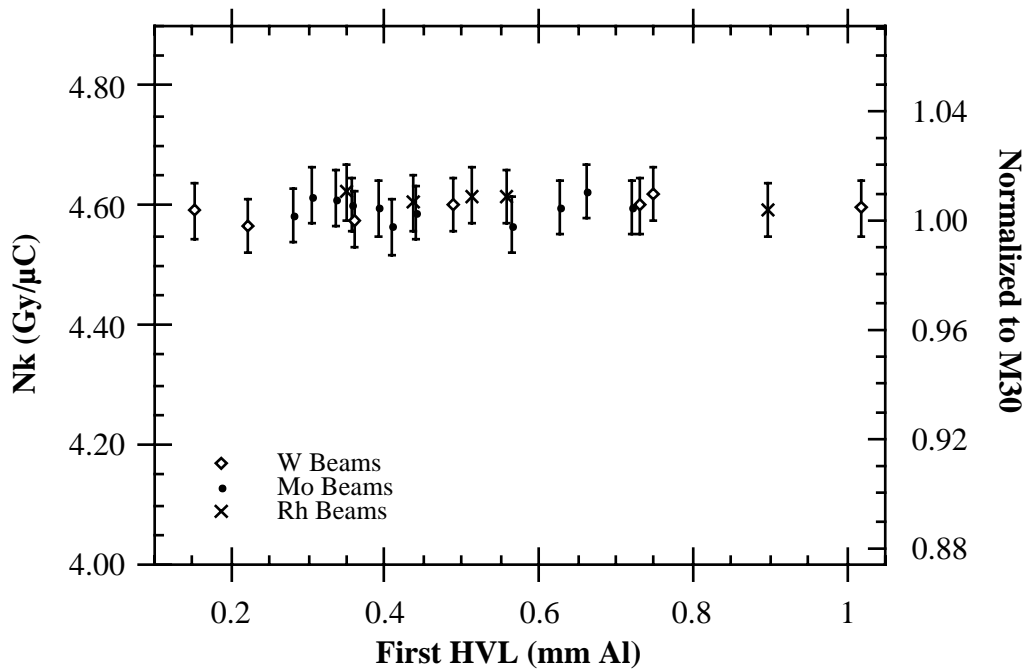
kerma measurements from molybdenum and rhodium anode x-ray tubes. A network of secondary level laboratories is in place for calibrating the instruments that FDA inspectors use in their yearly inspection of mammography facilities, and for calibrating the instruments that medical physicists use in their yearly on-site evaluations of mammography facilities.

The measurements performed for establishing mammographic calibration x-ray beams will be reviewed. Calibration standards with molybdenum and rhodium anode x-ray beams, with molybdenum and rhodium filters, respectively, were established using a variable length Attix Free air chamber. Results from a comparison of this free air chamber with the Ritz free air chamber will be given. The application of the Attix free air chamber to establish these beams at molybdenum and rhodium will be reviewed. The transfer of these beams to the ADCLs and CDRH will also be discussed. The particular application of the mammography beams at the FDA/CDRH will be reviewed, providing brief background information about the FDA's need for traceability of measurements. The difficulties and successes of the CDRH Calibration laboratories experience in matching the NIST beams and accreditation requirements will be reviewed. Following the establishment of Molybdenum and Rhodium beams, a comparison was made of the response of mammography ionization chambers to each of these beams and that of the tungsten anode, aluminum filter beam at 0.36 mm Al half value layer. These results for two chambers are shown in the following graphs (Figures 1 and 2).

**Figure 1: PRM model MC-1  
Air Kerma Calibration Factor vs First HVL**



**Figure 2: MDH RadCal model 10x5-6M  
Air Kerma Calibration Factor vs First HVL**



#### STANDARDS FOR GENERAL DIAGNOSTIC X-RAY BEAMS

Most diagnostic x-ray exams are carried out at x-ray potentials between 80 and 120 kV and use filtration typical of the NIST moderately filtered (M) series of x-ray beams. However, NIST does not offer either the M80 or M120 beams as standard options. Because of the importance of these beams for diagnostic instrument calibration, experiments using a free air chamber were done to establish these two particular tungsten anode beams for general diagnostic chamber calibrations. The method of establishing beams appropriate for calibrations at 3.0 mm Al half value layer and 10.0 mm Al half value layer will be reviewed. The M80 beam (HVL of 3.0 mm Al) is appropriate for general diagnostic use. The M120 beam (HVL of 10.0 mm Al) is appropriate for CT chamber use. These two beams fill in a gap in the spectra needed for diagnostic chambers. The method used by NIST for the establishment of these beams and their agreement with other beams in the series are important results.