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Standard for Determination of Slice Thickness in Diagnostic Magnetic Resonance Imaging

National Electrical Manufacturers Association

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Determination of Slice Thickness in
Diagnostic Magnetic Resonance Imaging

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CONTENTS

Preamble

This standard is one in a series of test standards developed by the medical diagnostic imaging industry for the measurement of performance parameters governing image quality of magnetic resonance (MR) imaging (MRI) systems. These test standards are intended for the use of equipment manufacturers, prospective purchasers, and users alike.

Manufacturers are permitted to use these standards for the determination of system performance specifications. This standardization of performance specifications is of benefit to the prospective equipment purchaser, and the parameters supplied with each NEMA measurement serve as a guide to those factors that can influence the measurement. These standards can also serve as reference procedures for acceptance testing and periodic quality assurance.

It must be recognized, however, that not all test standards lend themselves to measurement at the installation site. Some test standards require instrumentation better suited to factory measurements, while others require the facilities of an instrumentation laboratory to ensure stable test conditions necessary for reliable measurements.

The NEMA test procedures are carried out using the normal clinical operating mode of the system. For example, standard calibration procedures, standard clinical sequences, and standard reconstruction processes shall be used. No modifications to alter test results shall be used unless otherwise specified in these standards.

The NEMA Magnetic Resonance Section has identified a set of key magnetic resonance image quality parameters. This standards publication describes the measurement of one of these parameters.

Equivalence

It is intended and expected that manufacturers or others who claim compliance with these NEMA standard test procedures for the determination of image quality parameters shall have carried out the tests in accordance with the procedures specified in the published standards.

In those cases where it is impossible or impractical to follow the literal prescription of a NEMA test procedure, a complete description of any deviation from the published procedure must be included with any measurement claimed equivalent to the NEMA standard. The validity or equivalence of the modified procedure will be determined by the reader.

Uncertainty of the Measurements

The measurement uncertainty of the image quality parameter determined using this standards publication is to be reported, together with the value of the parameter. The justification for the claimed uncertainty limits shall also be provided by a listing and discussion of sources and magnitudes of error.

Foreword

This standards publication is classified as a NEMA standard unless otherwise noted. It describes two methods for determining slice thickness in diagnostic magnetic resonance imaging. The methods presented are essentially numerical in character and, consequently, will require the preparation and use of supplementary dedicated computer software to perform the computations.

The methods are based upon the determination of the slice profile, from which the slice thickness is obtained as the full width at half maximum (FWHM). The slice profile is obtained either by direct measurement with a thin inclined slab of signal-producing material or by numerical differentiation of the measured edge response function (ERF) from an inclined surface of a wedge immersed in signal-producing material. A correction technique is provided to compensate for errors caused by tilt of the phantom.

With the inclined slab approach, better signal-to-noise ratio (SNR) can be realized through the use of direct measurement[1]. However, the extremely thin slabs required for measurement of very thin slices are not practical to fabricate. Differentiation of the ERF degrades the SNR that is obtained for the slice profile and usually requires the averaging of several measurements but does permit measurement of thinner slices since fabrication is not limiting.

Slices of any thickness, which can provide adequate signal, may be evaluated with the wedge procedure; the slab method is suitable for thicker slices.

This standards publication is intended for use by MRI system manufacturers, manufacturers of accessory equipment (including special purpose radio-frequency coils), and MRI end users.

This standards publication has been developed by the Magnetic Resonance Section of the National Electrical Manufacturers Association. User needs have been considered throughout the development of this publication. Proposed or recommended revisions should be submitted to:

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1300 North 17th Street, Suite 900
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Section approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the section was composed of the following members:

Computer Imaging Reference Systems—Norfolk, VA
GE Healthcare, Inc.—Milwaukee, WI
Hitachi Medical Systems America, Inc.—Twinsburg, OH
Invivo—Gainesville, FL
Medipattern Corp.—Toronto, Ontario

Medtronic Navigation – Yokneam, Israel
Philips Healthcare—Bothell, WA
Siemens Healthcare, Inc.—Malvern, PA

Toshiba America Medical Systems—Tustin, CA
AllTech Medical Systems America—Solon, OH

[1] For additional information, see *MS 1, Determination of Signal-to-Noise Ratio (SNR) in Diagnostic Magnetic Resonance Imaging*.

Rationale

Slice thickness is measured along the dimension perpendicular to the slice plane and is a measure of the thickness of the anatomy projected onto the plane of the image. Since slice thickness depends on the radiofrequency (RF) pulse shape and sequencing, transmit gain, RF field homogeneity, the selection gradient, and other parameters, the slice thickness is a significant measure of the proper adjustment of a diagnostic magnetic resonance imaging system and its image quality.

Section 1

1.1 Scope

This standards publication provides a method for determining the slice thickness of proton images. Both the typical and the typically thinnest slices in routine clinical use for a particular system are determined at one location within the specification volume and only one of the three orthogonal orientations (transverse, sagittal, or coronal). Imaging types and conditions not addressed by this standard include spectroscopy, chemical shift imaging, and warped slices.

1.2 Definitions

1.2.1 Baseline Pixel Offset Value

The baseline pixel offset value is the pixel value for a particular MR system that represents a noise-free signal level of zero.

1.2.2 Contiguous Slices

Contiguous slices are adjacent slices for which the separation of consecutive profile centers is equal to one FWHM.

1.2.3 Edge Response Function (ERF)

The edge response function is the integral of the slice profile versus **z**, from a fixed initial value of **z** to a variable ending value of **z**.

1.2.4 Intrinsic Pixel Size

For this standard, the “intrinsic” pixel size is defined as the image domain distance **d** (in meters) such that 1/**d** (in meters^{-1}) is the span of the measured data in the Fourier domain.

1.2.5 Slice Coordinate

The slice coordinate, denoted by **z**, is the dimension perpendicular to the slice plane.

1.2.6 Slice Profile

The slice profile is conceptually a plot of magnetic resonance (MR) signal intensity perpendicular to the slice plane arising from a uniform sample that is larger than the **z** dimension to be analyzed.

1.2.7 Slice Thickness

The slice thickness is the full width at half maximum (FWHM) of the slice profile.

1.2.8 Specification Volume

The specification volume is the imaging volume within which a manufacturer guarantees image performance specifications. Images or portions of images outside this volume may not necessarily meet performance specifications, but may still be useful for diagnostic purposes. For head scans, the specification volume must enclose, as a minimum, a 10-cm diameter spherical volume (dsv) centered in the RF head coil. For body scans, the specification volume must enclose, as a minimum, a 20-cm dsv centered in the RF body coil.