NEMA Standards Publication

NEMA MS 9-2008 (R2014, R2020)

Standard for Characterization of Phased Array Coils for Diagnostic Magnetic Resonance Images

National Electrical Manufacturers Association

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Characterization of Phased Array Coils
for Diagnostic Magnetic Resonance Images

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Contents

Preamble

This is one of 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 assure 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 two of these parameters (SNR and Uniformity) for phased array coils.

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. 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 is intended for use by manufacturers of MRI systems and accessory equipment and by MRI end users.

It describes a method for evaluating phased array radio-frequency (RF) coils used with MRI systems. Phased array coils consist of multiple receive-only coil elements that are used to detect signals from a limited portion of the anatomy. The output of each coil element, or combined set of elements, is connected to the input of an independent receiver chain that is part of a set of multiple receiver chains. Phased array coils may be composed of surface coils, flexible coils, pairs of coils such as Helmholtz coils, or coils that surround a specific anatomical region as well as combinations of these coils. Phased array coils achieve good signal-to-noise performance because of their increased filling factor and the simultaneous use of smaller, higher signal-to-noise receive coil elements.

The purpose of this procedure is to provide a Standard means for measuring and reporting the signal-to-noise ratio (SNR) and uniformity of signal intensity in images acquired with phased array coils. These quantities are helpful in evaluating the impact of system changes on performance or in demonstrating effectiveness for FDA applications.

The measurement methods have been designed for compatibility with existing NEMA methods for determining the SNR and signal intensity uniformity of head, body, and special purpose coil images (see MS 1, MS 3, and MS 6). Evaluations are performed on images generated using Standard clinical scan protocols.

This Standards publication is intended for use by MRI system manufacturers, manufacturers of accessory equipment (including RF coils), and MRI end users.

This Standards publication has been developed by the Magnetic Resonance Section of the Medical Imaging Technology Alliance, a division 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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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 Corporation – Toronto, ON, Canada
Medtronic Navigation – Yokneam, Israel
Philips Healthcare – Andover, MA.
Siemens Medical Solutions, Inc. – Malvern, PA.
Toshiba America Medical Systems – Tustin, CA

Rationale

This Standard makes extensive references to three earlier Standards in its treatment of Phased Array coils. To aid the reader, it is strongly recommended that copies of these earlier Standards be on hand while using this Standard. The earlier Standards referenced herein are:

MS 1 *Determination of Signal-to-Noise Ratio (SNR) in Diagnostic Magnetic Resonance Imaging*
MS 3 *Determination of Image Uniformity in Diagnostic Magnetic Resonance Images*
MS 6 *Determination of Signal-to-Noise Ratio and Image Uniformity for Single-Channel Non-Volume Coils in Diagnostic MR Imaging*

Phased array coils are constructed to optimize the signal-to-noise ratio (SNR) of images from a restricted volume of interest within the patient. This measurement procedure seeks to estimate the SNR and uniformity inside the imaging volume of the phased array coil.

Phased array coils that consist of volume coil elements (sub-coils) may provide a uniform signal response over the sensitive volume. Therefore in this Standard SNR and uniformity for volume sub-coils may be measured and characterized using methods similar to those used for volume coils such as a head or body coil (MS 1 and MS 3).

For some sub-coils used in the construction of a phased array coil, the increased signal-to-noise performance may be accompanied by a loss of image uniformity. While image uniformity is generally a desirable goal, the reduction of signal from areas outside the region of interest can be exploited to reduce motion artifacts or to reduce wrap-around artifacts caused by undersampling when the field of view is small. In this Standard, SNR and uniformity of surface coil elements of a phased array is measured using the methods prescribed in MS 6.

The SNR is a sensitive, but rather non-specific, measure of MR system performance. It can be used to assess the effect of alterations in the MR system (excluding the coil), or it can be used to compare the performance of two coils. Given that the sensitivity of some phased array coils is spatially dependent, the assessment of the effect of alterations in the MR system can be achieved by measuring the SNR about a fixed reference point relative to the coil position. Since different phased array sub-coils are designed for different coil-to-tissue distances, it is not possible to fix a single reference position that is appropriate for all sub-coils, complicating direct comparison of different coils. The reference position selected shall approximate the position of the anatomical feature for which the selected sub-coil is used or intended.

The loading of phased array RF coils varies substantially from application to application and even from exam to exam depending on coil placement. Because of these variations, a generic loading scheme is not included in this Standard. Since both loaded and unloaded SNR's are sensitive to changes in the remainder of the MR system (although the loaded SNR may be more representative of clinical conditions), either shall be permitted in this measurement procedure.

Phantoms are objects that contain MR signal producing material and are generally used for SNR and uniformity testing of RF coils. It is recognized that as field strength (frequency of operation) increases, wavelength effects become more significant, particularly above 64MHz. Therefore, this Standard allows for the use of water-based or non-aqueous (e.g. oil-based) phantom fluids, without regard to field strength or frequency of operation, and emphasizes instead that the phantom fluid that is actually used be adequately specified for purposes of reproducibility.

The use of geometric distortion correction algorithms and image uniformity correction algorithms is becoming increasingly common, and in some situations necessary. Both types of corrections will alter

image uniformity results reported in this Standard. While it was the original intent of this Standard to characterize the coil without these corrections, it is also the intent of the Standard to test the coil under typical clinical conditions. .

Multiple measurement procedures are offered for SNR and image uniformity as per the methods of MS1 and MS3. The preferred methods are referred to as primary methods. The primary measurement procedures may require access to MRI system software functions normally available only to the MRI system manufacturer. Other possible methods are referred to as alternate methods. The alternate measurement procedures employ user accessible software functions.

Scope

This Standards publication defines test methods for measuring the signal-to-noise ratio and image uniformity of MR images produced using receive-only phased array coils. Other coil configurations have been addressed in MS 1, MS 3, and MS 6.