AAPM Recommendations Regarding Notification and Alert Values for CT Scanners: Guidelines for Use of the NEMA XR 25 CT Dose-Check Standard[1]

A new U.S. technical standard (XR 25) has been published by the National Electrical Manufacturers Association (NEMA)[1]. CT scanners in compliance with this standard can be configured to inform users when scan settings would likely yield values of $CTDI_{vol}$ or *DLP* that would exceed pre-assigned values. Compliant scanners allow users, before proceeding with scanning, to confirm or correct settings that might otherwise lead to unnecessarily high exposures. Manufacturers may include pre-assigned values in their default protocols, but all values are user-configurable.

Definitions:

There are two important definitions in the XR 25 standard[1].

Notification Value: A value of $CTDI_{vol}$ (in units of mGy) or *DLP* (in units of mGy-cm) used to trigger a notification when the value would likely be exceeded by the prescribed scans.

When the system projects that a notification value will be exceeded for any of the prescribed scans, the user is notified via a pop-up window prior to scanning and is required either to verify that the settings are correct or to change them. If the settings were correct, the operator could confirm the settings and proceed without additional action. Alternatively, the operator could enter an explanatory comment before proceeding with scanning. When a scan is performed that exceeds a notification value, the system records the date and time, a unique study identifier, the associated notification value and actual dose index value, and any operator comment that might have been entered. This record is available for site review and audit.

A notification value can be set for each scan within a complete examination protocol. Before each scan, the projected values of $CTDI_{vol}$ and *DLP* are compared to their respective notification values. That is, each phase of a multi-phase examination is assessed independently of the other phases. Different notification values can be set for each scan of an examination protocol.

Alert Value: A value of $CTDI_{vol}$ (in units of mGy) or *DLP* (in units of mGy-cm) used to trigger an alert when the system projects that the prescribed scans within an ongoing examination would result in a cumulative dose index value that exceeded the user-configured alert value.

The cumulative dose index value is compared to the alert value at each anatomic position throughout an examination. While any individual scan might not trigger a notification or alert, if the cumulative dose index value at any anatomic position were expected to exceed the alert value when the next scan was performed, an alert would be triggered prior to scanning.

An alert value is associated with a complete examination protocol, not with individual scans. On some systems, different alert values may be able to be set for different examination protocols. However, only a single alert value is required by the XR 25 standard[1].

An alert warrants more stringent review before proceeding and requires a higher level of action by the user. One purpose of alerting the user is to avoid acute injury, such as erythema or epilation. For this purpose, the FDA[2] has suggested an alert value for $CTDI_{vol}$ of 1000 mGy, which would deliver approximately half the dose associated with the onset of skin injury.

To proceed with scanning following an alert, the operator would be required to enter his or her name and either confirm or change the scan settings. The operator could additionally enter an

explanatory comment. Practices can configure the scanner to require a password to be entered before proceeding. If a scan were performed that resulted in a cumulative dose index value that exceeded an alert value, the system would record the date and time, operator's name, a unique study identifier, the associated alert value, actual cumulative dose index value, and any operator comment that might have been entered. This record is available for site review and audit.

Application to Clinical Practice:

The XR 25 standard[1] specifies the features that must be incorporated in CT systems. It does not specify how the features are to be used clinically. We anticipate at least two different ways that these new features will be used in clinical practice:

1) *To identify and track all situations where dose indices may exceed established diagnostic reference levels (DRLs).*

   Some regions or countries with established DRLs require that all examinations having dose indices that exceed the DRL be identified and specific information recorded, potentially including a rationale for the use of dose indices above the DRL (e.g., in the situation of an obese patient). The features provided by the XR 25 standard may facilitate compliance with these requirements.

2) *To avoid excessively high patient exposures by identifying dose indices that are much higher than typical for a given examination type and providing an opportunity for the operator to confirm or change settings before proceeding.*

   DRL values typically represent the 75th percentile from a regional or national sample of clinically used dose indices for a standard patient size. Because one third of the US population is obese[3], the use of DRLs as notification values would result in notifications occurring very frequently. This might de-sensitize users to the notifications and diminish their potential value in avoiding erroneously high exposures. The AAPM-recommended notification values are therefore higher than published DRL values. These values may allow higher-than-optimal dose settings in some cases, but because they will be triggered less frequently, the tendency for users to ignore the notifications might be reduced. In addition to obese patients, children, who are more radiosensitive than adults, require special consideration and different notification and alert values due to their smaller size.

AAPM Recommendations:

The AAPM Working Group on Standardization of CT Nomenclature and Protocols[4], which includes members from the FDA, ACR, and manufacturers, has established a particular set of notification values (Table 1). Manufacturers may use these as default values for CT scanners compliant with the XR 25 standard[1]. The AAPM-recommended values ***do not*** correspond to optimal or "target" settings, ***are not*** considered acceptable "upper limits" of dose, and ***do not*** represent diagnostic reference levels.

Rather, the purpose of the AAPM-recommended Notification and Alert values is to have the technologist confirm settings that would likely lead to "higher than usual" dose index values, *prior to scanning the patient*. The objective is to call the user's attention to potentially erroneous high-dose settings. Depending on the patient size or diagnostic task, the settings may be completely appropriate and the examination should proceed as planned. Specifically, the XR 25 standard does not provide a mechanism to take patient size into account when evaluating dose indices. Hence, for obese patients, use of CTDIvol or DLP values that exceed the notification

levels is likely to occur but may be completely appropriate. The purpose of the alerts is to present a "time-out" opportunity for the user to confirm scan settings.

The notification values in Table 1 are starting points. As facilities gain more experience using the NEMA "CT Dose-Check" standard[1], they are encouraged to work with a medical physicist to adjust the values to better suit their individual practice.

Table 1: Notification Values recommended by the AAPM Working Group on Standardization of CT Nomenclature and Protocols

CT Scan Region (of each individual scan in an examination)	CTDIvol Notification Value (mGy)
Adult Head	80
Adult Torso	50
Pediatric Head	
<2 years old	50
2 – 5 years old	60
Pediatric Torso	
<10 years old (16-cm phantom)[a]	25
<10 years old (32-cm phantom)[b]	10
Brain Perfusion (examination that repeatedly scans the same anatomic level to measure the flow of contrast media through the anatomy)	600
Cardiac	
Retrospectively gated (spiral)	150
Prospectively gated (sequential)	50

[a] As of January 2011, GE, Hitachi and Toshiba scanners use the 16-cm-diameter CTDI phantom as the basis for evaluating dose indices ($CTDI_{vol}$ and DLP) displayed and reported for pediatric body examinations.

[b] As of January 2011, Siemens and Philips scanners use the 32-cm-diameter CTDI phantom as the basis for evaluating dose indices ($CTDI_{vol}$ and DLP) displayed and reported for pediatric body examinations.

If there is doubt as to which phantom size is associated with the dose index values displayed and reported for your scanner, please contact the manufacturer for assistance.

References:

1. *Computed Tomography Dose Check* (NEMA Standards Publication XR 25-2010, October 2010, http://www.nema.org/stds/xr25.cfm).

2. http://www.fda.gov/Radiation-EmittingProducts/RadiationSafety/RadiationDoseReduction/ucm232551.htm

3. KM Flegal, MD Carroll, CL Ogden, LR Curtin. Prevalence and Trends in Obesity Among US Adults, 1999-2008 AMA. *JAMA* 303:235-241 (2010).

4. http://www.aapm.org/pubs/CTProtocols/default.asp