



2217 US Highway 70 East
Garner, NC 27529
Main: 800.366.5343
Fax: 919.772.2530
WWW.VIZTEK.NET

Viztek is committed to providing the highest image quality possible in our CR & DR product lines. There are several factors that directly affect the overall quality of CR & DR based images. The exposure parameters of an image are outside the scope of the device manufacturer and thus are the sole responsibility of the technologist performing the radiographic examination. This document assumes that proper technique values are being applied to all exposures. Viztek recommends that all technologists employ the **ALARA** principle during all radiographic exposures. If you have questions about exposure setting, please contact your X-Ray equipment manufacturer.

Viztek utilizes a suite of image processing modules collectively referred to as symphony 3, which work together, passing data from one stage of the image processing pipeline to the next. Everything needed to take a raw unprocessed image to a high quality diagnostic image is included in the Opal-UAI application.

Specifically, what tasks does the symphony 3 automate?

The symphony 3 is comprised of five modules that are designed to work together seamlessly. They are:

1. A flat field correction module which adjusts for the uneven strength of the X-ray field across the surface of the detector.
2. Automatic detection and removal of the collimator in the image.
3. Calculation of the Viztek Exposure Index (EI)
4. Image Enhancement (IE), a module that enhances the image by suppressing noise and sharpening anatomical details.
5. Automatic Window Width and Level, a module that automatically selects optimal window brightness and contrast.

How does the Exposure Index provide quality control of dose and image quality together?

In conventional radiology a well-established connection exists between a detector's exposure and film brightness. In digital radiology the detector has a much wider dynamic range. Image filtering allows the X-Ray systems to produce similar images under a wide range of exposure conditions. Heavily under-exposed images result in a high level of noise, and reduced anatomical details. Over-exposed images are difficult for an observer to detect. Filtering allows over-exposed images to appear properly exposed. The inability to detect over-exposure could lead to an unjustified increment of the dose.

Several X-Ray manufacturers display an "index" value of the acquired image. This is to help the operator judge if an exposure is correct. This index is called 'Dose Index' or 'Exposure Index'. Definitions of this index can vary greatly between manufacturers. Indexes measured by various devices, even in the same facility, are not necessarily comparable. These differences can make it extremely difficult to set guidelines for X-Ray exposure across the radiology department, and almost impossible to define guidelines across healthcare organizations. Ultimately, the operator may be unaware of overexposure.

Dose control is one of the most important topics of discussion in radiology today. To help address the issue and enable organizations to define accurate, nation-wide exposure index guidelines, the International Electrotechnical Committee created the IEC-62494-1 "Medical electrical equipment – Exposure Index of Digital X-ray Imaging Systems" standard. This standard was approved August 2008.

Viztek's image processing is based on the IEC-62494-1 standard. Our Exposure Index calculation is IEC 62494 compliant. Some example material: <http://www.aapm.org/meetings/amos2/pdf/42-12066-57479-443.pdf>



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The exposure index will only be correct if the image has been shuttered to eliminate the collimator.

The IEC specification requires anatomical pixel to be extracted in a specific way. From there, the number is dependent on "inverse calibration" which relates dose to pixel value. This dose / pixel response changes depending on the scan sensitivity (speed class).

EXPOSURE INDEX DEFINITION

Exposure Index (EI) is the measure of the amount of exposure received by the image receptor (IR). It is dependent on mAs, total detector area irradiated, and beam attenuation. The exposure index is indicative of the image quality. Equipment manufacturers provide a recommended EI range for optimal image quality (Bontrager & Lampignano, 2005, p. 52).

EI in digital radiography can be compared to film speed and blackening in film-screen. When film was used, the accuracy of the exposure was obvious based on the appearance of the image. Digital systems post-process images and display adequate contrast and brightness at a much wider range. Therefore, adequate exposure can only be assessed through image noise or burn-out. Secondary workstations such as those used by technologists for image review, are often of lower resolution and brightness than those used for diagnosis. Because of this, it is often difficult to assess whether an image is noisy or not. The exposure index is meant to be an indication of whether the noise levels are acceptable (AAPM, 2009).

Errors in the calculation can occur resulting in an inaccurate EI. This can arise when the software fails in determining which part of the image is the patient anatomy, for example, in the presence of gonadal shielding or prosthesis. **EI cannot be solely relied on, therefore the technologist must remain critical of the appearance of the image and the accuracy of the EI (AAPM, 2009).**



NOTE 1:

There is no reason to repeat a radiographic exam just because the index number showed a high or low patient exposure. Image quality was probably more than satisfactory (unless the exposure was so high that the detector was saturated).



NOTE 2:

Index numbers are not the end-all; exposure and image quality are of paramount importance. Do not get "stuck" on using index numbers as a means to evaluate patient exposure.



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Viztek Exposure Index Table:

Exam	EI RANGE	AEC
Thorax PA	250-500	x
Thorax LAT	250-500	x
Thorax portable	250-500	
Ribs	250-500	x
Sternum	250-500	x
Skull	250-500	x
Clavicle	250-500	x
Shoulder	250-500	x
Humerus	250-500	x
Elbow	500-1000	
Forearm	500-1000	
Hand	500-1000	
Finger	500-1000	
Cervical Spine	250-500	x
Thoracic Spine	250-500	x
Lumbar Spine	250-500	x
Sacrum	250-500	x
Abdomen	250-500	x
Pelvis	250-500	x
Hip	250-500	x
Femur	250-500	x
Knee	250-500	x
Lower leg (Tibia)	250-500	
Ankle	500-1000	
Calcaneus	500-1000	
Forefoot	500-1000	
Toes	500-1000	



NOTE:

Table Values are based on experience and not statistical evaluation

EI is derived from the mean detector entrance exposure which is derived from the mean pixel value of the image. Most systems use a histogram analysis in order to calculate the mean pixel value (Neitzel, 2004, p. S231).

Although EI is always derived from the IR exposure, equipment manufacturers calculate the numeric value differently, resulting in different ranges and definitions (Carlton & Adler, 2006, p. 367; Neitzel, 2004, p. S231). Also, there is variation between units purchased from the same manufacturer based on different IRs and software (Carlton & Adler, 2006, p. 367). Different IRs have different detective quantum efficiency (DQE). A high DQE results in lower noise levels (AAPM, 2009, p. 3). Therefore, all systems have a different index and are difficult to compare across systems.

Fuji CR

Fuji uses a sensitivity number (S) that is related to the amount of amplification required by the photomultiplier tube to adjust the digital image. S is inversely proportional to exposure. Properly exposed images should have an S between 150-250 (Carlton & Adler, 2006, p. 367).



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Kodak CR

Kodak uses the term Exposure Index, which is directly proportional to exposure. Properly exposed images should have an EI between 1,800-2,200 (Carlton & Adler, 2006, p. 367). A change of 300 in the EI indicates a change of a factor of 2 in the exposure to the IR.

Agfa CR

Agfa uses log median exposure (LgM). This system compares the exposure level of the image to a baseline established for the department. Since it is based on a log system, an increase of 0.3 means the dose was doubled (Carlton & Adler, 2006, p. 367). An optimal exposure lies between 1.9 and 2.5.

Additional Information

In 2008, the International Electrotechnical Commission (IEC) developed and published the International Standard IEC 62494-1 on the definition and scaling of the exposure index for digital radiography. According to the standard the EI shall be proportional to the exposure (air kerma) and shall be scaled as $EI = 100 * X$, where X is the air kerma at the detector, at the calibration beam quality.

The American Association of Physicists in Medicine (2009), published a document in July, 2009 with the purpose of identifying a standard index which reflects the adequacy of the exposure received by the IR.

Please refer to Publication No. E-10-2 published by Conference of Radiation Control Program Directors, Inc available at WWW.CRCPD.ORG for guidance on Computed Radiography and Digital Radiography State X-Ray Inspection Protocol. This document contains survey procedures developed by CRCPD's H-33 Task Force for the Inspection Protocol of Diagnostic X-ray facilities using CR/DR Technology. The intention is to provide guidance for state inspectors to test phototimed radiographic X-ray equipment that use CR and DR imaging systems.

Viztek recommends that the technologist uses the PACEAMAN method to evaluate image quality. PACEMAN is a technique for radiographers to use to determine if a radiograph is of diagnostic quality.

It was devised in the 1980's by Roger Windle in Adelaide, South Australia to help other radiographers and students have a structured way in which to critique radiographic images

It is an acronym used to remember the following

1. **P**osition
2. **A**rea
3. **C**ollimation
4. **E**xposure
5. **M**arkers
6. **A**esthetics
7. **N**ame

Below is a summary of the qualities that are needed for each letter of PACEMAN

1. **P - Position:**
 - a. Is the patient in the correct position?
 - b. Is the patient rotated?
 - c. Does the image correctly show any needed joint spaces?
2. **A - Area:**



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- a. Is enough of the area being filmed covered? eg: In an abdominal film is pubic symphysis to diaphragms covered?
- b. Have you exposed an area that is not required?
3. **C - Collimation:**
 - a. Is the image properly collimated? eg is four way collimation seen on an extremities film?
4. **E - Exposure:**
 - a. Were the exposure factors set correctly?
 - b. Does the image show the correct contrast and density?
 - c. Are there any factors that need to be changed to produce a better image?
5. **M - Markers:**
 - a. Have markers been placed on the image?
 - b. Are they correctly identifying left and right?
6. **A - Aesthetics:**
 - a. Is the image nice to look at?
 - b. Is it centered on the film?
 - c. Is there four way collimation?
7. **N - Name:**
 - a. Does the image correctly identify the patient?
 - b. Does it have any other relevant identification details? eg episode number or department labels?

References:

American Association of Physicists in Medicine. (2009). An Exposure Indicator for Digital Radiography. Retrieved from http://www.aapm.org/pubs/reports/rpt_116.pdf

Bontrager, K. L., & Lampignano, J. P. (2005). Textbook of radiographic positioning and related anatomy (6th ed.). Elsevier Science.

Carlton, R. R. & Adler, A. M. (2005). Principles of radiographic imaging: An art and a science. Delmar Learning.

International Electrotechnical Commission (2008). IEC 62494-1 ed. 1 Medical electrical equipment - Exposure index of digital x-ray imaging systems - Part 1: Definitions and requirements for general radiography

Neitzel, U. (2004). Management of pediatric radiation dose using Philips digital radiography. Pediatric Radiology, 34(Suppl 3), S227-S233

Conference of Radiation Control Program Directors, Inc. (2010) Publication number E-10-2 COMPUTED RADIOGRAPHY (CR) AND DIGITAL RADIOGRAPHY (DR) STATE X-RAY INSPECTION PROTOCOL