Exposure Indicators
for
CARESTREAM Digital Radiography Systems

DR Service Codes: 1534, 8087, 4228, 7171, 7049, 8820, 2540

Carestream

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Description

Provide an overview of the Carestream and IEC exposure indicators for Carestream DR receptors.

Exposure Indicators

The Carestream exposure index allows the radiographer to match the exposure to the desired speed class of operation. ***The speed class is set in a given department by consulting with an interpreting radiologist.*** The radiologist's feedback on sample images helps determine the level of image noise he or she can accept. It is important to note, that as speed class increases, the amount of image noise will increase. Once an acceptable noise level is established, a radiographer can identify the speed class of operation for the imaging system and the corresponding technique charts. It is the responsibility of the radiographer to select a technique that provides enough exposure to reduce the amount of noise while adhering to ALARA standards.

The exposure index is indirectly proportional to the speed class of operation. If you are using the **Carestream Exposure Index** values, for every 300 exposure index increase, the speed class is reduced by half. In other words, if the exposure index increases from 1400 to 1700, the speed class is reduced from a 400 speed class to a 200 speed class. If you are using the **IEC Exposure Index** values, when the deviation index reaches +3, the speed class is reduced by half. Regardless of which exposure indicators are selected, as the exposure index increases, the dose to the patient increases.

The charts below are designed to provide the radiographer with a guide to determine the proper **Carestream Exposure Index** or **IEC Exposure Index** based on the speed class of operation selected for your department, or particular procedures.

Carestream Exposure Index

The Carestream exposure index is not necessarily unique to the receptor type. However, Computed Radiography (CR) systems typically operate at a lower speed class than Digital Radiography (DR) systems. Therefore, your facility may choose to operate your CR at a different speed class than the DR.

Once a decision is made by the radiologist as to what speed class should be used, simply follow the chart below to determine what the aim exposure index should be. For example, if 400 speed class of operation is selected for the DRX GOS detector, the target exposure index for adult chest exams should be between 1390 and 1490.

Carestream Exposure Index vs. Speed Class of Operation for DRX GOS Detector

	DRX GOS	DRX GOS	DRX GOS	DRX GOS
	Exposure Index	Exposure Index	Exposure Index	Exposure Index
Speed	Extremities	65-80 kVp exams	81-100 kVp exams	Adult Chest
100	1810-1930	1870-1990	1950-2070	1980-2100
200	1510-1630	1570-1690	1650-1770	1680-1800
300	1370-1470	1420-1540	1500-1620	1530-1650
400	1220-1320	1280-1380	1360-1460	1390-1490
500	1120-1210	1180-1270	1260-1350	1290-1380
600	1060-1110	1120-1170	1210-1260	1240-1290
700	1000-1050	1060-1110	1150-1200	1180-1230
800	950-990	1010-1050	1100-1140	1130-1170
900	900-940	960-1000	1050-1090	1080-1120
1000	860-890	920-950	1010-1040	1040-1070

Notes and Conditions: On average, images were captured on the DRX-1 (GOS) from several U.S. sites. These charts do not pertain to data acquired OUS due to differing beam conditions.

Carestream Exposure Index vs. Speed Class of Operation for DRX CsI Detector

	DRX-1C CsI	DRX-1C CsI	DRX-1C CsI	DRX-1C CsI
	Exposure Index	Exposure Index	Exposure Index	Exposure Index
Speed	Extremities	65-80 kVp exams	81-100 kVp exams	Adult Chest
100	1820-1940	1880-2000	1940-2060	1970-2090
200	1520-1640	1590-1710	1640-1760	1670-1790
300	1360-1480	1430-1550	1490-1610	1520-1640
400	1230-1330	1290-1390	1350-1450	1380-1480
500	1130-1220	1200-1280	1260-1340	1290-1370
600	1070-1120	1140-1190	1200-1250	1230-1280
700	1010-1060	1080-1130	1140-1190	1170-1220
800	960-1000	1030-1070	1080-1120	1120-1160
900	910-950	980-1020	1030-1070	1080-1110
1000	860-900	930-970	980-1020	1020-1060

Notes and Conditions: On average, images were captured on the DRX-1 (CsI) from several U.S. sites. These charts do not pertain to data acquired OUS due to differing beam conditions.

IEC Exposure Index

The IEC exposure index is unique to the receptor type being used and to the exam performed. Three default Target Exposure Index (EI) values are preloaded into the system. The three values represent the default Target EI for bucky, non-bucky, and pediatric exams.

Once a determination of speed class of operation is made, the Key Operator will need to adjust the **Target EI's** to correspond to the EI/speed charts below for that particular receptor type. When an exposure is made, the IEC EI will be displayed followed by the **deviation index (DI)** in parenthesis. For example: EI: 360.25 (1.2). The deviation index quantifies the difference between the *actual EI* and the *Target EI*. The DI allows the radiographer to track and adjust their exposures with this feedback. When the actual EI is equal to the Target EI, the DI will equal 0. A positive or negative DI indicates the amount of exposure greater or lesser than the target EI. It does not necessarily mean that an image needs to be repeated. If the deviation is greater than $\pm$ 3, the exposure index will be highlighted in red to indicate a high/low exposure that may need further review.

The DI chart below outlines how to use the deviation index. In the example above, the DI was calculated as 1.2. If we look at the chart, we see that a DI of 1 means the resulting exposure was ~26% higher than the Target EI. Our DI was 1.2 so we can estimate that we are slightly higher, perhaps closer to 30%. Although it is a good image, it is merely an indicator to the radiographer that he/she may be able to reduce their exposure factors the next time they perform that particular exam and still acquire an acceptable image and reduce the dose to the patient.

Deviation Index	% off target
3	~100% too high
2	~58% too high
1	~26% too high
0	Correct
-1	~21% too low
-2	~37% too low
-3	~50% too low

IEC Exposure Index vs. Speed Class of Operation for DRX GOS Detector

	DRX-1 - IEC Exposure Index			
Speed	**Extremities**	**65-80 kVp exams**	**81-100 kVp exams**	**Adult Chest**
100	594	679	831	889
200	294	336	413	442
300	194	222	274	293
400	143	164	203	217
500	112	129	159	171
600	93	107	133	143
700	77	89	110	119
800	68	78	98	105
900	59	69	86	93
1000	52	61	76	82

Notes and Conditions: On average, images were captured on the DRX-1 (GOS) from several U.S. sites. These charts do not pertain to data acquired OUS due to differing beam conditions.

IEC Exposure Index vs. Speed Class of Operation for DRX CsI Detector

	DRX-1C - IEC Exposure Index			
Speed	**Extremities**	**65-80 kVp exams**	**81-100 kVp exams**	**Adult Chest**
100	620	723	824	883
200	307	358	409	439
300	203	237	271	291
400	150	175	201	216
500	117	138	158	170
600	97	115	132	142
700	80	95	109	118
800	71	84	96	104
900	62	74	85	92
1000	55	65	75	81

Notes and Conditions: On average, images were captured on the DRX-1 (CsI) from several U.S. sites. These charts do not pertain to data acquired OUS due to differing beam conditions.

SUMMARY:
IEC 62494-1 standard can be implemented on CSH CR/DR systems. New EI value can be calculated, using conversion factor (C0), from current pixel values (in CSH linear space) and existing segmentation software. No change to existing system calibration procedure required. New IEC functionality can be added in parallel to existing software, and does not affect existing system functions

Appendix:

IEC 62494-1 Exposure Index:

Exposure Index (EI) related to "Value of Interest" as follows: $EI = c_0 \cdot g(V) = \frac{g(V)}{100 \mu Gy}$

c_0 = 100 μGy^{-1}, where g(V) is Inverse Calibration Function (Image Receptor Air Kerma/Detector Entrance Exposure for "Value of Interest," V).

CSH Implementation IEC EI:

Decision not to change Calibration Conditions to those of IEC:

IEC 62494-1 Calibration	CSH Calibration
70 kVp ± 4 kVp	80kVp
Filter: 21 mm Al or 0.5 mm Cu + 2 mm Al	Filter: +0.5 mm Cu, +1 mm Al
Half-Value Layer: 6.8 ± 0.3 mm	

Assumption: relationship between IEC and CSH/Kodak calibration conditions can be represented by constant conversion factor, C0 = K/K_{IEC}, where K, K_{IEC} are the resp. detector sensitivities under Kodak and IEC calibrations.

Various CSH detectors measured under IEC and CSH calibration conditions. Results are averaged measurements over multiple CSH CR/DR systems. Uncertainty is < 2%.

Detector Type	Conversion Factor, C0
CR (all screen types)	1.0
DRX-1 (Gd_2O_2S)	0.93
DRX-1 (CsI)	0.95
Trixell 4600 (CsI)	0.95
Varian 43 x 43 cm (CsI)	0.95

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