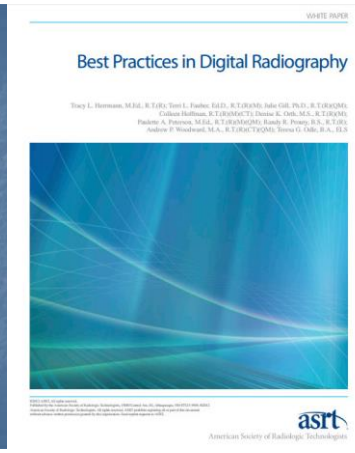
# Mastering Digital Radiography

**WCEC 20th**
**Student – Educator – Radiographer Conference**

Dennis Bowman, RT(R), CRT (R)(F)
Community Hospital of the Monterey Peninsula (CHOMP) - Staff Radiographer
Owner/Consultant - Digital Radiography Solutions, FluoroRadPro
Speaker - MTMI




## ASRT Best Practices in Digital Radiography

- Radiographers need to take responsibility for understanding and appropriately performing digital radiography procedures because it is their professional duty and **an essential component of the radiographers' practice standards and code of ethics.**

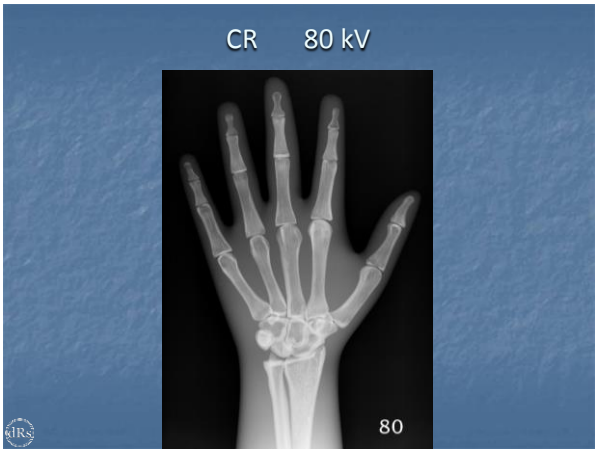
## One of the biggest changes with digital radiography is we can use much higher kV

- The following slides show a hand phantom exposed from 50 to 100 kV to demonstrate the minute differences visualized on an image using higher kV and lower mAs with both CR and DR.

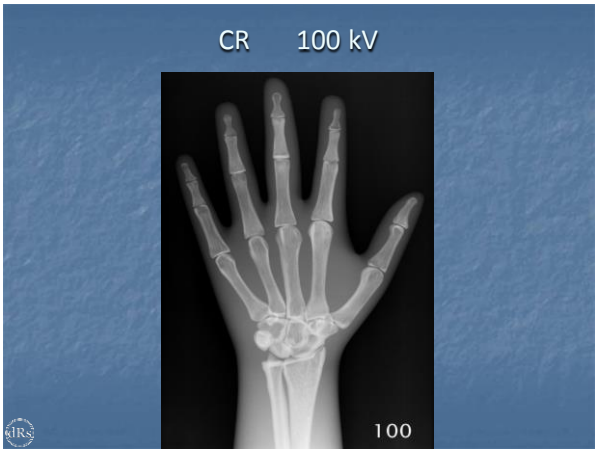
CR 50 kV

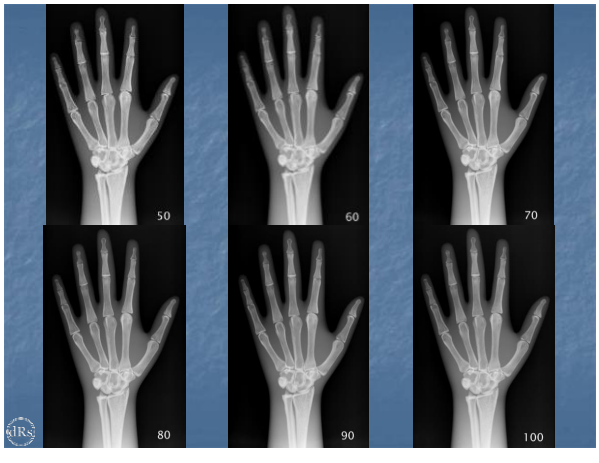

CR 60 kV

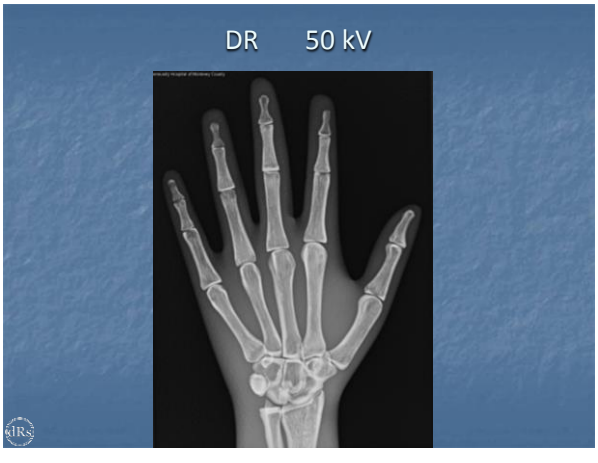

CR 70 kV
70


CR 80 kV
80


CR 90 kV
90


CR 100 kV
100


50
60
70
80
90
100


DR 50 kV

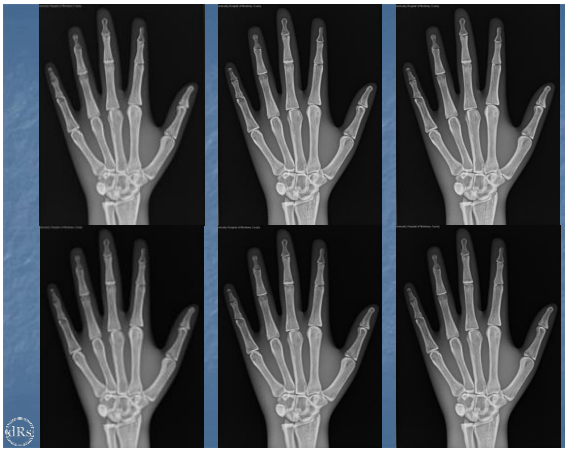
DR 60 kV

DR 70 kV

DR 80 kV

DR 90 kV

DR 100 kV



## These are the 15-20 kV (higher than film) digital optimum kVs developed by Barry Burns

**DIGITAL OPTIMUM kV**

| Body Part | kV |
|---|---|
| Chest (Bucky/Grid) | 110-125 |
| Chest (Non Grid) | 85-90 (105) |
| Abdomen | 85-90 |
| Abdomen (Iodine) | 75-80 |
| Extremities (Table Top) | 65-75 |
| Extremities (Grid) | 75-85 |
| Extremities (Bucky) | 80-90 |
| AP Spines | 80-95 |
| C-Spine Lateral | 80-100 |
| T-Spine Lateral | 80-100 |
| L-Spine Lateral | 80-100 |
| Ribs (Upper and Lower) | 80-90 |
| Skull | 80-90 |
| BE – (Regular) | 110-120 |
| BE – (Air Contrast) | 100-110 |
| **Pediatric:** | |
| Infant Extremities | 50-65 |
| Pediatric Chest (Non Grid) | 70-85 |

## From London, Ontario, a peer reviewed research article published for Elsevier's Medical Imaging and Radiation Sciences

- "Examining Practitioners' Assessments of Perceived Aesthetic and Diagnostic Quality of High kVp-Low mAs Pelvis, Chest, Skull, and Hand Phantom"
- Study included 91 practitioners (radiologists, radiology residents, radiographers and radiography students).
- Images taken 20 and 30 kV higher (with mAs compensation) than the "standard" preprogrammed technical factors used at the clinical sites.

## Conclusion: You can go up 20 kVp higher with a compensated lowering of mAs and acquire images of diagnostic quality

- Of the 4 groups of examiners (radiologists, radiology residents, radiographers and radiography students), who do you believe were the most exacting and hard to please when it came to critiquing the quality of the images?

## Universal CR Technique Chart - 100% More mAs

| E.I. Range | TARGET E.I. | Part | View | SID | Small | | Medium | | Large | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Inches | kV | mAs | kV | mAs | kV | mAs |
| 400-100 S | 200-164 S | Abdomen B/G (Most mAs) | Supine 21cm | 40 | 85 | 20.0 | 85 | 32.0 | 85 | 50.0 |
| 150-75 S | 75-50 S | Ankle TT | AP 11cm | 40 | 70 | 3.6 | 70 | 4.2 | 70 | 4.8 |
| 400-100 S | 200-164 S | Cervical Spine B/G | AP 11cm | 40 | 85 | 5.0 | 85 | 6.4 | 85 | 8.0 |
| 400-100 S | 200-164 S | Cervical Spine B/G | Lateral 11cm | 72 | 85 | 14.8 | 85 | 18 | 85 | 23.0 |
| 400-100 S | 200-164 S | Cranium B/G | AP 20cm | 40 | 85 | 8.8 | 85 | 11.2 | 85 | 13.6 |
| 150-75 S | 75-50 S | Hand TT | PA 3cm | 40 | 66 | 1.4 | 66 | 1.6 | 66 | 2.0 |
| 400-100 S | 200-164 S | Hip TT | AP 18cm | 40 | 75 | 7.0 | 75 | 8.6 | 75 | 10.8 |
| 400-100 S | 200-164 S | Hip B/G | Lateral (Danelius-Miller) 24cm | 40 | 90 | 54.0 | 90 | 80.0 | 90 | 108.0 |
| 400-100 S | 200-164 S | Lumbar Spine B/G | AP 21cm | 40 | 90 | 18.6 | 90 | 27 | 90 | 37 |
| 400-100 S | 200-164 S | Lumbar Spine B/G | Lateral 27cm | 40 | 96 | 40.0 | 96 | 53 | 96 | 75 |
| 400-100 S | 200-164 S | Paranasal sinuses B/G | Parietoacanthial (Waters) 24cm | 40 | 85 | 12.0 | 85 | 15.0 | 85 | 18.0 |
| 400-100 S | 200-164 S | Shoulder B/G | AP 18cm | 40 | 85 | 8.4 | 85 | 12.0 | 85 | 16.0 |
| 400-100 S | 200-164 S | Thoracic spine B/G | AP 21cm | 40 | 85 | 16.4 | 85 | 22 | 85 | 28 |
| 400-100 S | 200-164 S | Thoracic spine B/G | Lateral 33cm | 40 | 90 | 35 | 90 | 48.0 | 90 | 61 |

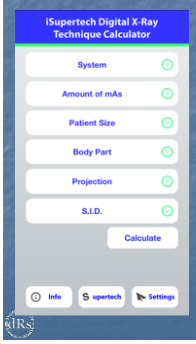
## Size of the Patient – The techniques are of a small, medium and large **male**

- Small = 120-160 lbs.
- Medium = 160-200 lbs.
- Large = 200-240 lbs.
- Females would be approximately 10 lbs. lighter.

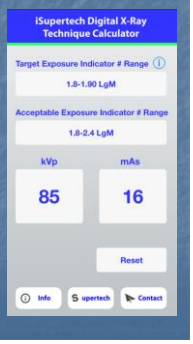
## Universal DR Chart - Least mAs

| E.I. Range | TARGET E.I. | Part | View | SID | Small | | Medium | | Large | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Inches | kV | mAs | kV | mAs | kV | mAs |
| 200-600 EXI | EXI 200-266 | Abdomen B/G | Supine 21cm | 40 | 85 | 6.50 | 85 | 10.00 | 85 | 16.00 |
| 200-600 EXI | EXI 200-266 | Ankle TT | AP 11cm | 40 | 70 | 1.2 | 70 | 1.4 | 70 | 1.6 |
| 200-600 EXI | EXI 200-266 | Cervical Spine B/G | AP 11cm | 40 | 85 | 1.90 | 85 | 2.40 | 85 | 3.00 |
| 200-600 EXI | EXI 200-266 | Cervical Spine B/G | Lateral 11cm | 72 | 85 | 5.50 | 85 | 6.60 | 85 | 8.80 |
| 200-600 EXI | EXI 200-266 | Cranium B/G | AP 20cm | 40 | 85 | 3.3 | 85 | 4.20 | 85 | 5.1 |
| 200-600 EXI | EXI 200-266 | Hand TT | PA 3cm | 40 | 66 | 0.5 | 66 | 0.6 | 66 | 0.75 |
| 200-600 EXI | EXI 200-266 | Hip B/G | AP 18cm | 40 | 85 | 4.20 | 85 | 6.30 | 85 | 7.80 |
| 200-600 EXI | EXI 200-266 | Hip B/G | Lateral (Danelius-Miller) 24cm | 40 | 90 | 20.00 | 90 | 30.00 | 90 | 40.00 |
| 200-600 EXI | EXI 200-266 | Lumbar Spine B/G | AP 21cm | 40 | 90 | 7.00 | 90 | 10.00 | 90 | 14.00 |
| 200-600 EXI | EXI 200-266 | Lumbar Spine B/G | Lateral 27cm | 40 | 96 | 15.00 | 96 | 20.00 | 96 | 28.00 |
| 200-600 EXI | EXI 200-266 | Paranasal sinuses B/G | Parietoacanthial (Waters) 24cm | 40 | 85 | 4 | 85 | 5 | 85 | 6 |
| 200-600 EXI | EXI 200-266 | Shoulder B/G | AP 18cm | 40 | 85 | 3.1 | 85 | 4.5 | 85 | 6.0 |
| 200-600 EXI | EXI 200-266 | Thoracic spine B/G | AP 21cm | 40 | 85 | 5.5 | 85 | 7.5 | 85 | 9.5 |
| 200-600 EXI | EXI 200-266 | Thoracic spine B/G | Lateral 33cm | 40 | 90 | 13.0 | 90 | 18.0 | 90 | 23.0 |

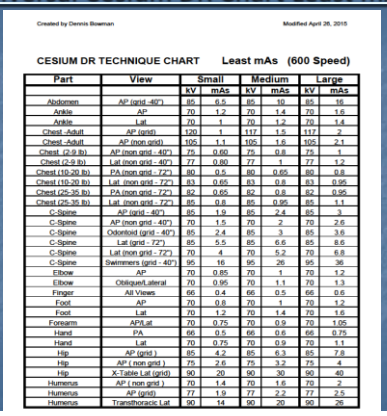
## iSupertech Digital Technique Calculator




- CR-Agfa (LgM)
- CR-Carestream (EI)
- CR-Fuji (S)
- CR-Konica (S)
- DR-Konica (S)
- DR-Gad (EXI)
- DR-Carestream (EI)
- DR-GE (DEI)
- DR-GE (DI)
- DR-Konica (S)
- DR-Philips (EI_s)
- DR-Siemens (EXI)




## Universal Cesium DR Chart Least mAs



Created by Dennis Bowman — Modified April 26, 2015

**CESIUM DR TECHNIQUE CHART — Least mAs (600 Speed)**

| Part | View | Small | | Medium | | Large | |
|---|---|---|---|---|---|---|---|
| | | kV | mAs | kV | mAs | kV | mAs |
| Abdomen | AP (grid -40") | 85 | 6.5 | 85 | 10 | 85 | 16 |
| Ankle | AP | 70 | 1.2 | 70 | 1.4 | 70 | 1.6 |
| Ankle | Lat | 70 | 1 | 70 | 1.2 | 70 | 1.4 |
| Chest -Adult | AP (grid) | 120 | 1 | 117 | 1.5 | 117 | 2 |
| Chest -Adult | AP (non grid) | 105 | 1.1 | 105 | 1.6 | 105 | 2.1 |
| Chest (2-9 lb) | AP (non grid - 40") | 75 | 0.60 | 75 | 0.8 | 75 | 1 |
| Chest (2-9 lb) | Lat (non grid - 40") | 77 | 0.80 | 77 | 1 | 77 | 1.2 |
| Chest (10-20 lb) | PA (non grid - 72") | 80 | 0.5 | 80 | 0.65 | 80 | 0.8 |
| Chest (10-20 lb) | Lat (non grid - 72") | 83 | 0.65 | 83 | 0.8 | 83 | 0.95 |
| Chest (25-35 lb) | PA (non grid - 72") | 82 | 0.65 | 82 | 0.8 | 82 | 0.95 |
| Chest (25-35 lb) | Lat (non grid - 72") | 85 | 0.8 | 85 | 0.95 | 85 | 1.1 |
| C-Spine | AP (grid - 40") | 85 | 1.9 | 85 | 2.4 | 85 | 3 |
| C-Spine | AP (non grid - 40") | 70 | 1.5 | 70 | 2 | 70 | 2.6 |
| C-Spine | Odontoid (grid - 40") | 85 | 2.4 | 85 | 3 | 85 | 3.6 |
| C-Spine | Lat (grid - 72") | 85 | 5.5 | 85 | 6.6 | 85 | 8.6 |
| C-Spine | Lat (non grid - 72") | 70 | 4 | 70 | 5.2 | 70 | 6.8 |
| C-Spine | Swimmers (grid - 40") | 95 | 16 | 95 | 26 | 95 | 36 |
| Elbow | AP | 70 | 0.85 | 70 | 1 | 70 | 1.2 |
| Elbow | Obliques/Lateral | 70 | 0.95 | 70 | 1.1 | 70 | 1.3 |
| Finger | All Views | 66 | 0.4 | 66 | 0.5 | 66 | 0.6 |
| Foot | AP | 70 | 0.8 | 70 | 1 | 70 | 1.2 |
| Foot | Lat | 70 | 1.2 | 70 | 1.4 | 70 | 1.6 |
| Forearm | AP/Lat | 70 | 0.75 | 70 | 0.9 | 70 | 1.05 |
| Hand | PA | 66 | 0.5 | 66 | 0.6 | 66 | 0.75 |
| Hand | Lat | 70 | 0.75 | 70 | 0.9 | 70 | 1.1 |
| Hip | AP (grid ) | 85 | 4.2 | 85 | 6.3 | 85 | 7.8 |
| Hip | AP ( non grid ) | 75 | 2.6 | 75 | 3.2 | 75 | 4 |
| Hip | X-Table Lat (grid) | 90 | 20 | 90 | 30 | 90 | 40 |
| Humerus | AP ( non grid ) | 70 | 1.4 | 70 | 1.6 | 70 | 2 |
| Humerus | AP (grid) | 77 | 1.9 | 77 | 2.2 | 77 | 2.5 |
| Humerus | Transthoracic Lat | 90 | 14 | 90 | 20 | 90 | 26 |

## Merrill's Atlas of Radiographic Positioning and Procedures

- In mid 2013 Bruce Long, First Author of Merrill's, hired me to create the first ever digital technique charts for the Merrill's Atlas.
- In it's 50+ year history they have always had film/screen techniques.
- In the 13th edition which was released in February of this year, has almost 250 digital techniques included (half CR and half DR).
- Each technique also has the ESE Dose.

## Differences of the Least mAs to 100% More mAs technique charts

- The Least mAs chart uses the smallest mAs of all the charts (least dose to patient, most chance of noise).
- The 33% More mAs chart uses 33% more mAs/dose than the Least mAs chart.
- The 66% More mAs chart uses 66% more mAs/dose than the Least mAs chart.
- The 100% More mAs chart uses 100% (double) more mAs/dose than the Least mAs chart.

## How to use these four charts

- **Begin** with the "**100% More mAs**" because this has the least chance of noise.
- If you have a diagnostic image and the EI numbers show you can use less mAs, go to the "66% More mAs" chart.
- If again you have a diagnostic image and the EI numbers show you can use less mAs, go to the "33% More mAs" chart.
- Finally, if you have a diagnostic image and the EI numbers show you can still drop the mAs, go to the "Least mAs" chart.

## Difference between all charts

| Difference Between All Technique Charts (in Speed and mAs) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DR Cesium Least mAs | DR Cesium 33% More | DR Cesium 66% More | DR Cesium 100% More | DR Gado-linium | CR Least mAs | CR 33% More | CR 66% More | CR 100% More |
| 600 Speed | 500 Speed | 400 Speed | 300 Speed | 450 Speed | 450 Speed | 375 Speed | 300 Speed | 225 Speed |
| 10 mAs | 13.3 mAs | 16.6 mAs | 20 mAs | 15 mAs | 15 mAs | 20 mAs | 25 mAs | 30 mAs |

Here is how much dose you save your patient when you increase the kV and decrease the mAs at a 72" SID.

**Radiation Dose Saved**

| SID | kV | mAs | ESE Dose (mR) | Radiation Saved (%) | 50% EI Decrease (mAs) | 50% EI Dose (mR) | Total Dose Reduction (%) |
|---|---|---|---|---|---|---|---|
| 72" | 70 | 20 | 33.0 | | | | |
| 72" | 81 | 10 | 22.1 | 33.0% | 5.0 | 11.1 | 66.5% |
| 72" | 85 | 8 | 19.4 | 41.3% | 4.0 | 9.7 | 70.7% |
| 72" | 90 | 6.3 | 17.0 | 48.5% | 3.2 | 8.5 | 74.2% |
| 72" | 96 | 4 | 12.2 | 63.1% | 2.0 | 6.1 | 81.6% |

It is ***impossible*** to prove you used the ideal technique if your only gauge is the finished image contrast and density.

- In other words, your eyes can only see mottle and burn, but can't tell what is the perfect technique.

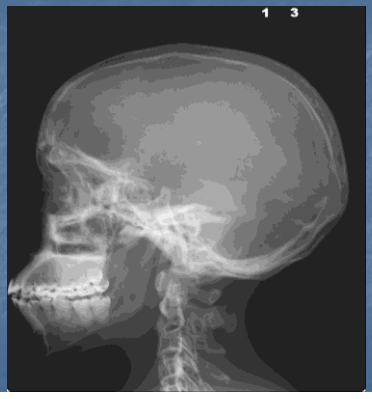
Fuji 85 kV @ 8 mAs - S# 171

85 kV @ 32 mAs - S# 38

85 kV @ 200 mAs - S# 6

85 kV @ 400 mAs - S# 3

85 kV @ 500 mAs - S# 4




Canon 85 kVp @ 2 mAs - REX# 358

85 kVp @ 4 mAs - REX# 686

85 kVp @ 8 mAs - REX# 1199

85 kVp @ 16 mAs - REX# 2199

85 kVp @ 25 mAs - REX# 3337

85 kVp @ 32 mAs - REX# 4317

## How much can you overexpose for CR and DR?

- For all CR (except Agfa) you can use a minimum of 50 times, and probably closer to 100 times, too much mAs and have a perfectly diagnostic/passable image.
- For most DR you can use about 10-15 times too much mAs.

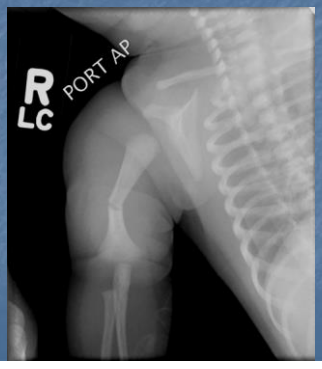
## Critiquing digital images

- The EI numbers are the number 1 way to critique your image.
- You should definitely use the magnification mode to check for noise and burn.
- You should always be able to Level and Window and make your image look well penetrated and contrasty.

## Post collimation (shuttering)

- ***All*** radiologists are legally responsible for everything that is on the original image.
- To use post collimation you **must** show a border of white or pure black to prove you did not crop out any anatomy.

Here's a portable humerus on a newborn.
The tech could have shuttered like this.

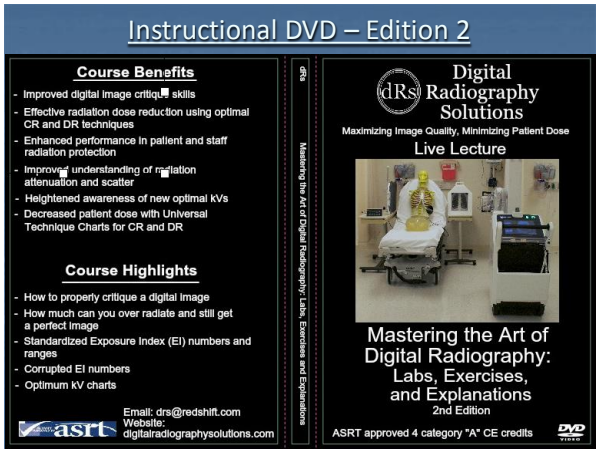




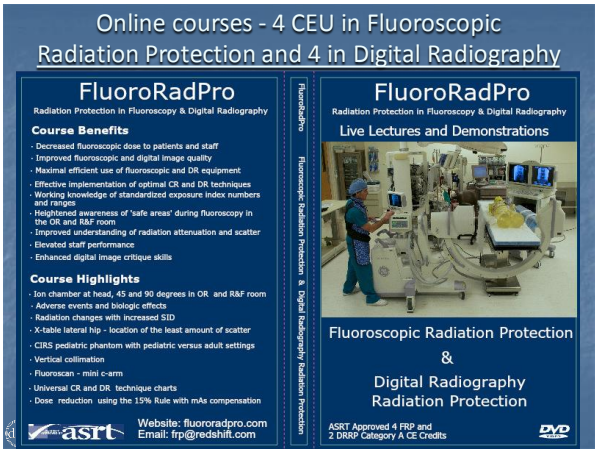
## ASRT Best Practices in Digital Radiography
## Collimation and Electronic Masking

- A best practice in digital radiography is to collimate the x-ray beam to the anatomic area appropriate for the procedure. Electronic masking to improve image viewing conditions should be applied in a manner that demonstrates the actual exposure field edge to document appropriate collimation. Masking must not be applied over anatomy that was contained in the exposure field at the time of image acquisition

## Instructional DVD – Edition 2

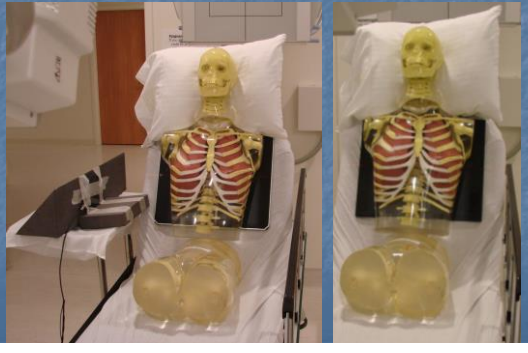



## Online courses - 4 CEU in Fluoroscopic Radiation Protection and 4 in Digital Radiography

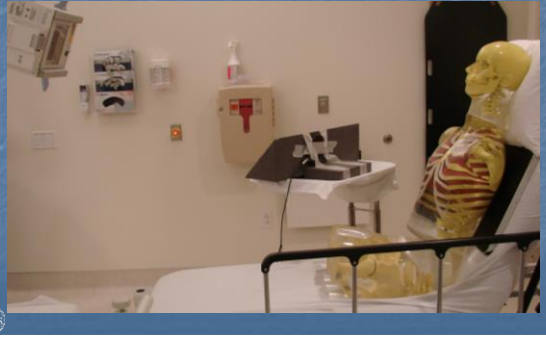



## How much scatter radiation occurs during an AP chest?

## We did this experiment many times with and without grids, at 115 and 85 kV, and at 3 different angles. This one is taken at 90 degrees to the patient.



## This one is taken at 45 degrees to the patient.



## And this one we are calling 0 degrees.

## Natural Background Radiation - 2006

- 1R =1 Rad
- 1 milliR (mR) = 1/1000 of a Rad
- 1 microR (uR) = 1/1000 of a mR
- **Natural Radiation** = 304 milliR/year
- 304 milliR = 304,000 microR
- 304,000 microR/year = **844 microR/day**

Here are all the doses for 0, 45 and 90 degrees (arrows at 6')

85@3.2 and 115@4

**Dose exposure due to scatter from Portable Chest Xrays**

| Angle of Chamber (Deg) | Distance (ft) | Dose #1 (microR) | Dose #2 (microR) | Average Dose (microR) |
|---|---|---|---|---|
| 90 | 1 | 96.0 | 94.6 | 95.3 |
| 90 | 2 | 42.7 | 42.0 | 42.4 |
| 90 | 3 | 21.1 | 22.0 | 21.6 |
| 90 | 4 | 13.3 | 12.7 | 13.0 |
| 90 | 5 | 10.6 | 9.0 | 9.8 |
| 90 | 6 | 6.9 | 6.1 | 6.5 |
| 45 | 1 | 195.5 | 196.2 | 195.9 |
| 45 | 2 | 79.3 | 80.7 | 80.0 |
| 45 | 3 | 38.3 | 39.2 | 38.8 |
| 45 | 4 | 24.3 | 23.8 | 24.1 |
| 45 | 5 | 16.2 | 17.9 | 17.1 |
| 45 | 6 | 11.6 | 12.0 | 11.8 |
| 45 | 7 | 9.4 | 9.1 | 9.3 |
| 45 | 8 | 7.1 | 6.4 | 6.8 |
| 0 | 6 | 34.0 | 33.1 | 33.6 |
| 0 | 7 | 24.5 | 23.0 | 23.8 |
| 0 | 8 | 17.4 | 16.0 | 16.7 |
| 0 | 9 | 14.0 | 14.2 | 14.1 |
| 0 | 10 | 10.5 | 11.6 | 11.1 |
| 0 | 11 | 8.4 | 8.9 | 8.7 |
| 0 | 12 | 6.3 | 7.5 | 6.9 |
| 0 | 13 | 5.3 | 6.4 | 5.9 |
| 0 | 14 | 0.0 | 0.0 | 0.0 |
| 0 | 15 | 0.0 | 0.0 | 0.0 |
| 0 | 16 | 0.0 | 0.0 | 0.0 |

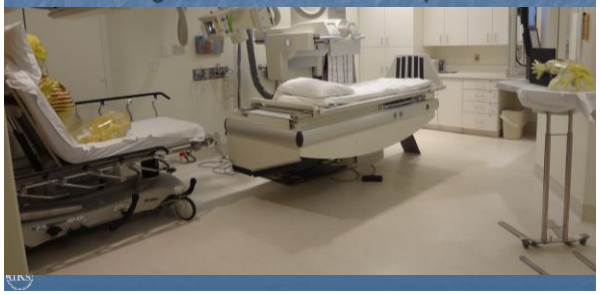
Chest technique of 85@3.2 was used for all exposures. Ionization Chamber angle is measured from mid sagittal plane.

**Dose exposure due to scatter from Portable Chest Xrays**

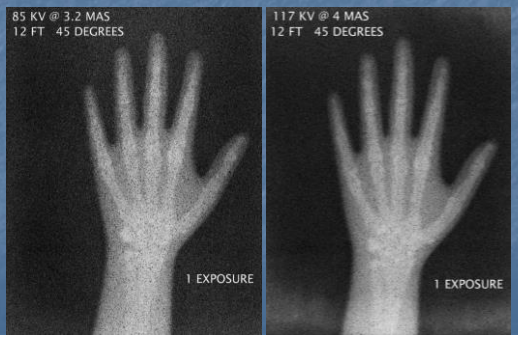
| Angle of Chamber (Deg) | Distance (ft) | Dose #1 (microR) | Dose #2 (microR) | Average Dose (microR) |
|---|---|---|---|---|
| 90 | 1 | 316.0 | 320.0 | 318.0 |
| 90 | 2 | 125.8 | 127.2 | 126.5 |
| 90 | 3 | 68.3 | 67.6 | 68.0 |
| 90 | 4 | 42.2 | 41.0 | 41.6 |
| 90 | 5 | 27.1 | 28.3 | 27.7 |
| 90 | 6 | 19.7 | 19.7 | 19.7 |
| 45 | 1 | 744.0 | 778.0 | 761.0 |
| 45 | 2 | 295.0 | 295.0 | 295.0 |
| 45 | 3 | 150.7 | 151.2 | 151.0 |
| 45 | 4 | 98.3 | 97.6 | 98.0 |
| 45 | 5 | 66.2 | 65.2 | 65.7 |
| 45 | 6 | 48.6 | 47.4 | 48.0 |
| 45 | 7 | 33.6 | 32.7 | 33.2 |
| 45 | 8 | 27.6 | 27.5 | 27.6 |
| 0 | 6 | 76.0 | 75.1 | 75.6 |
| 0 | 7 | 50.5 | 51.8 | 51.2 |
| 0 | 8 | 39.3 | 39.8 | 39.6 |
| 0 | 9 | 32.3 | 31.9 | 32.1 |
| 0 | 10 | 25.4 | 27.0 | 26.2 |
| 0 | 11 | 22.4 | 21.8 | 22.1 |
| 0 | 12 | 17.0 | 16.9 | 17.0 |
| 0 | 13 | 14.3 | 14.4 | 14.4 |
| 0 | 14 | 12.6 | 12.5 | 12.6 |
| 0 | 15 | 10.2 | 9.9 | 10.1 |
| 0 | 16 | 8.3 | 8.2 | 8.3 |

Chest technique of 115@4 was used for all exposures. Ionization Chamber angle is measured from mid sagittal plane.

This experiment used the arm/hand phantom and a 10x12 CR cassette. We set it up where many techs stand when making a PCXR exposure. This photo and the following image have the cassette at: 45 degrees and 12 feet from the patient.

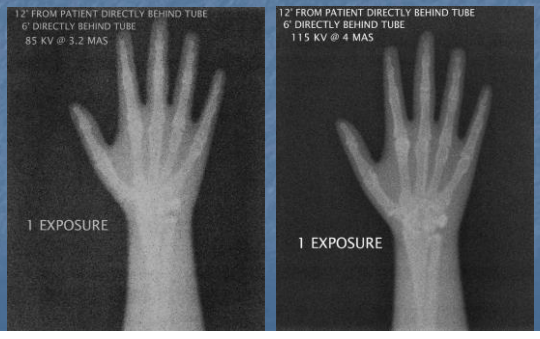


An image cannot lie. Even though the scatter dose is way down in the micro R's, there is enough radiation to make this image – with 1 exposure!!




This photo and the following image was taken with the phantom/cassette 12 feet from the patient directly behind the tube (which is 6 feet from the patient).

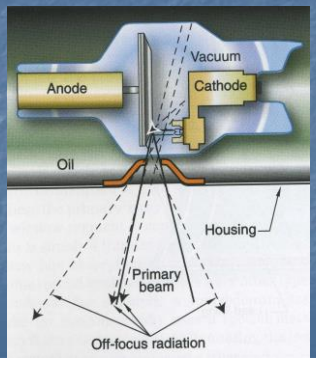
This just proves that a few MicroR is still enough radiation to do the job.



If you're thinking like we were, then you're wondering how much (if any) of that dose came from back of the tube, not the patient. It turns out that at 12 inches from the backside of the tube the dose was so small that the dosimeter could not read it.

The perfect place to stand when making an exposure is directly behind the tower. You lean your head out while giving the breathing instructions, then move your head back behind the tower while making the exposure.

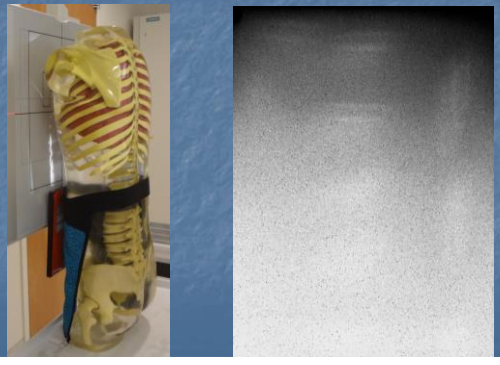
## Off-Focus Radiation



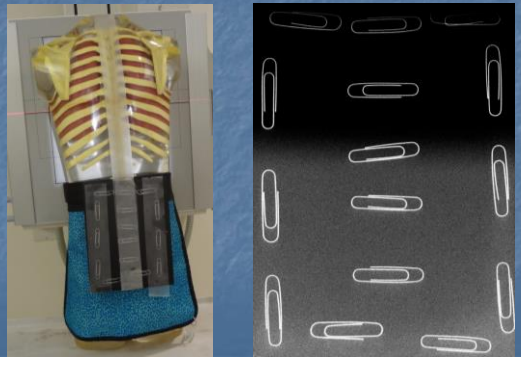

Art courtesy of "Principles of Radiographic Imaging " by Rick Carlton

Checking to see if it is wiser to shield a patient in the front or the back for a PA chest x-ray. Collimated to 14x17 with shield and cassette below primary beam.

Shield and cassette in front.
117 kV @ 2.5 mAs LgM .540

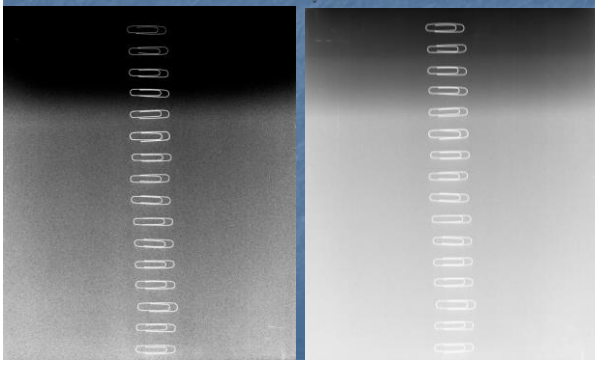


Shield and cassette in back.
117 kV @ 2.5 mAs LgM 1.53

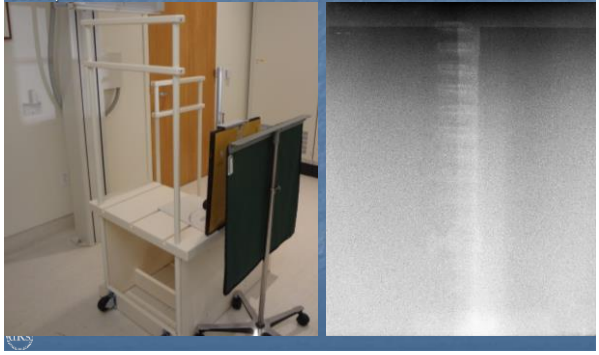


See how much Off-Focus Radiation actually comes out of the aperature.
CR cassette with paper clips spaced every inch, bottom of 14x17 lightfield just above the cassette.
None of the primary beam is hitting the cassette.

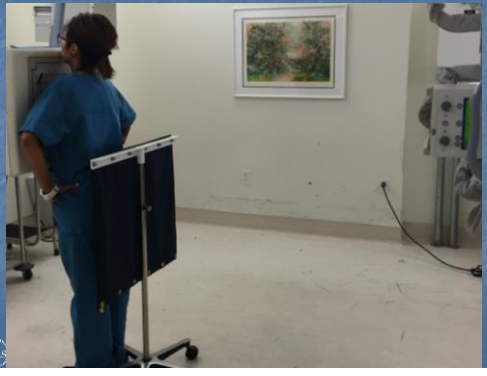
117 kV @ 2.5 mAs LgM 1.23 1200 Speed 72 kV @ 20 mAs LgM 1.69



Cassette blocked with a .5mm lead apron.
117 kV @ 2.5 mAs LgM 0.511
1200 Speed

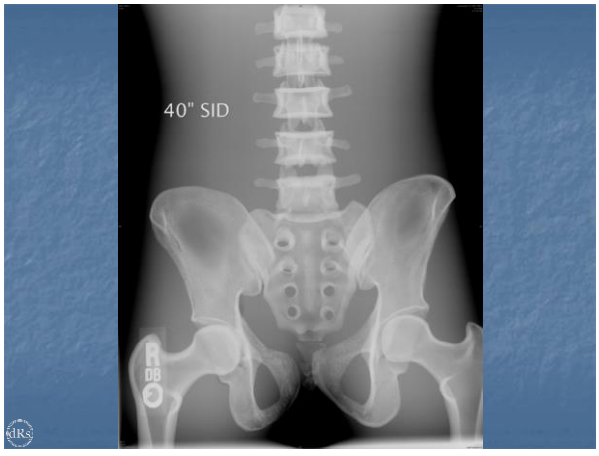


Because of Off-Focus Radiation, the shield needs to be placed on the side of the tube



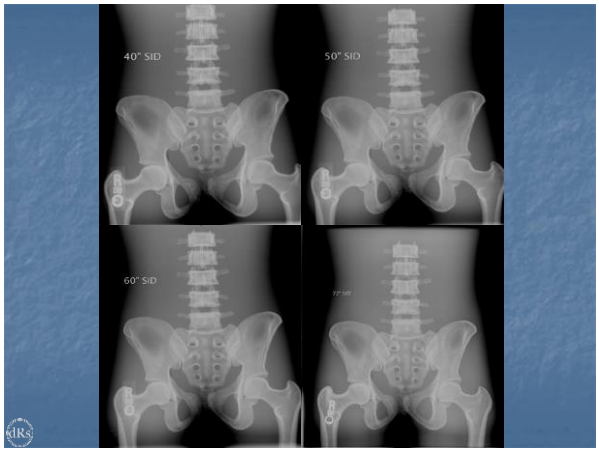
If your patient is pregnant, you will need to double shield on the tube side.

How much more anatomy can be seen on an abdomen when the SID is increased, or 72" (SID) is the new 40" (SID)!!










Peer Reviewed article in the Jan/Feb 2015 issue of Radiologic Technology, it was proven <u>that increasing SID will decrease patient dose</u>

- Entrance surface dose, including backscatter was reduced by 39% and effective dose by 41% when the SID was increased from 100 cm (40”) to 140 cm (55”).
- Also the image quality is increased because the magnification and geometric unsharpness are reduced.

# Digital Radiography Solutions

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Dennis Bowman
RT(R), CRT(R)(F)

831.601.9860
drs@redshift.com
www.digitalradiographysolutions.com

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Dennis Bowman
(831) 601-9860
Leslie Stiff-Martin
(831) 320-7925

*website:*
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*email:*
frp@redshift.com