



Diagnostic Imaging Specialists Corp

DISC DR Radchex Plus Operating Manual

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Theory of Operation

This instrument was designed using the basic physics principle: “All that is needed for quality assurance (QA) is an image and the dose that made the image”. If both stay constant, then systems are good to use.

The DR Radchex *PLUS* instrument has been developed specifically for QC and QA of digital radiographic systems. It can, as well, be used for QA on analog (film/screen) radiographic systems. Within the cassette, there is a 30.8 x 30.8 cm imaging phantom that contains several imaging objects. This phantom area includes 1 mm of Aluminum (cassette back), 1.5 mm copper plate inside the cassette, and two solid-state radiation detectors. The copper plate provides a patient-simulated exposure time. The radiation detectors, one measuring “entrance” exposure to the imaging phantom, the other measuring “exit” exposure from the imaging phantom are mounted in the imaging phantom. This allows an image to be created simultaneously as the two detectors measure the entrance and exit radiation that makes the image.

The radiation measuring area of the two detectors (Sensitive Area) is located and shown as “Detector Area” on the front of the imaging phantom (2 x 2 cm). After an exposure, the OLED displays the air kerma in mR and mGy entering and exiting from the imaging phantom. These 2 values are calibrated and traceable to an air chamber dosimeter located at the entrance and exit sides of the imaging phantom when the X-ray machine is set to 80 kVp.

NOTE: *If a solid-state dosimeter is used at the exit side of the cassette, values from this type of dosimeter can be from 15 to 20% lower than from air chamber dosimeters due to differences in scatter measurement.*

Operating Instructions

1. Position the DR Radchex *PLUS* on the table top with “**Head End**” facing left side of table, as shown in **Figure 1** (Right), and adjust collimator light to align with “**Light Field Alignment**” marks.

Note: Position X-Ray tube-to-imaging detector distance appropriate for grid and record grid used and use this distance for future QA tests.



Figure 1

2. Make sure that the center chamber of the AEC is positioned as shown in **Figure 2** below.

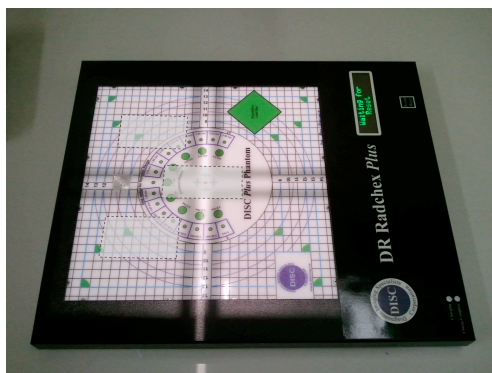


Figure 2

3. Turn on the meter using the “**Power/Reset**”.
4. The meter performs internal diagnostic tests and displays battery status.
5. If the OLED display shows “**Batteries Low**”, plug into charger before using.

6. Select Units (mR or mGy) by pressing and releasing the Power/Reset button. After 10 seconds the units will be locked in until the meter is turned off. When the meter is turned on the default will be what was used last.
7. OLED display shows "**Waiting for Reset**".
8. Press and hold "**Power/Reset**" button until the meter says "**Release button to Reset Meter**". Release the button.
9. Wait until display reads "**Ready to Expose**". The meter is now ready for an exposure.
10. Make exposure.

NOTE: *If you've reset the meter and then change your mind about taking an exposure, press and release the "Power/Reset"; this returns the meter to "Waiting for Reset".*

11. Once the exposure terminates, the Entrance Dose and Exit Dose are displayed on the OLED.
12. Quickly press and release the Power/Reset button to view Dose Ratio and HVL @ 80kVp. Quickly press and release again to go back to Entrance and Exit Dose.

After an exposure the Power/Reset button serves a triple purpose:

- ✓ *Toggles between metrics – Quick button press*
- ✓ *Resets the meter – A medium length button press of ~ 1 second (the display will prompt the user to Release the button to Reset the meter)*
- ✓ *To turn off the DR Radchex Plus - A long button press (~ 5 seconds) will shut off the meter (release button when prompted to power down)*

NOTE: *The meter will also automatically shut off after ~10 minutes of inactivity.*

Description of OLED displayed metrics

1. **Entrance Dose:** The DR Radchex has a solid-state radiation sensor imbedded in it that measures Radiation at the entrance to the phantom. The entrance dose value displayed on the OLED is calibrated to match the value produced by a traceable 6 cc Air Chamber dosimeter positioned at the entrance to the phantom, therefore the dose value shown on the OLED includes scatter radiation produced by the phantom.
2. **Exit Dose:** The DR Radchex also has a solid-state radiation sensor imbedded in it that measures radiation that exits the phantom. The Exit Dose value displayed on the OLED is calibrated to match the value produced by a traceable 6 cc Air chamber positioned on the exit side of the phantom.

Note: The phantom is positioned an inch and a half above the table top, therefore the value produced by the 6 cc air chamber includes the scatter radiation from the phantom as well as from the table top.

3. **Dose Ratio:** The Dose Ratio metric is simply the displayed Entrance Dose divided by the displayed Exit Dose. Since this Dose Ratio Metric is a comparison of a lightly filtered X-Ray beam (Entrance Dose) to a heavily filtered X-Ray beam (Exit Dose), the resultant Dose Ratio metric is very sensitive to even small changes in X-Ray beam hardness, regardless of whether the X-Ray Beam Hardness changes are caused by changes in tube head filtration or changes in kVp. This Dose Ratio metric is about 10% more sensitive to small changes in tube head filtration as compared to the traditional HVL metric. However, more significantly, this does metric is about 7 times more sensitive to small changes in kVp as compared to the traditional HVL metric.
4. **Calculated HVL at 80 kVp:** DISC experimentally established a relationship between our Dose Ratio metric and traditional HVL metric at 80 kVp.

NOTE: *Since the Dose Ratio Metric is much more sensitive to kVp change as compared to the traditional HVL metric, the DISC calculated HVL is only valid between 79 and 81 kVp.*

DR Radchex *Plus* Excel Templates for simple QA

Note: Microsoft Excel 2003 or newer must be installed to use these templates.

The Excel templates can be found on the USB Dongle that is supplied with the DR Radchex *Plus*.

1. Plug the USB into an available USB port. Wait for windows to finish installing drivers for the USB.
2. On your computer, click the Start button > My Computer.
3. Double click on the USB device shown under My Computer to open the USB.
4. Open the DR Radchex Plus folder. There are two templates to choose from, one for manual techniques and one for AEC techniques.

NOTE: You may also copy the templates and put them in a more convenient location (ex: My documents).

| DR Radchex Plus Template - Manual Techniques | | | | | | | | | | |
|---|------|---------|--------------------|---------------------------------------|----------------------------|--------------------|----------------|----------------------------|-------------------------------|---------------------------|
| Site Information | | | | | Technique | | | | | |
| Hospital/Clinic: Disc Corporation Sample | | | | | kVp: 80 | | | | | |
| Room #: Calibration Lab | | | | | Set mAs: 6.0 | | | | | |
| Bucky ID: 10:1 | | | | | Other Information: | | | | | |
| Grid ID: Table Bucky | | | | | Tolerance Limit(+/- %): 10 | | | | | |
| SID: 40" | | | | | | | | | | |
| Radiation QA Data | | | | QC Trend Calculator (% Change) | | | | | | |
| Test # | Date | Set mAs | Entrance Dose (mR) | Exit Dose (mR) | mAs | Entrance Dose (mR) | Exit Dose (mR) | Rel. Beam Hardness (Ex/En) | Entrance Tube Output (En/mAs) | Exit Tube Output (Ex/mAs) |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |

Figure 3

5. Fill in the grey cells with appropriate site information, technique, etc...
6. Test #1 metrics will serve as the benchmark to which all other test exposures will be compared to, therefore it is important that the X-Ray system be optimally calibrated before you start.
7. Once the X-ray system is at optimal performance, it is now time to setup your Benchmark Exposure.

Choosing benchmark setup and technique

AEC in-bucky exposures

- a. Place digital detector plate in bucky.
- b. Center DR Radchex Plus on bucky (Page 4- Figure 1 or Figure 2).
- c. Adjust SID to appropriate distance for grid.
- d. Select 80 kVp.
- e. Select AEC, Center Chamber and “0” density step.
- f. Reset the DR Radchex Plus meter and take the benchmark exposure.
- g. Document Benchmark test date, post exposure mAs, Entrance Dose, and Exit Dose in the template in the Test#1 row (highlighted in green).
- h. On all other subsequent QA test exposures, make sure that the technique, SID, and grid used are the same as for the benchmark exposure.

Manual in-bucky exposures

- a. Place digital detector plate in bucky.
- b. Center DR Radchex Plus on bucky (Page 4- Figure 1 or Figure 2).
- c. Adjust SID to appropriate distance for grid.
- d. Select 80 kVp.
- e. **Setting Benchmark mAs:** Select ~ 5 mAs, reset the DR Radchex Plus and take a test exposure. Observe the Exit Dose, if it's not close to 1mR, re-adjust as necessary and make another test exposure. Repeat these test exposures until you can determine a manual mAs setting that yields close to 1mR Exit Dose. This is the mAs setting that you can use for the benchmark exposure.
- f. Once the benchmark mAs has been determined, reset the DR Radchex Plus meter and take the benchmark exposure.
- g. Document Benchmark test date, set mAs, Entrance Dose, and Exit Dose in the template in the Test #1 row (highlighted in green).
- h. On all other subsequent QA test exposures, make sure that the technique, SID, and grid used are the same as for the benchmark exposure.

Manual Table-top exposures

- a. Position digital detector plate on tabletop.
- b. Center x-ray tube over digital detector.
- c. Set SID to 100 cm.
- d. Position DR Radchex Plus on top of digital detector plate and center DR Radchex (DISC Plus Phantom) to digital detector plate with head end of DR Radchex towards x-ray tube anode.
- e. Collimate x-ray beam to 30cm x 30cm (size of DISC Plus Phantom).
- f. Select ~80 kVp.
- g. **Setting Benchmark mAs:** Select ~ 4 mAs, reset the DR Radchex Plus and take a test exposure. Observe the Exit Dose, if it's not close to 0.5mR, re-adjust as necessary and make another test exposure. Repeat these test exposures until you can determine a manual mAs setting that yields close to 0.5mR Exit Dose. This is the mAs setting that you can use for the benchmark exposure.
- h. Once the benchmark mAs has been determined, reset the DR Radchex Plus meter and take the benchmark exposure.
- i. Document Benchmark test date, set mAs, Entrance Dose, and Exit Dose in the Excel template in the Test #1 row (highlighted in green).
- j. On all other subsequent QA test exposures, make sure that the technique and SID used are the same as for the benchmark exposure.

How the Excel templates work

The QA staff enters the Test Date, mAs (post exposure mAs for AEC and the manually set mAs for manual techniques), Entrance Dose and Exit Dose. The Excel template uses Test #1 Data as the benchmark exposure.

The Excel template will then populate three graphs for AEC template (mAs, Entrance Dose, and Exit Dose), and two graphs for the Manual template (Entrance Dose, and Exit Dose). These graphs automatically update every time data from a new test exposure is entered. These graphs will also show the Max and Min tolerance levels selected by the user.

The Excel template also includes a QC trend calculator which compares test exposure to the benchmark exposure (Test #1). If any of the six metrics compared exceeds the set tolerance limit, that metric is flagged (**Orange** = too high, **Blue** = too low). The troubleshooting guide will help determine what has drifted or changed.

DR Radchex Plus Template - Manual Techniques

Site Information

Technique

Hospital/Clinic:

Disc Corporation Sample

Room #:

Calibration Lab

Bucky ID:

10:1

Grid ID:

Table Bucky

SID:

40"

kVp:

80

Set mAs:

6.0

Other information:

Tolerance Limit(+/- %):

10

Radiation QA Data

QC Trend Calculator (% Change)

Test #

Date

Set mAs

Entrance Dose (mR)

Exit Dose (mR)

mAs

Entrance Dose (mR)

Exit Dose (mR)

Rel. Beam Hardness (Ex/En)

Entrance Tube Output (En/mAs)

Exit Tube Output (Ex/mAs)

Benchmark

Change:

1

10/10/2013

6.00

35.00

0.91

0.00%

0.00%

0.00%

0.00%

0.00%

0.00%

2

10/17/2013

6.00

35.00

0.92

0.00%

0.00%

1.10%

1.10%

0.00%

1.10%

3

10/24/2013

6.00

35.20

0.92

0.00%

0.57%

1.10%

0.52%

0.57%

1.10%

4

10/31/2013

6.00

35.20

0.90

0.00%

0.57%

-1.10%

-1.66%

0.57%

-1.10%

5

11/7/2013

6.00

34.90

0.91

0.00%

-0.29%

0.00%

0.29%

-0.29%

0.00%

6

11/14/2013

6.00

35.00

0.92

0.00%

0.00%

1.10%

1.10%

0.00%

1.10%

7

11/21/2013

6.00

42.70

0.96

0.00%

22.00%

5.49%

-13.53%

22.00%

5.49%

-1 mm Al

8

11/28/2013

6.00

29.50

0.86

0.00%

-15.71%

-5.49%

12.13%

-15.71%

-5.49%

+1mm Al

9

12/5/2013

6.00

32.50

0.73

0.00%

-7.14%

-19.78%

-13.61%

-7.14%

-19.78%

78 kVp

10

12/12/2013

6.00

37.10

1.07

0.00%

6.00%

17.58%

10.93%

6.00%

17.58%

82 kVp

11

12/19/2013

6.00

28.60

0.74

0.00%

-18.29%

-18.68%

-0.48%

-18.29%

-18.68%

5 mAs

12

12/26/2013

6.00

46.20

1.20

0.00%

32.00%

31.87%

-0.10%

32.00%

31.87%

8 mAs

13

Troubleshooting Guide

The following Metrics were used: Rel Beam Hardness, Entrance Tube Output, Exit Tube Output

Symptom(s)

Probable Cause

- Rel Beam Hardness ↓

- Entrance Tube Output ↑

- Rel Beam Hardness ↑

- Entrance Tube Output ↓

- Rel Beam Hardness ↓

- Exit Tube Output ↓

- Rel Beam Hardness ↑

- Exit Tube Output ↑

- Entrance Tube Output ↓

- Exit Tube Output ↓

- Entrance Tube Output ↑

- Exit Tube Output ↑

- Tube Head Filtration ↓

- Tube Head Filtration ↑

- kVp ↓

- kVp ↑

- mAs ↓ or SID ↑

- mAs ↑ or SID ↓

Figure 4 – Sample Template using Manual Technique

As you can see in Figure 4, test exposures 2 to 6 were not flagged by the QC trend calculator, however test exposures 7 through 12 were flagged. These are the exposures where some of the variables were changed. (i.e. the tube head filter, kVp, mAs)

As you can see from this example, setting a tolerance limit of +/- 10% will cause the trend calculator to flag 1mm change in tube head filtration, or a 2 kVp change, or an mAs change of > 10%.

DR Radchex *PLUS* Imaging Objects Scoring Guide

When using the DR Radchex PLUS, the evaluation of digital images and dose constancy from day-to-day (QA) relies on using constant geometry and constant exposure techniques from day-to-day. In addition, the digital image must be transferred to the viewing monitor without additional image processing and therefore, images must be viewed before processing (for processing or flat field images).

When using one's eyes for constancy test evaluation, the aim is not to establish the absolute values of the imaging system characteristics, but to confirm the routine performance of the entire X-ray system from day-to-day.

Constancy testing is based on "Time Invariance" which states that images made under comparable conditions, but at different times, should be identical. If not, the X-ray system is not consistent.

The DR Radchex PLUS Phantom allows several relevant performance characteristics to be assessed from day-to-day;

- Dynamic Range
- Detail Detectability
- Spatial Resolution
- Homogeneity and Artefact Recognition
- Light Field/X-ray Field Alignment

When scoring the DR Radchex PLUS imaging objects, the "score" can be determined by one of two methods.

1. By determining the maximum number of objects/line pairs that can be seen on the "for processing" (flat-field) image from day-to-day.
2. By comparing the number of objects/line pairs that can be seen on the "for processing" (flat-field) image to a reference (base line) image.

Ideally, the base line image score for the imaging objects are those produced just after the imaging system has been calibrated by the imaging vendor and are those measured during the acceptance test.

Dynamic range using the Copper Step Wedge

When viewing the high contrast copper "step-wedge" produced using a given kVp, the eye is used to determine the number of separate "gray steps" (contrast) observed. The "score" of the copper step-wedge image is the number of steps observed from day-to-day. The dynamic range, number of steps, should remain constant from day-to-day when using the same kVp.

Detail detectability using the Low Contrast Disks

When viewing the low contrast disks, the eyes are used to determine the number of “disks” that can be seen in contrast to the area surrounding each disk. Since the relationship between the disk’s contrast and image noise is important to the detectability of the disks (contrast-to-noise ratio) at a given dose, the higher the noise gets, the more difficult it is to recognize the disks. The criterion for low contrast detectability is the total number of disks that can be detected from day-to-day at a given dose. If noise gets higher, then the number of disks detected may decrease from day-to-day.

Homogeneity using four separate areas of the phantom

When using the eyes to view four marked opposing corner areas of the phantom, the “shade of grey” of each of the four areas should appear the same on the “for processing” image. If the grey shade appears different, then it may be due to differences in the radiation exposure at each of the corner areas (heel effect, filtration) or differences in the local sensitivity of the detector/plate.

To minimize heel effect, use the maximum possible tube-to-detector/plate distance. It has been documented that with increasing work time of an X-ray tube the emitted dose distribution of the X-ray field can change. If all four corner areas of the phantom appear the same shade of grey from day-to-day, then the score should be the same, if shades appear different, then the score changes.

High contrast spatial resolution using the lead bar pattern

When using the eyes to view the lead bar pattern (0.6 – 5.0 lp/mm), the imaging system attempts to reproduce each of the three line pairs seen on the lead-bar pattern as accurately as possible. The imaging system however is limited by how it can reproduce the pattern of spaces between the lead lines and the lead lines themselves. When the imaging system reaches its limit of resolving the lines and spaces between the lines, the lines appear to “join” and the line-space pattern is lost. At the point where the lines and spaces “run together”, this is the limit of the high contrast spatial resolution of the imaging system. If the number of line pairs that one visualizes from day-to-day changes, then the spatial resolution of the imaging system changes and the score changes.

Light field/x-ray field alignment

When viewing the radiographic field in comparison to the light field, one can use the eyes to determine how closely the two fields are aligned. The “marks” on the radiographic grid are one centimeter apart and the eyes can be used to determine how closely these grid lines align with the visible grid lines.

DISC Auto-analysis Software packages

Please refer to the Users manual for DISC Auto analysis software packages.

DR Radchex *Plus* TECHNICAL INFORMATION

INSTRUMENT SPECIFICATIONS:

| | |
|--|--|
| X-Ray Energy Dependence | Air-kerma values displayed are within +/- 2% of a traceable 6cc air Chamber between 60 and 100 kVp |
| Entrance Detector Minimum Dose Rate | 10.0 mR/sec (87.7 uGy/sec) |
| Entrance Detector Maximum Dose Rate | 4.0R/sec (17.54 mGy/sec) |
| Exit Detector Maximum Dose Rate | 300.00 mR/sec(2.631 mGy/sec) |
| Power On/Off | Manual switch; Automatic off after 10 minutes of inactivity |
| Power Requirements | Built-in NiMH rechargeable battery pack (9.6V) |
| Typical Battery Life Between Charging | >20 Hours |
| Operating Environment | 15°C to 35°C (59°F to 95°F) |
| Electronic Cassette Specifications | Dimensions: 15" x 18" x 1.2" |
| | Weight: 5.24kg (11.5lbs) |

LIMITED WARRANTY for DR Radchex *PLUS*

This product, except the use, is warranted by Diagnostic Imaging Specialists Corporation (DISC), to the original purchaser to be free from defects in material and workmanship under normal use for a period of one (1) year from the date of purchase. During the warranty period, and upon proof of purchase, the product will be repaired or replaced (with the same or similar model) at our option, without charge for either parts or labor at the DISC factory. The purchaser shall bear all shipping, packing, and insurance costs to the DISC factory. The warranty will not apply to this product if the product has been misused, abused, or altered. Without limiting the foregoing, bending or dropping of unit, broken electrical wires, visible cracking of the product components and/or enclosures are presumed to be defects resulting from misuse or abuse.

NEITHER THIS WARRANTY NOR ANY OTHER WARRANTY EXPRESS OR IMPLIED, INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY, SHALL EXTEND BEYOND THE WARRANTY PERIOD. NO RESPONSIBILITY IS ASSUMED FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITING THE SAME TO MATHEMATICAL ACCURACY OR PRECISION OF THE PRODUCT. SOME PROVINCES AND OR STATES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS AND SOME PROVINCES AND OR STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THAT THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY.

This warranty gives the product owner specific legal rights, and the owner may also have other rights which vary from province to province or state to state.