Kodak DIRECTVIEW Total Quality Tool

AAPM Summer School 2004

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HEALTH IMAGING
A BETTER VIEW OF LIFE.

KODAK Digital Capture Solutions

Milestones

- KODAK DIRECTVIEW PTS Software (1997)

- KODAK DIRECTVIEW EVP Software (1999)

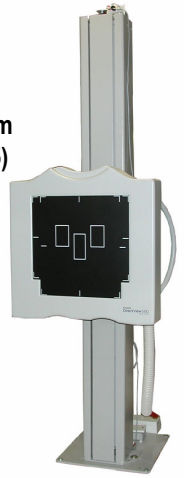
- KODAK DIRECTVIEW Total Quality Tool (2001)

- First KODAK CR System (1993)

- Next-generation CR—multi-cassette system with unique "drop-and-go" workflow (1995)

- KODAK DIRECTVIEW CR 950 System (2003)

- KODAK Black Surround / Masking Software (1997)



- KODAK DIRECTVIEW Remote Operations Panel (2000)

- KODAK DIRECTVIEW V3 Software (2002)

- KODAK DIRECTVIEW CR 500 System (2003)

2003

- KODAK DIRECTVIEW CR 850 System (2003)

- KODAK DIRECTVIEW DR System s (2000)

Early Innovator—Kodak patents storage phosphor technology—a foundation for the first CR systems in the industry

KODAK DIRECTVIEW CR 500 System

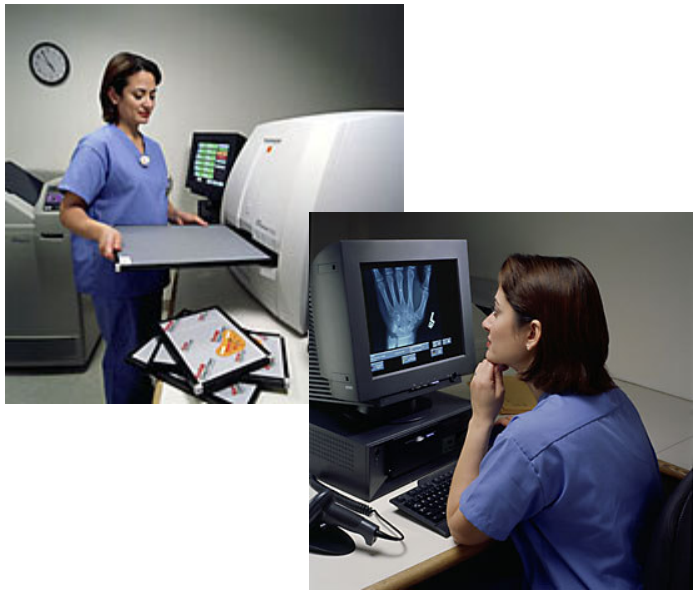
New!

Fast tabletop CR with premium quality, performance, and features

- Process over **60 cassettes/hour**
- **High-performance** digital imaging in a **compact, modular system**
- **Image quality**, **advanced image processing** = full size CR
- **Easy-to-use** interface of premium Kodak DirectView CR systems
- Cassettes are lightweight and durable

Application

- **Radiology department, clinic or office, ICU, CCU, or other facility**
- **Moderate exam volumes**



Compact size without compromising quality or throughput

KODAK DIRECTVIEW CR 850 System

Fastest single-cassette CR (35x43)

- Process up to **104 cassettes/hour, 91 14x17 size /hour**
- Streamlined footprint 25 X 29 in.
- **Forward images** diagnostic workstation after review or auto-route if desired
- **Easy-to-use** interface is designed for consistency across Kodak DirectView CR *and* DR systems

Application

- **Distributed CR applications—radiology department, ER, ICU, or other**
- **Medium-to-high exam volumes**

…and lighter cassettes!

Speed where its needed

KODAK DIRECTVIEW CR 950 System

New!

Multiple-cassette centralized processing with decentralized workflow

…and lighter cassettes!

- Drop-and-go workflow
  - Process up to 86 cassettes/hour (8 exposed / 8 erased cassettes at one time)
  - Support multiple x-ray examination rooms
  - Reduce time away from the patient
- 16 cassette management system
  - 8 in/8 out
- Easy-to-use interface is designed for consistency across Kodak DirectView CR and DR systems

Application

- **Centralized general radiography**
- **Multiple x-ray imaging rooms**
- **Medium-to-high exam volumes**

Enables drop-and-go workflow

KODAK DIRECTVIEW Remote Operations Panel

- **Extend CR functionality** to the point of patient care
- Wall-mounted **touch-screen** panel
- **Network up to ten remote operations panels** to a DirectView CR system to extend system reach

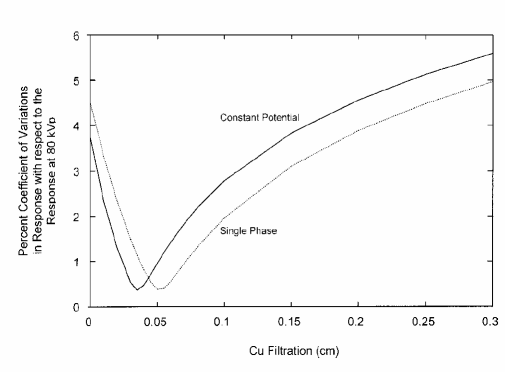
More time with patients, less time with CR

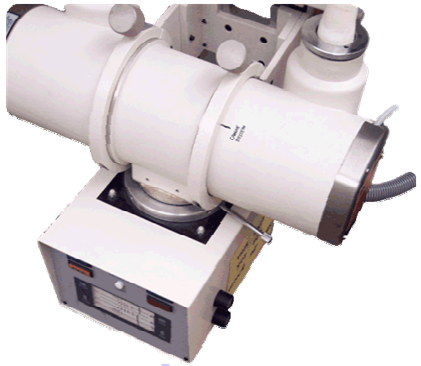
Quality Assurance

Designed In – Not Added On.

- Exposure Calibration.
- Exposure tracking and reporting.
- Repeat statistics.
- Manual QC documentation
- Automatic QC capability

Exposure Calibration





2.6 mm Al
Inherent Filtration

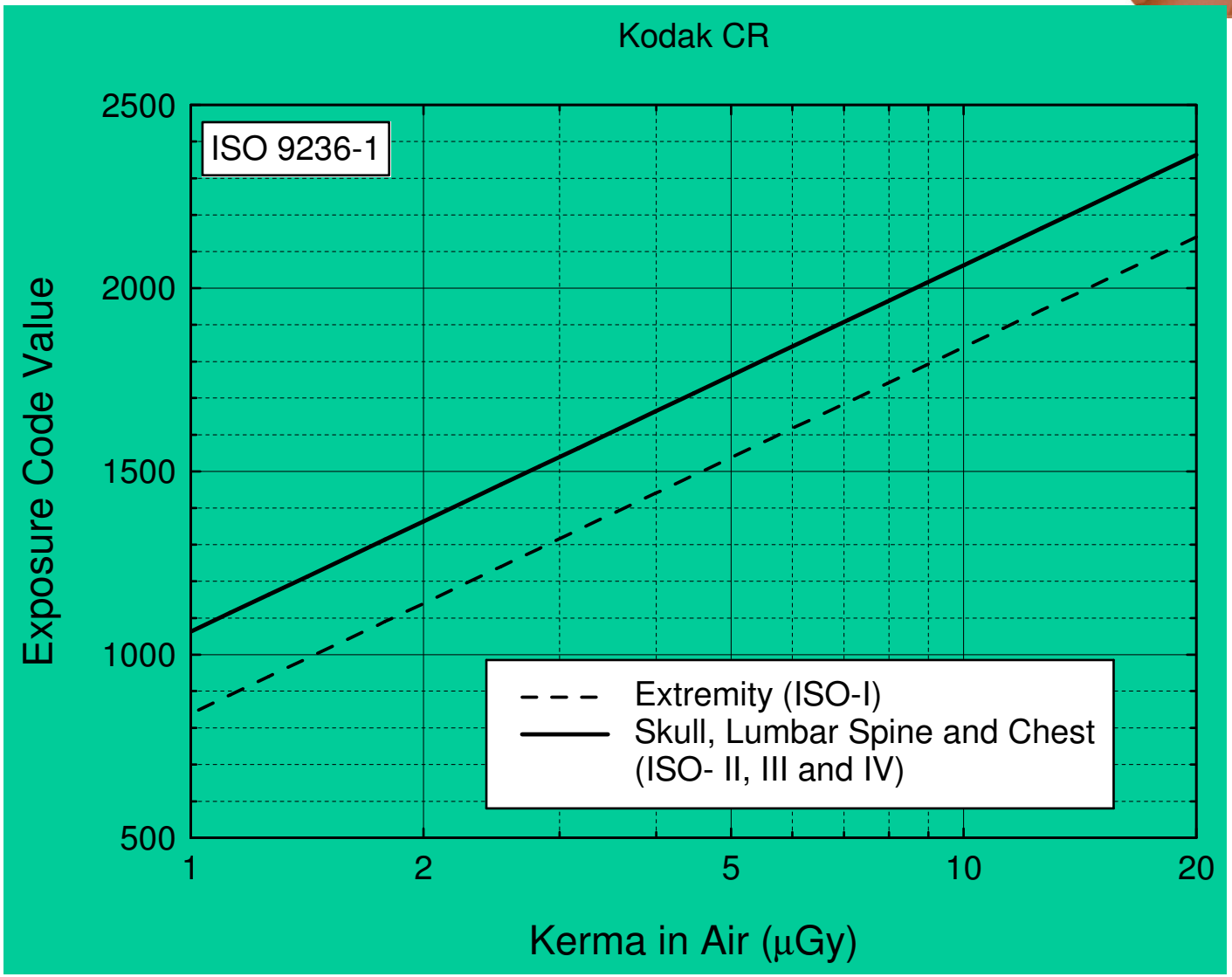
0.5 mm Cu
1.0 mm Al

10.0 ± 0.2 mR
@ 80 kVp

≥ 180 cm

Lead Apron

Dose Response - Computed Radiography



ISO-9236-1 Speed Measurement

Table 2 — Specification of techniques

Technique number	Approximate X-ray tube voltage [1] kV	Half-value layer mm Al	Exposure times ms	Distance between the back of the phantom and the detector [2] mm
I Extremities	50	3,0	100 ± 50	60
II Skull	70	5,7	200 ± 100	60
III Lumbar spine and colon	90	7,4	200 ± 100	60
IV Chest	120	8,5	20 ± 10	60

1) The geometry for establishing the tube voltage is described in 7.2.5. The beam qualities for determination of the

Dimensions

7 Determination of speed

7.1 Definition

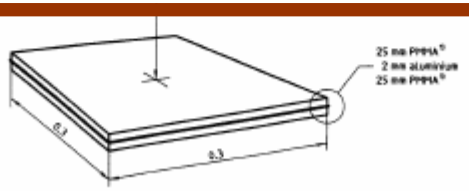
The speed S is calculated from:

$$S = K_0/K_S$$

where

K_0 is 10^{-3} Gy

K_S is the air kerma (in grays) incident on the combination behind a phantom to produce a net density of 1,0.



1) Polymethyl methacrylate.

Figure 4 — Phantom for technique I

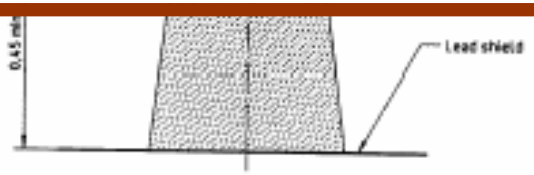
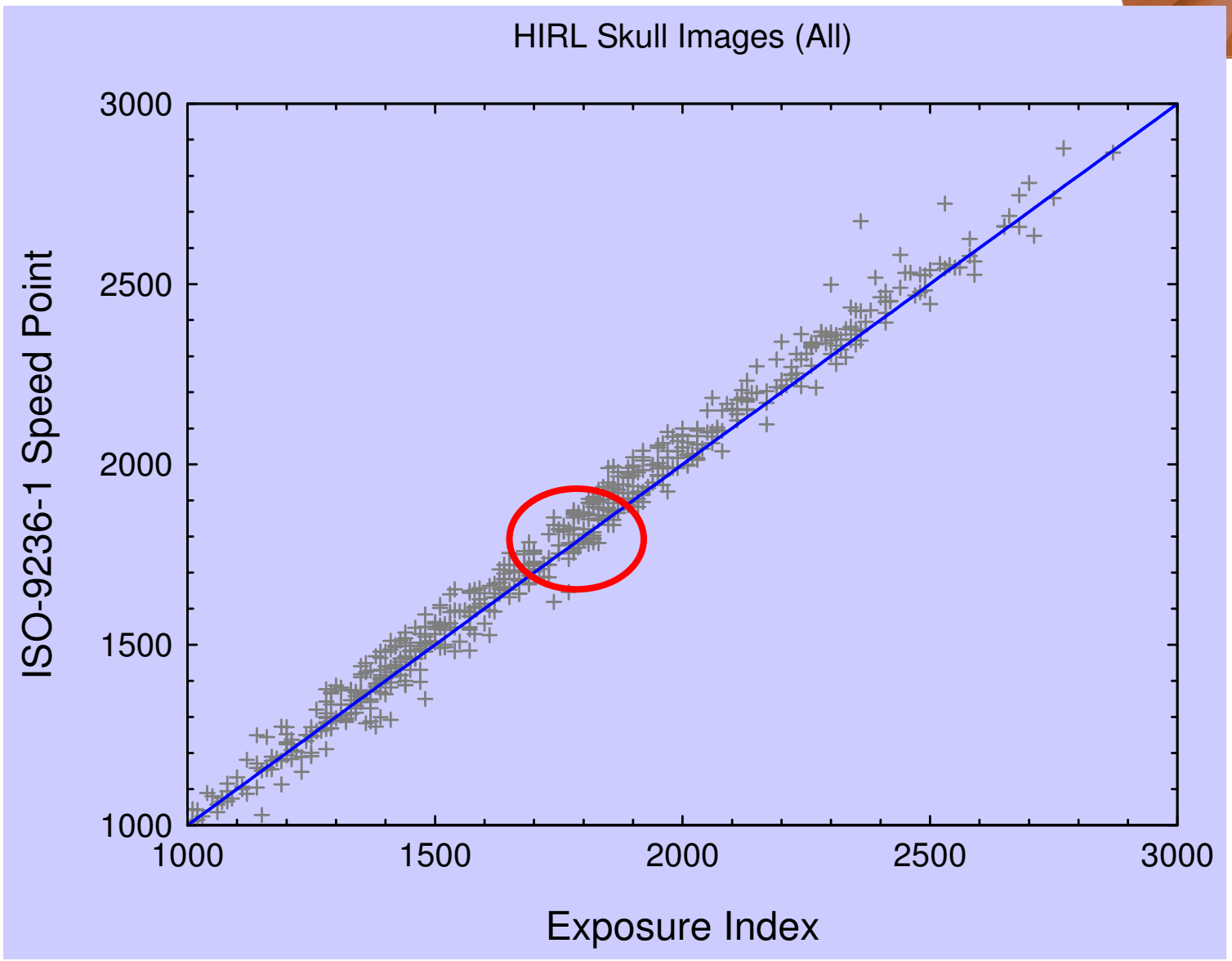
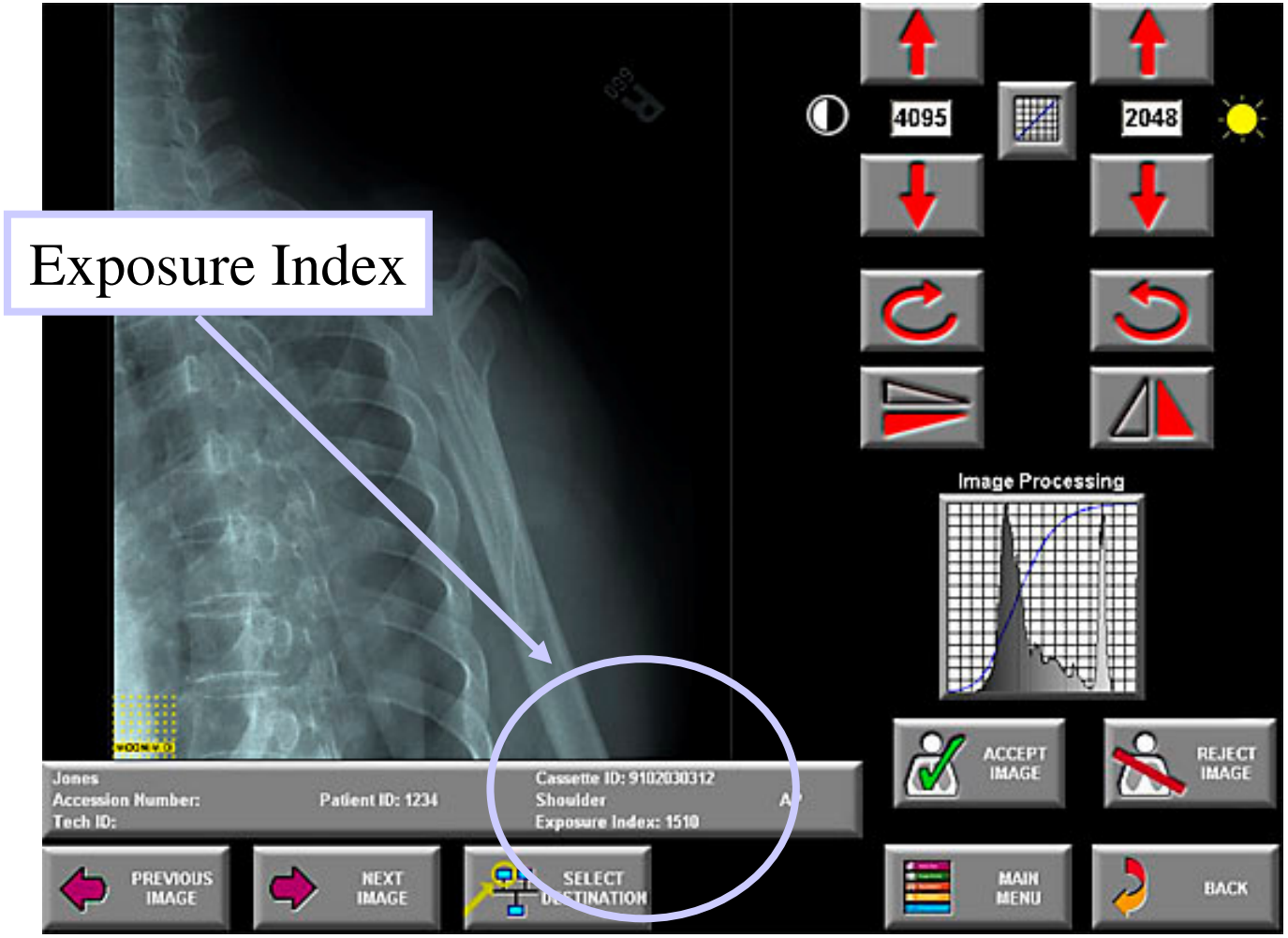


Figure 6 — Geometric set-up for the measurement of speed (techniques I, II and III)

Exposure Index vs. ISO Speed



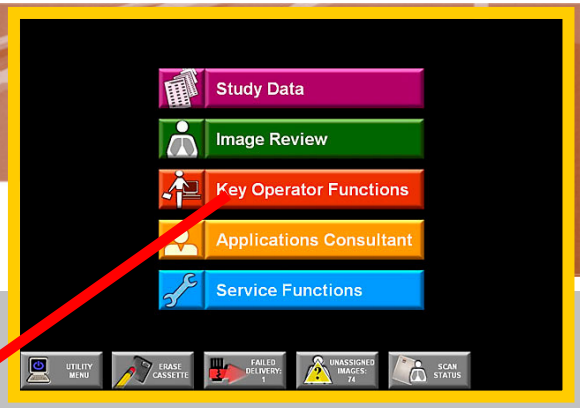
Exposure Index Reporting



DICOM Tags

Attribute Name	Tag	Description
ACQ KVP	0018,0060	Peak kV
ACQ Exposure Time	0018 1150	Exposure time in ms
ACQ X-ray Tube Current	0018,1151	Tube Current in mA
ACQ Exposure	0018 1152	Tube current-time product in mAs
ACQ Relative X-ray Exposure	0018 1405	Exposure Index

Clinical Quality Assurance



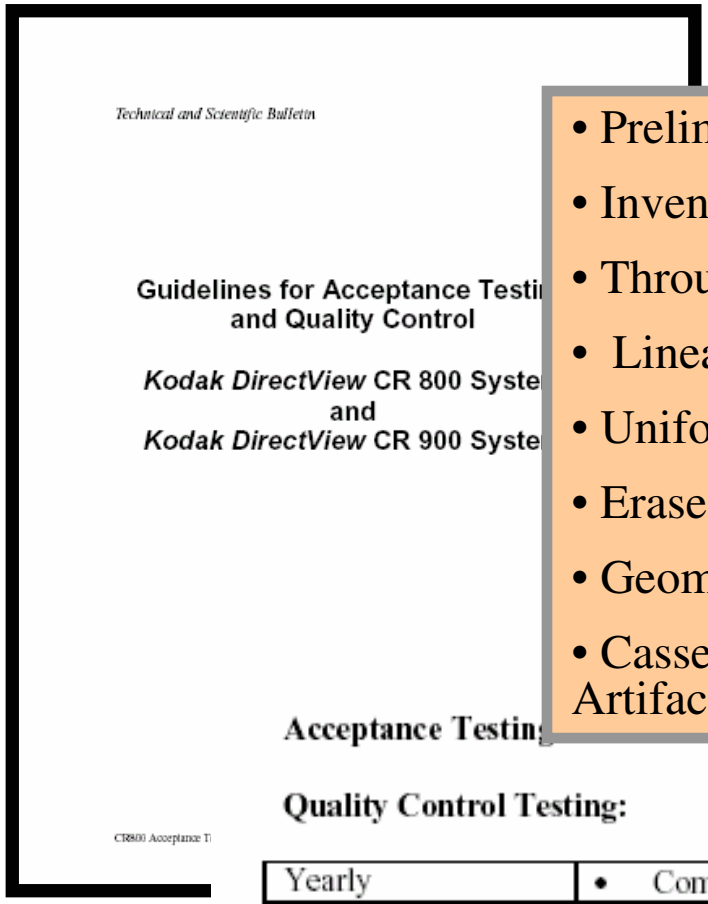
Overview of Key Operator Features and Advantages

Features	Path to the Feature Location	Advantages
Cassette Statistics	Key Operator > Statistics > Cassette Statistics	On a cassette basis, view statistics such as number of scans, accepts, and rejects
Destination Statistics	Key Operator > Statistics > Destination Statistics	On a destination basis, view statistics such as the number of failed and successful deliveries
Tech Statistics	Key Operator > Statistics > Tech Statistics	On a technologist basis, view statistics such as number of accepts, rejects, and average exposure value
Scan Cycles	Key Operator > Statistics > Scan Cycles	View the number of erase cycles for each pair of erase lamps
Destination Status Summary	Key Operator > Statistics > Destination Status Summary	On a destination basis, view statistics such as number of jobs sent, jobs failed, and job status

CR & DR Exposure Index Logging

Tech ID	Body Part	Projection	Exposure Index	Exam Date	Exam Time	Scan Date	Scan Time	Patient ID	Accession Number	Reject Comments
BEW	Chest	PA	1960	5/6/2004	09:22:57	5/6/2004	09:26:16	3492139	1123474	
BEW	Chest	Lateral	2020	5/6/2004	09:22:57	5/6/2004	09:27:19	3492139	1123474	
BEW	Facial Bones	PA	2110	5/6/2004	09:38:10	5/6/2004	09:38:40	10323889	1123504	
BEW	Facial Bones	PA	1980	5/6/2004	09:38:10	5/6/2004	09:40:16	10323889	1123504	
BEW	Chest	AP	2130	5/6/2004	09:38:10	5/6/2004	09:42:33	10323889	1123504	
BEW	Abdomen	AP	2070	5/6/2004	09:50:10	5/6/2004	09:52:33	3769247	1123507	Clipped Anatomy
BEW	Abdomen	AP	2050	5/6/2004	09:50:10	5/6/2004	09:53:39	3769247	1123507	
RMG	Chest	Lateral	1950	5/6/2004	11:06:25	5/6/2004	11:11:17	1970086	1123778	
RMG	Chest	PA	1990	5/6/2004	11:06:25	5/6/2004	11:12:21	1970086	1123778	
BEW	Chest	PA	2000	5/6/2004	11:16:04	5/6/2004	11:18:12	5325378	1123803	
BEW	Chest	Lateral	1900	5/6/2004	11:16:04	5/6/2004	11:19:19	5325378	1123803	
MMW	Abdomen	AP	2430	5/6/2004	11:20:30	5/6/2004	11:20:49	2833481	1123810	Patient Motion
MMW	Abdomen	AP	2410	5/6/2004	11:20:30	5/6/2004	11:22:03	2833481	1123810	
MMW	Chest	PA	1720	5/6/2004	11:43:58	5/6/2004	11:45:42	7328693	1123915	
MMW	Chest	Lateral	1840	5/6/2004	11:43:58	5/6/2004	11:46:57	7328693	1123915	
BEW	Chest	PA	1950	5/6/2004	11:44:26	5/6/2004	11:48:09	5665344	1123920	
BEW	Chest	Lateral	1910	5/6/2004	11:44:26	5/6/2004	11:49:12	5665344	1123920	

Manual Acceptance Testing and Quality Control


Technical and Scientific Bulletin

Guidelines for Acceptance Testi
and Quality Control

Kodak DirectView **CR 800 Syste**
and
Kodak DirectView **CR 900 Syste**

CR800 Acceptance T

- Preliminary testing (x-ray machine, displays, printers)
- Inventory & Inspection
- Throughput
- Linearity
- Uniformity & Artifacts
- Erase Function
- Geometry
- Cassette testing (Exposure Response, Uniformity and Artifacts)

Acceptance Testin

Quality Control Testing:

Yearly	• Complete acceptance test
Twice yearly	• **Cassette Exposure Response, Uniformity and Artifacts** - Test the 10 mR system response and visually check the resulting image from each cassette for uniformity and artifacts.
Monthly	• Visually inspect all screens for dust and scratches
Weekly	• Erase all unused cassettes • Verify luminance calibration of workstation displays
Daily	• Verify printer-processor density calibration

Kodak TQT – CR Testing Matrix

Manufacturing ⇔ Service ⇔ User

Exposure Response
- *Linearity & Noise*

Spatial Resolution - MTF
- *Slow scan & fast scan*
- 50% *and* 95% $f_{Nyquist}$

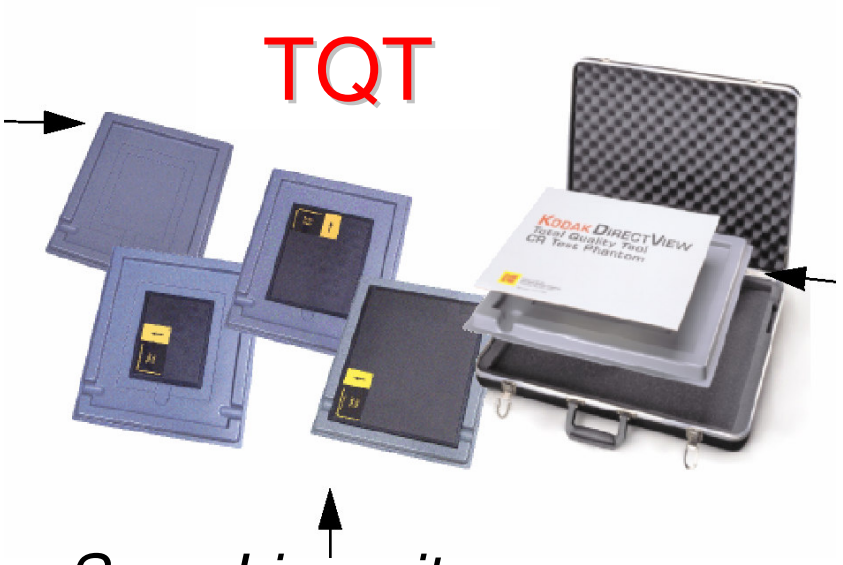
Geometric Accuracy
- *Pixel Spacing, Aspect Ratio, Scan Linearity*

Field Uniformity

Erase

Artifacts:
- *Streaks, Pixel-Position Error, Line-Position Error*

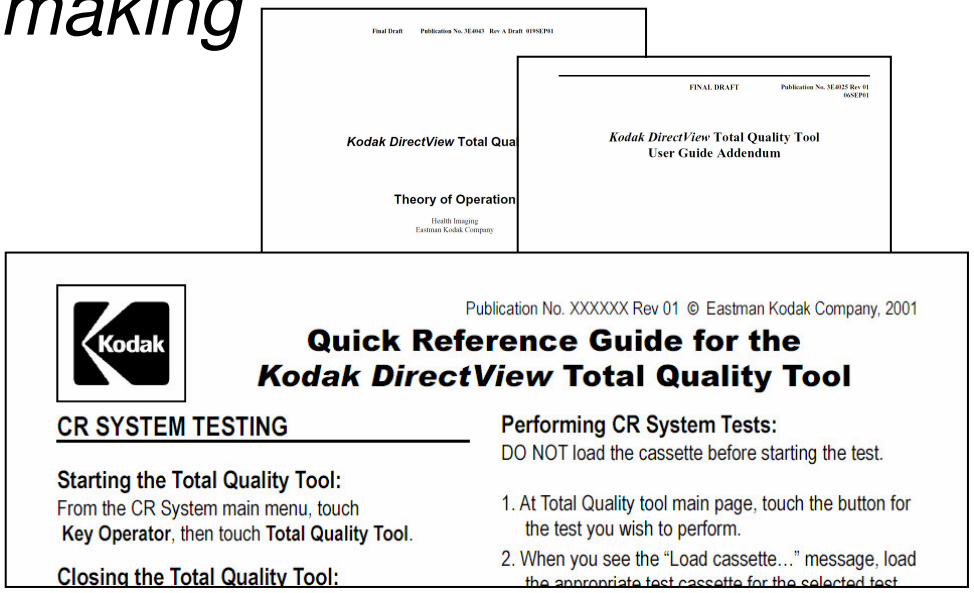
System Electronic Noise



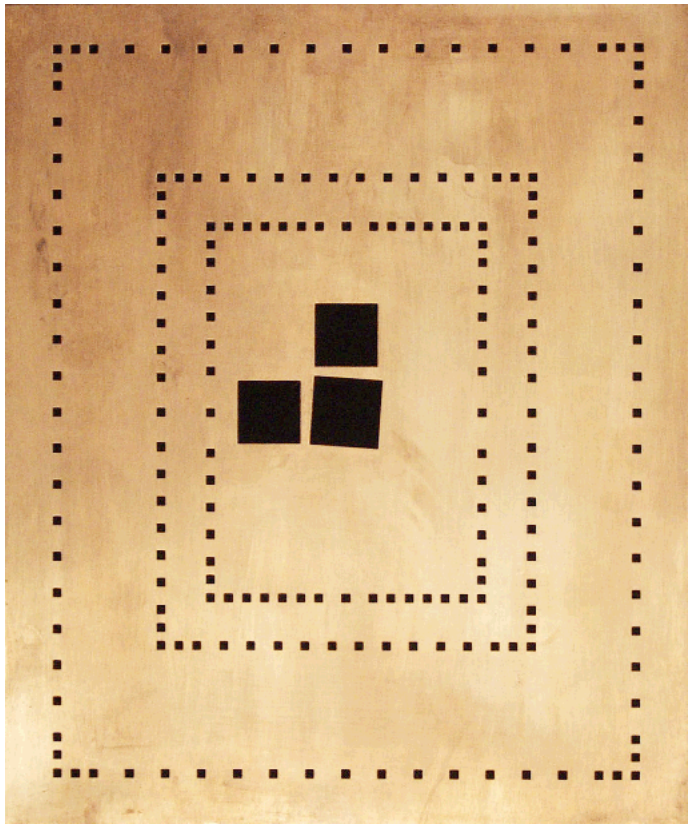
Acceptance Testing and Quality Control

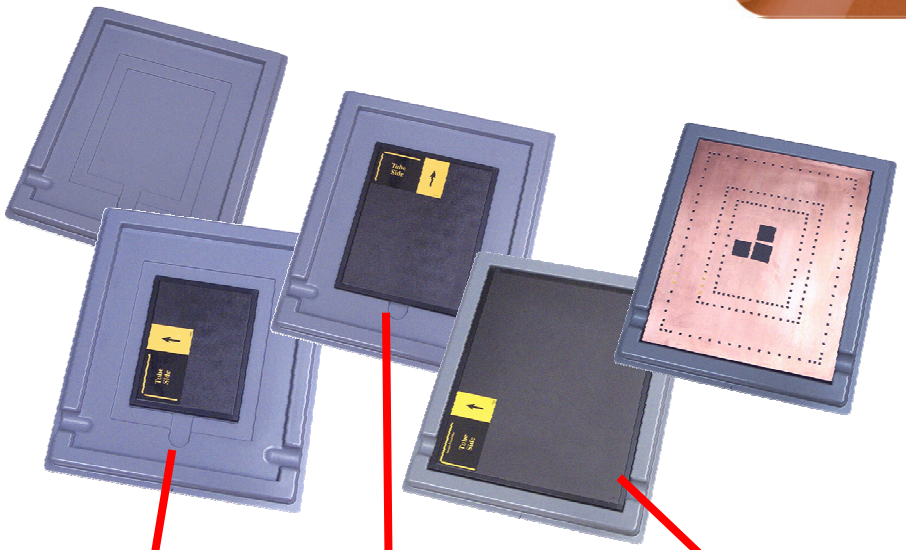
Kodak Total Quality Tool

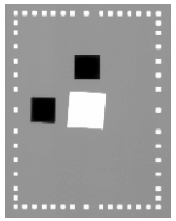
- **Phantom** - *targets for quantitative analyses*
- **Procedure** - *acquire phantom and flat-field images using controlled exposures*
- **Analysis Software** - *automatic image analyses and decision making*
- **Documentation**
  - **Theory of Operation**
  - **User Guide Addendum**
  - **Quick Users**



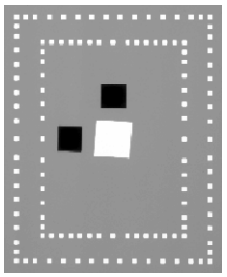
Kodak TQT Phantom



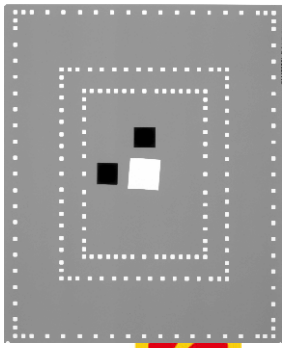




18 x 24 cm

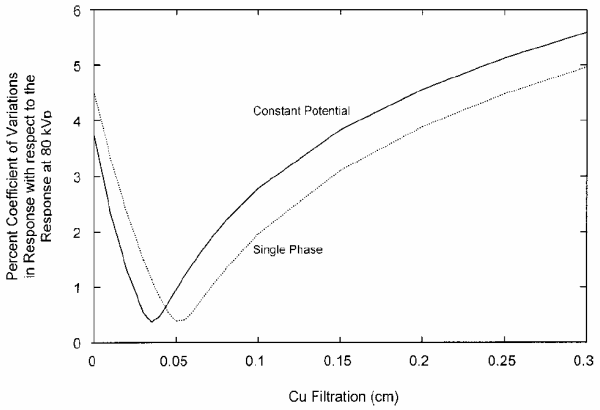


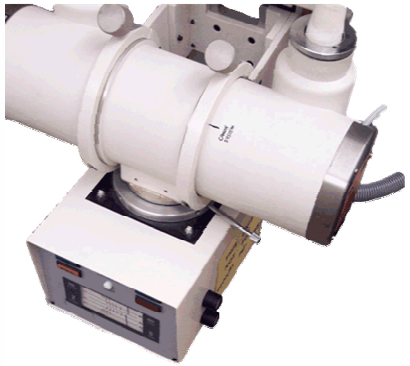
24 x 30 cm



35 x 43 cm

Kodak TQT Procedure

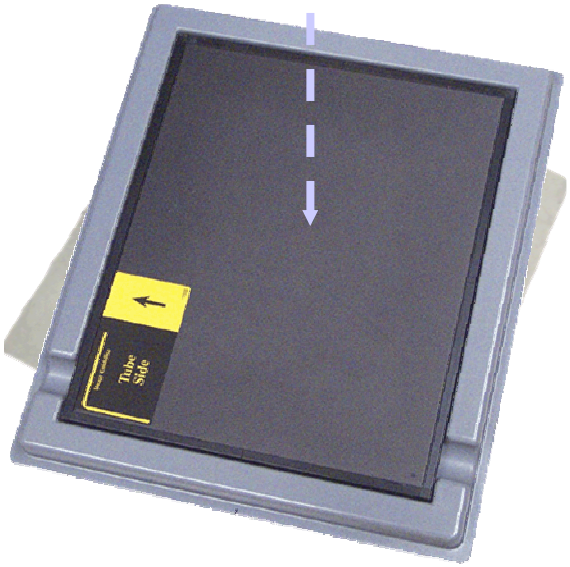




0.5 mm Cu
1.0 mm Al

≥ 180 cm

10.0 ± 0.2 mR
@ 80 kVp



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Quick Reference Guide for the *Kodak DirectView* Total Quality Tool

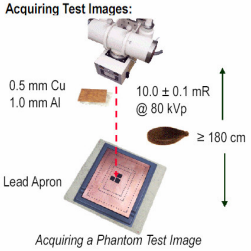
CR SYSTEM TESTING

Starting the Total Quality Tool:
From the CR System main menu, touch **Key Operator**, then touch **Total Quality Tool**.

Closing the Total Quality Tool:
Touch **Main Menu**.

Workflow Tips for CR System Testing:
1. Acquire the Phantom test image and Flat Field test image on separate cassettes.
2. Perform the Phantom Image Test and then the Flat Field Image Test.
3. Use the erased cassette from the Flat Field Image Test to perform the Erase Image Test and the System Noise Test.

Acquiring Test Images:



Acquiring a Phantom Test Image

1. For the Phantom image, place a cassette in the phantom tray and place the Phantom Test Plate inside the tray.
   For the Flat Field image, do not place the phantom test plate in the tray.
2. Position the tray so the image can be acquired.
3. Prepare a lead apron.
4. Limit the exposure level for test images to 10.0 +/- 0.1 mR @ 80 kVp.
5. Wait 15 minutes between exposure and screen reading.

Performing CR System Tests:
DO NOT load the cassette before starting the test.

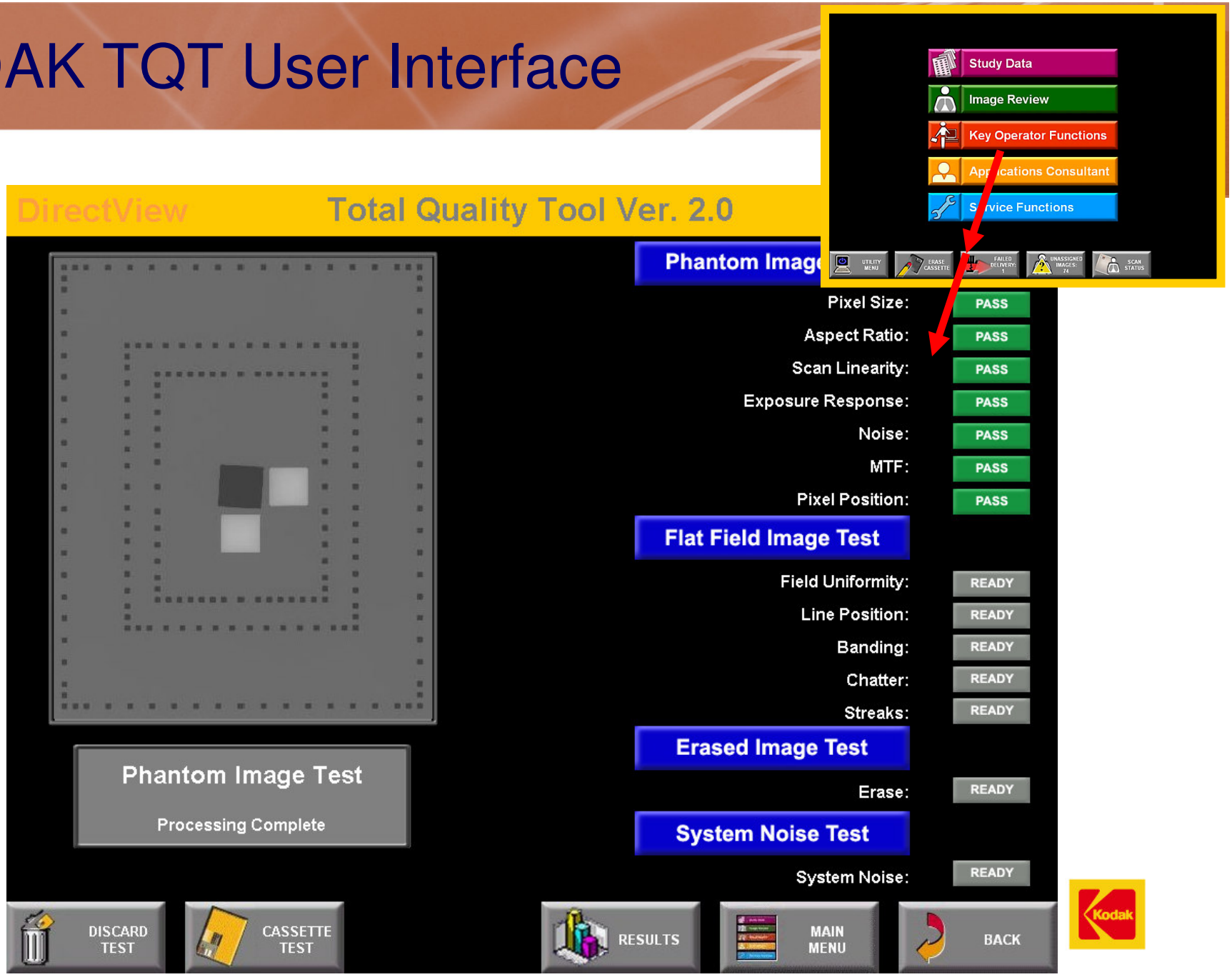
1. At Total Quality tool main page, touch the button for the test you wish to perform.
2. When you see the "Load cassette…" message, load the appropriate test cassette for the selected test. FAIL or N/A results will be displayed if an incorrect cassette is used.
3. When the message changes to "Processing Complete", check the results indicators. See "Troubleshooting" on the reverse side for information on failure (red FAIL), approaching specification limit (amber PASS), or N/A results.

Viewing the Results Graph for a Specific Subtest/Cassette:
1. From the Total Quality Tool main page, touch **Results**.
2. Go to the results page for the test you want to see (Results Page 1 for Phantom Image Test, Results Page 2 for all others).
3. Touch one of the cassette size buttons at the bottom of the page.
   NOTE: Always select a cassette size and type before selecting the subtest.
4. Touch the appropriate cassette size button to change the cassette type from GP to HR (or vice versa).
5. Touch (pic) to the right of the subtest name.

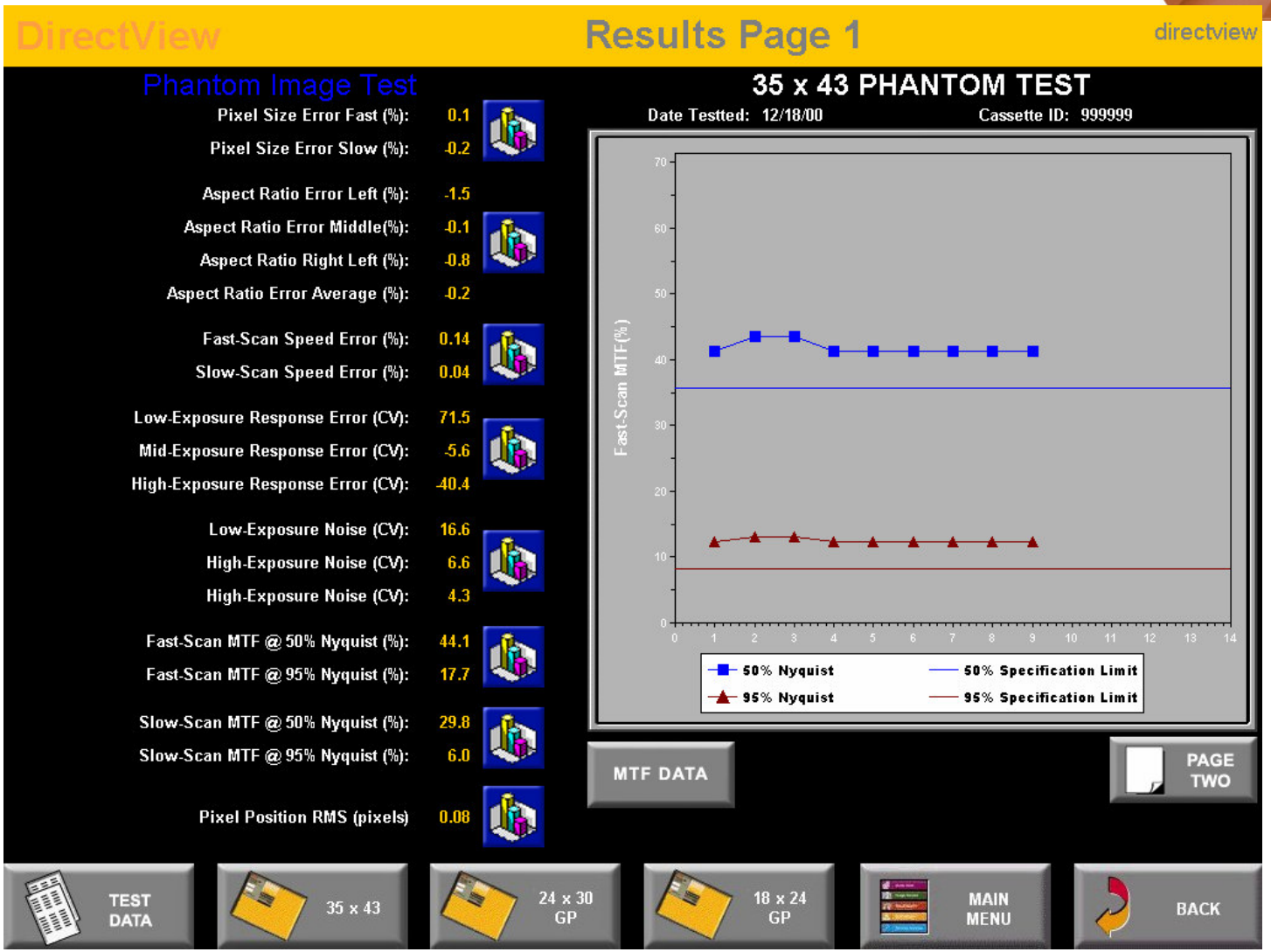
Accessing the Test Data Summary:
1. Touch **Results** on the Total Quality Tool's main page.
2. Touch **Test Data** to access a summary of the data for (up to) the last 13 tests performed.

Exporting the Test Summary Data:
1. Open the CR System door. Insert a 3½" high-density, blank formatted disk into the disk drive and close the door.
2. Touch **Export** to start processing.

KODAK TQT User Interface



Test Result Details



Detailed Tracking and Reporting

DirectView

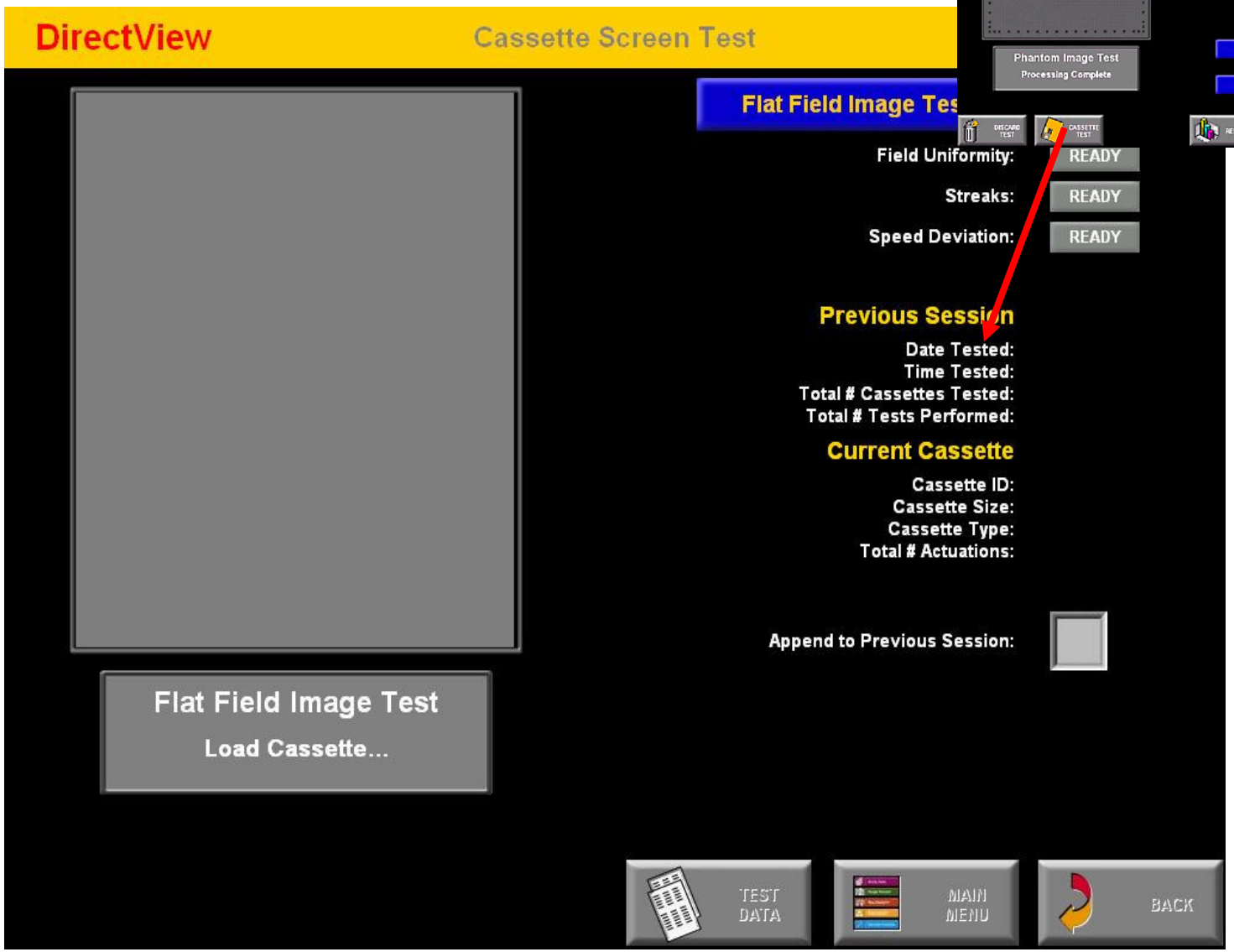
35 x 43 Test Results

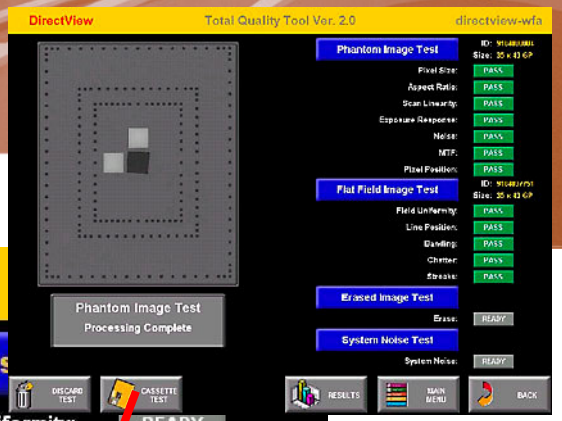
directview

Phantom Test		Flat Field Test		Erased Test		System Noise Test		
Date	2000/07/17	2000/07/17	2001/01/05	2001/01/05	2000/07/17	2000/07/17	2000/07/17	2000/07/17	2000/07/17
Cassette ID	9104000004	9104000004	9104037750	9104037750	9104000004	9104000004	9104000004	9104000004	9104000004
Pass/Fail	FAIL	FAIL	PASS	PASS	FAIL	FAIL	FAIL	FAIL	FAIL
Pixel Size Error Fast(%)	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
Pixel Size Error Slow(%)	0	0	0	0	0	0	0	0	0
Aspect Ratio Error Left(%)	1.2	1.2	1.8	1.8	1.2	1.2	1.2	1.2	1.2
Aspect Ratio Error Middle(%)	0.7	0.7	0.9	0.9	0.7	0.7	0.7	0.7	0.7
Aspect Ratio Error Right(%)	0.4	0.4	0.1	0.1	0.4	0.4	0.4	0.4	0.4
Aspect Ratio Error Average(%)	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Fast-Scan Speed Error(%)	0.12	0.12	0.33	0.33	0.12	0.12	0.12	0.12	0.12
Slow-Scan Speed Error(%)	0.05	0.05	0.02	0.02	0.05	0.05	0.05	0.05	0.05
Low-Exposure Response Error(CV)	-33.6	-33.6	20.7	20.7	-33.6	-33.6	-33.6	-33.6	-33.6
Mid-Exposure Response Error(CV)	-4.1	-4.1	5.2	5.2	-4.1	-4.1	-4.1	-4.1	-4.1
High-Exposure Response Error(CV)	189	189	46.9	46.9	189	189	189	189	189
Low-Exposure Noise(CV)	12	12	13.4	13.4	12	12	12	12	12
Mid-Exposure Noise(CV)	4.3	4.3	4.8	4.8	4.3	4.3	4.3	4.3	4.3
High-Exposure Noise(CV)	3.2	3.2	3.6	3.6	3.2	3.2	3.2	3.2	3.2
Fast-Scan MTF @50% Nyquist(%)	41.4	41.4	43.6	43.6	41.4	41.4	41.4	41.4	41.4
Fast-Scan MTF @95% Nyquist(%)	12.4	12.4	13.1	13.1	12.4	12.4	12.4	12.4	12.4
Slow-Scan MTF @50% Nyquist(%)	43.2	43.2	45.8	45.8	43.2	43.2	43.2	43.2	43.2
Slow-Scan MTF @95% Nyquist(%)	16.6	16.6	19.7	19.7	16.6	16.6	16.6	16.6	16.6
Pixel Position RMS(pixels)	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03

EXPORT | 35 x 43 | 24 x 30 GP | 18 x 24 GP | MAIN MENU | BACK

Cassette Quality Assurance





Kodak TQT Summary

Kodak DirectView CR Image Quality Tool is used in production, by service and by users.

- Precise and accurate quality control testing
- Highly reproducible quantitative results
- Detects sub-visible changes in CR image quality performance to initiate timely preventive maintenance
- Avoids hours of tedious and labor-intensive effort with a highly automated procedure
- Full data reporting in Excel format