CR PHANTOM (200 x 275 mm) Long-Term Stability Test Procedure for DÜRR NDT Computed Radiography Systems

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Revision History:

Rev. 02-7 / 2018-06-24

- Initial public release.

Rev. 02-8 / 2018-07-20

- Add note about waiting time between exposure and scanning.
  (I. Test set-up: 2. Procedure and scan mode)

Rev. 02-9 / 2018-12-12

- Update definitions for “Line profile width” and “Noise”.
  (Definitions)
- Add note about applicable standards for CR Phantom test specimen.
  (I. Test set-up: 1. Equipment)
- Setup diagram now explicitly shows that central beam is at 90° to CR Phantom and object.
  (I. Test set-up: 1. Equipment)
- 1000 mm SDD used in test setup is a minimum value.
  (I. Test set-up: 2. Procedure and scan mode)
- Change method to check for appropriate dose (Statistics tool is now used instead of the Line Profile tool).
  (I. Test set-up: 3. Image pixel value (dose))
- Line profile width now completely covers the duplex IQI (previously was 60% of IQI width).
  (II. Test procedure: 2. Basic Spatial Resolution)
- Correct image figure labels.
  (II. Test procedure: 5. Laser Jitter)
- Remove all usages of the terms “slow scan direction” and “fast scan direction” – instead only “transport scan direction” and “laser scan direction” are used to avoid ambiguity.

Rev. 02-10 / 2019-05-02

- Removal of EN 14784-1 from text and replacement of the test report figures to the current design

Foreword:

This documents describes an evaluation procedure of Computed Radiography (CR) systems for industrial radiology for the purpose of enabling process control and ensuring long-term stability of the CR system.

This document defines the fundamental parameters of a CR system to be measured and the associated method in order to determine baseline performance and to track the long-term stability of the system.

Notice:

The descriptions in this manual are only intended to facilitate the usage of the "CR Phantom" test specimen with the "D-Tect" image viewing software. In no case can these descriptions be considered as a substitute for any related or referenced technical standards. In the case that the descriptions in this document conflict with any such standard, the scope of the standard must be strictly adhered to.

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Copyright Notes:

List of Abbreviations:

DW	Duplex wire
IP	Imaging plate
PV	Pixel value
SDD	Source-to-Detector Distance
ROI	Region of interest
CBG	Contrast Brightness Gamma
BSR / SR_b	Basic Spatial Resolution
IQI	Image quality indicator

Definitions:

Laser direction: Pixel line read in the direction of laser movement.

Transport direction: Pixel line read in the direction of the imaging plate transport.

Line profile width: Number of adjacent pixel lines averaged when calculating the line profile in an image.

Pixel value: Digital signal value - in relation to the applied dose level comparable to the film density in conventional radiography. Numerical range depends on the sampling depth (or sampling resolution) of the scanner, e.g. 16-bit gives possible values of 0 to 65535.

Noise: Unwanted disturbances/variations in a signal (i.e. digital image).

Table of contents

I. Test set-up

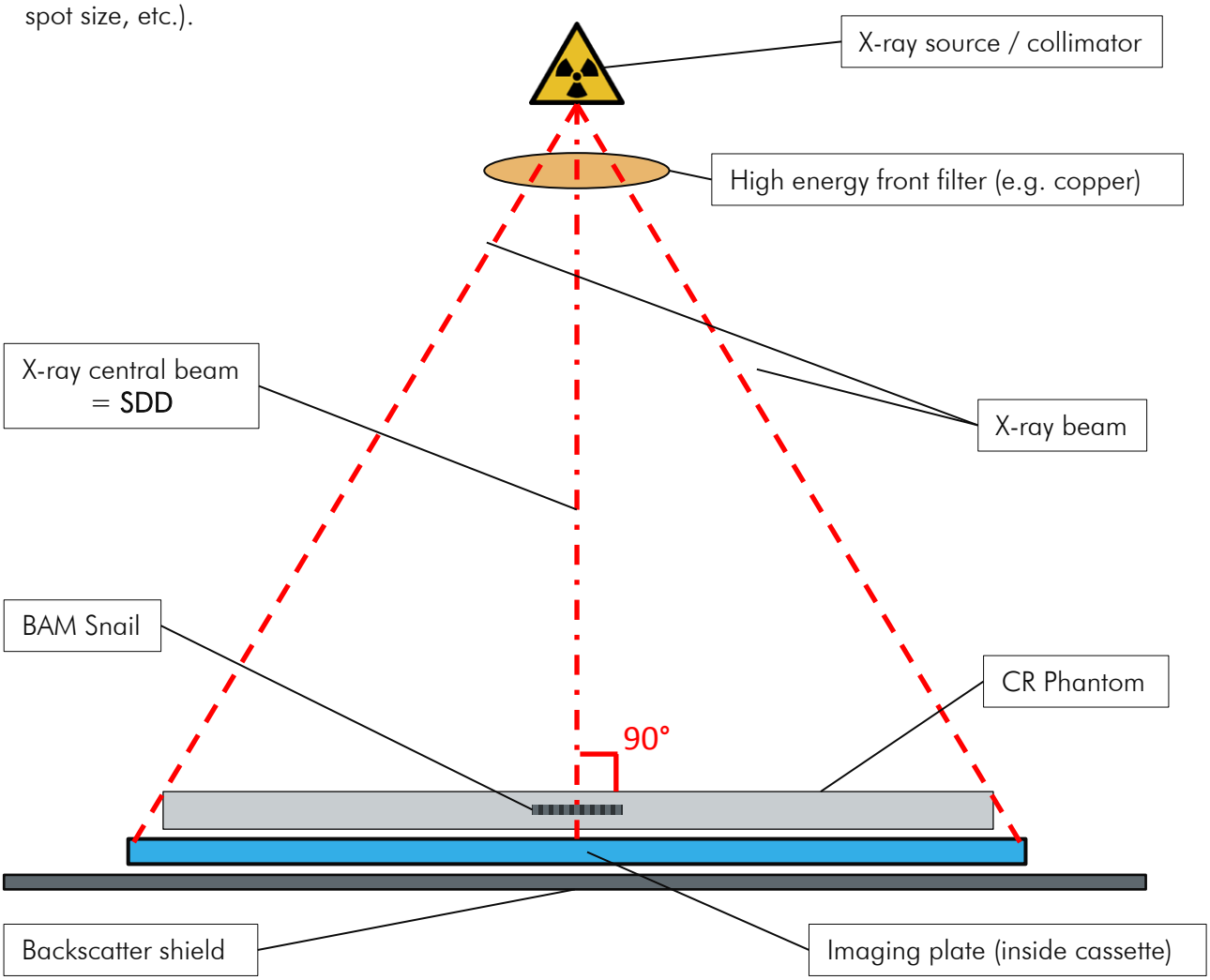
1. Equipment

Required Equipment:

- CR Phantom (CRPH100001) – with test artefacts according to ISO 16371-1 and ASTM E 2445
- Imaging plate:
  - 24 x 30 cm Blue (XL2430CM113) or
  - 24 x 30 cm Blue (HDIP2430108)
- CR 35 imaging plate protector: 24 x 30 cm (2132-021-50)
- Rigid cassette: 24 x 30 cm (KUNKA243007)
- 1.5 mm thick mild steel plate (to be used behind imaging plate to prevent backscatter)
- Tape measure to measure source-detector distance (SDD)
- Spirit level to check that imaging plate and CR Phantom are level
- Laser pointer or plumb line to ensure X-ray beam central alignment
- DÜRR HD-CR 35 NDT Plus scanner
- DÜRR D-Tect Viewer software

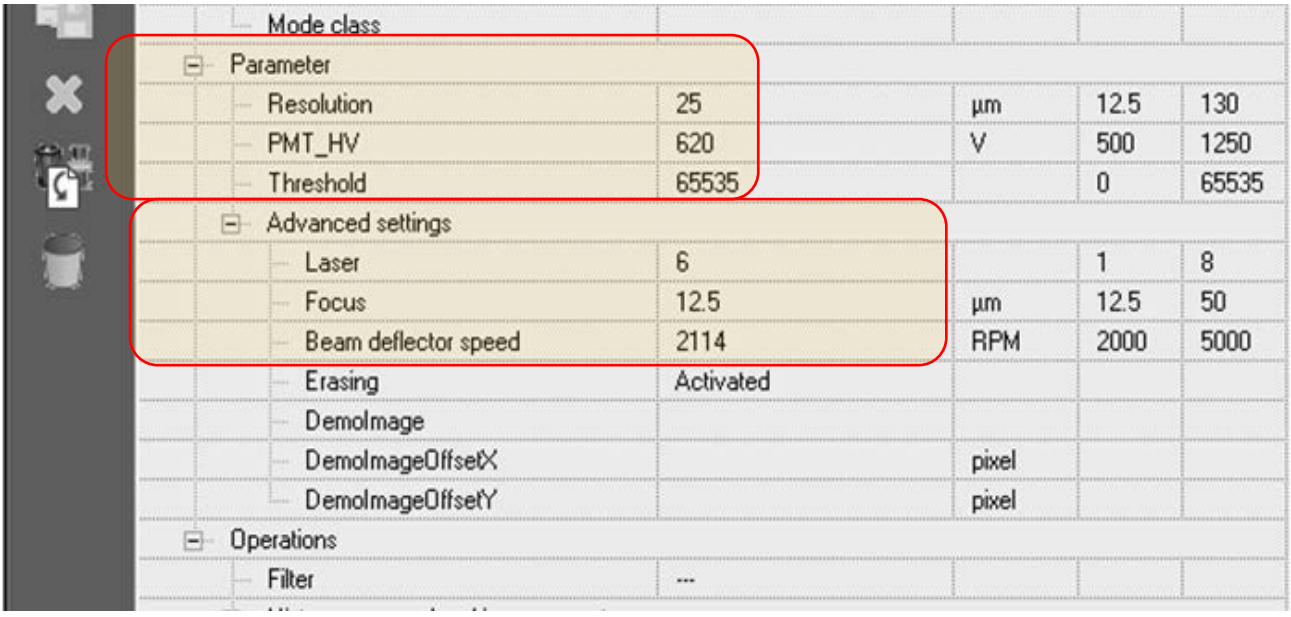
Procedure:

Note: The following procedure is a general procedure and may not be suitable for all customer applications. It is therefore important that the technician implementing this procedure takes the limitations of their X-ray equipment into account (such as those related to kV range, SDD range, focal spot size, etc.).



Procedure (continued):

1. Firstly, ensure that the X-ray equipment has warmed up and is ready for use.
2. Place rigid cassette (containing imaging plate) on top of a 1.5 mm steel plate to prevent backscattering.
3. Adjust (and check with a measuring tape) the x-ray tube and/or table to obtain a minimum SDD of 1000 mm.
4. Place the CR Phantom on the top of the rigid cassette (centered and parallel on the cassette edges)
5. Using a spirit level, check that the CR Phantom is level in both dimensions. Adjust if required.
6. Using a laser spot device or plumb line, ensure the BAM Snail is central to the X-ray central beam.
7. Re-check 3 to 5 and adjust if required.
8. It is recommended to scan the imaging plate using a scan mode with a 25 µm scan resolution (this prevents excessively large image files which may cause software processing issues).



Mode class				
Parameter				
Resolution	25	µm	12.5	130
PMT_HV	620	V	500	1250
Threshold	65535		0	65535
Advanced settings				
Laser	6		1	8
Focus	12.5	µm	12.5	50
Beam deflector speed	2114	RPM	2000	5000
Erasing	Activated			
DemoImage				
DemoImageOffsetX		pixel		
DemoImageOffsetY		pixel		
Operations				
Filter	---			

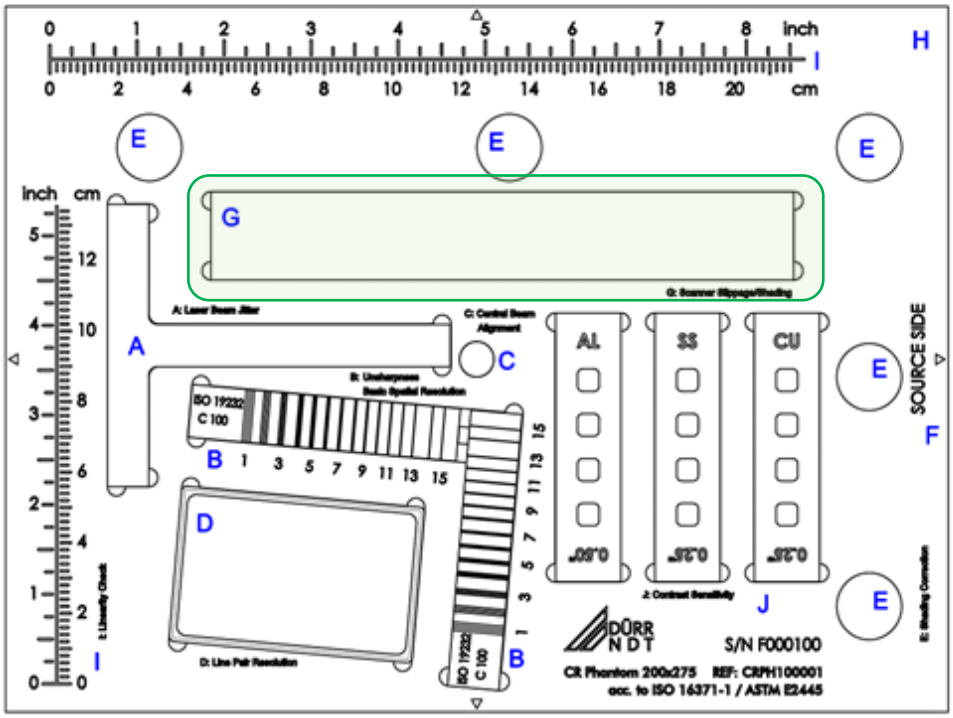
The scan mode settings can accessed via the CRNetConfig / CRScanConfig tool by pressing F2 and clicking the "Scan modes" tab.

The same scan mode must always be used for the long-term stability test as the scan mode parameters have a direct impact on the test results!

Enter the scan mode settings under the section scanner parameters in the CR Phantom report

Note: It is recommended to wait at least *10 minutes* after exposing the IP before scanning it - this is to reduce any variations due to fading effects.

PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**
Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	



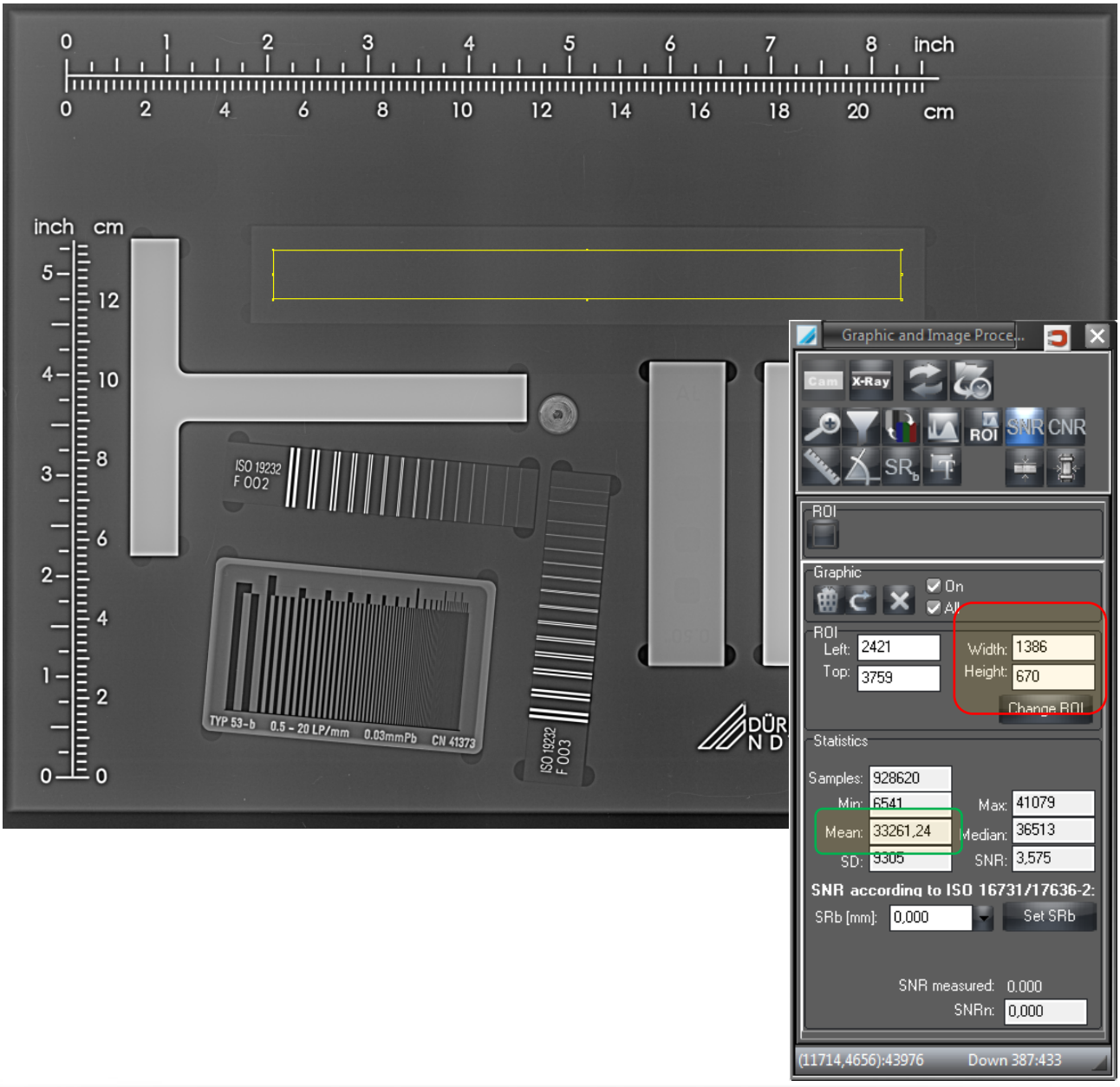
Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
C	BAM-Schnecke	Zentralstrahlausrichtung	BAM Snail	Central Beam Alignment
D	Linienpaar-BPK	Linienpaarauflösung	Line Pair IQI	Line Pair Resolution
E	EL, EC, ER Messstellen	Bildinhomogenität	EL, EC, ER Measuring Points	Shading Correction
F	Markierung Kassettenposition	Kassettenpositionierung	Cassette Positioning Locator	Positioning of Cassette
G	homogener Al-Streifen	Abtastschlupf, Bildinhomogenität	homogeneous AL Strip	Scanner Slippage, Shading
H	PMMA-Platte	Trägerplatte	Lucite Plate	Carrier Plate
I	cm/inch Lineal	Geometrische Verzerrung	cm/inch Ruler	Linearity Check
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity

Image Interpretation:

The image should have measured pixel values between 30,000 and 35,000 on the homogeneous aluminum strip (Ref G) when the Statistics / SNR tool is used to measure the Mean pixel value (as shown below).

Perform the test exposure with a 90 kV X-ray tube voltage and adjust the X-ray tube current and time to achieve the aforementioned recommended pixel values. Default values for the X-ray tube current (mA) and exposure time cannot be recommended because this is dependent on the particular X-ray system being used.

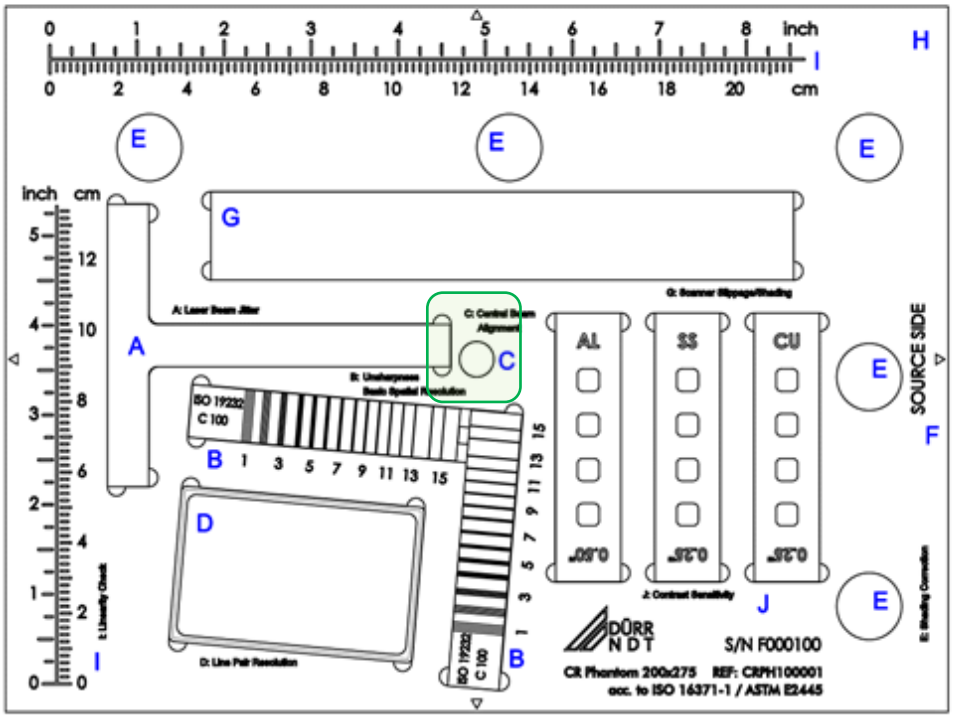
Below is a typical result image from a low X-ray energy (90 kV) exposure with the aforementioned scanner settings:



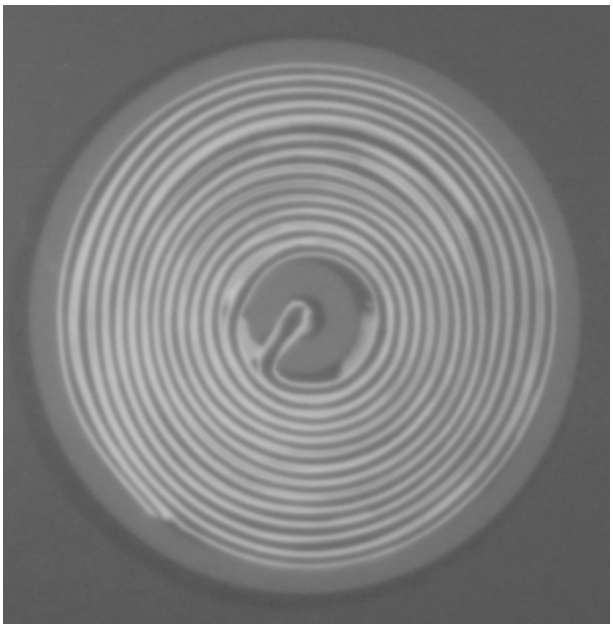
II. Test procedure

1. Central beam alignment

PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**
Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	



Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
C	BAM-Schnecke	Zentralstrahlausrichtung	BAM Snail	Central Beam Alignment
D	Linienpaar-BPK	Linienpaarauflösung	Line Pair IQI	Line Pair Resolution
E	EL, EC, ER Messstellen	Bildinhomogenität	EL, EC, ER Measuring Points	Shading Correction
F	Markierung Kassettenposition	Kassettenpositionierung	Cassette Positioning Locator	Positioning of Cassette
G	homogener Al-Streifen	Abtastschlupf, Bildinhomogenität	homogeneous AL Strip	Scanner Slippage, Shading
H	PMMA-Platte	Trägerplatte	Lucite Plate	Carrier Plate
I	cm/inch Lineal	Geometrische Verzerrung	cm/inch Ruler	Linearity Check
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity



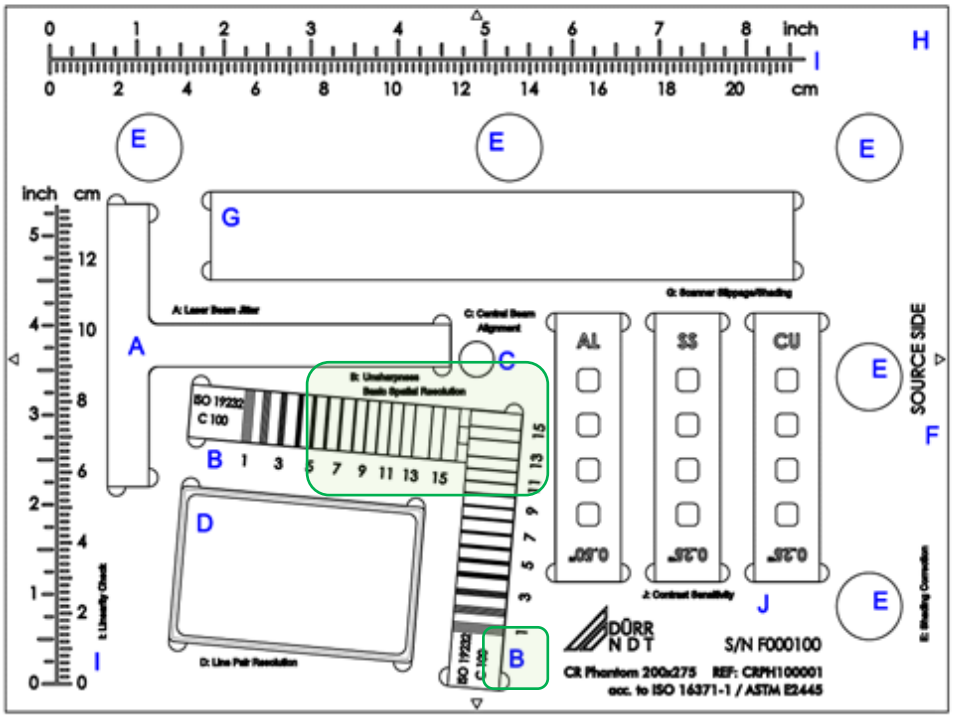
The image on the left is a cropped section of a scan of the BAM Snail (Ref. C) and is an example of a satisfactory result.

The test is satisfactory if the dark and light spiral bands can be differentiated without any merging. This indicates that the IP and CR Phantom are level, and the X-ray beam has been centered in the middle of the BAM Snail (Ref. C).

The image on the left shows an unacceptable BAM Snail (Ref. C) test result.

A “Butterfly” or “Bow-Tie” image result indicates that both the CR Phantom and IP are not level or that the X-ray beam has not been centered to the middle of the BAM Snail.

PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**
Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	



Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
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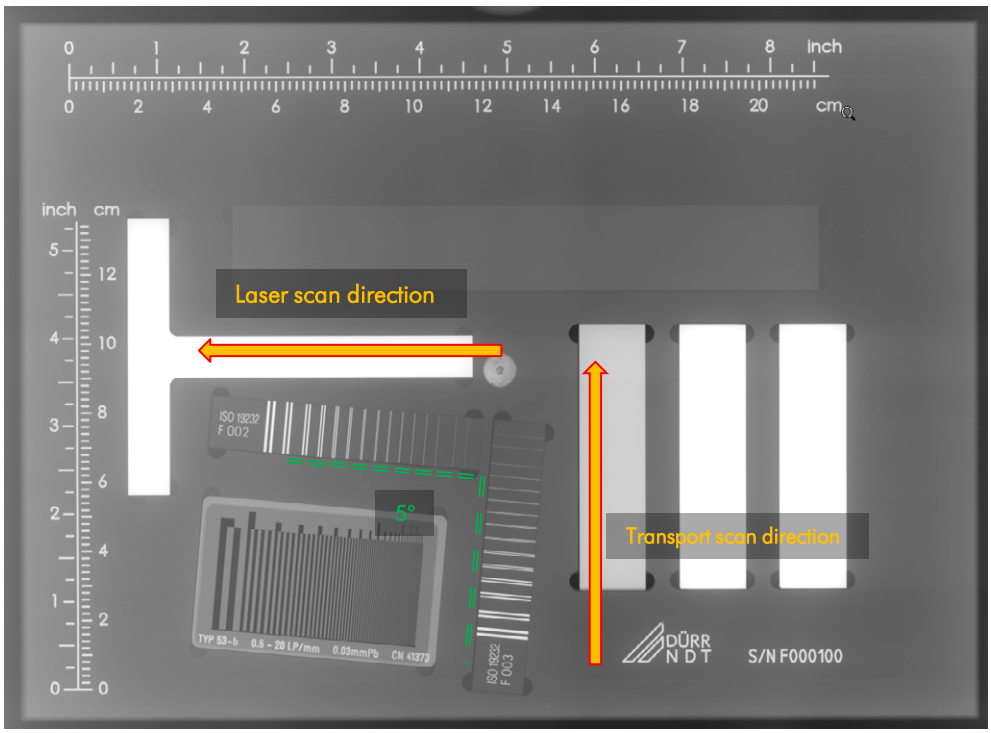
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity

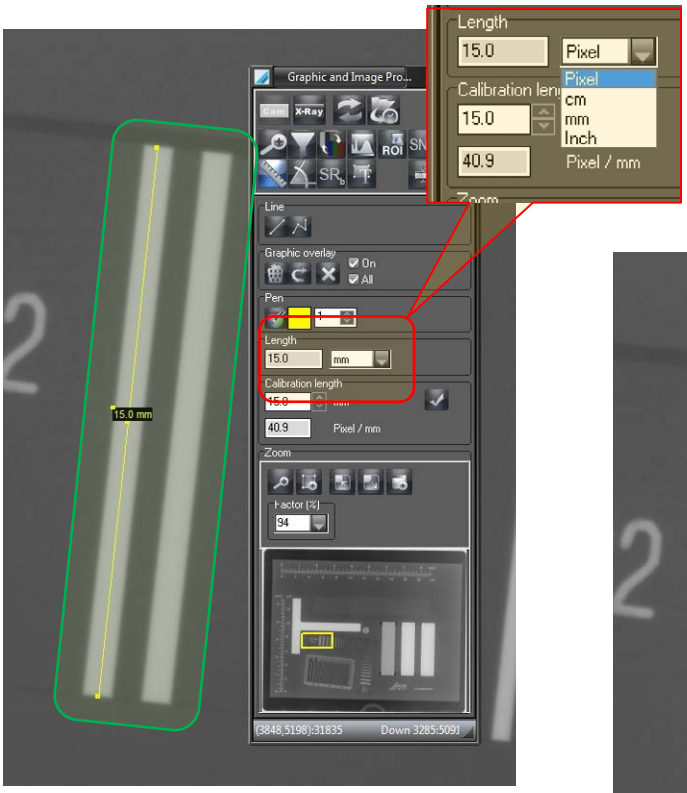
Duplex Wire Method:

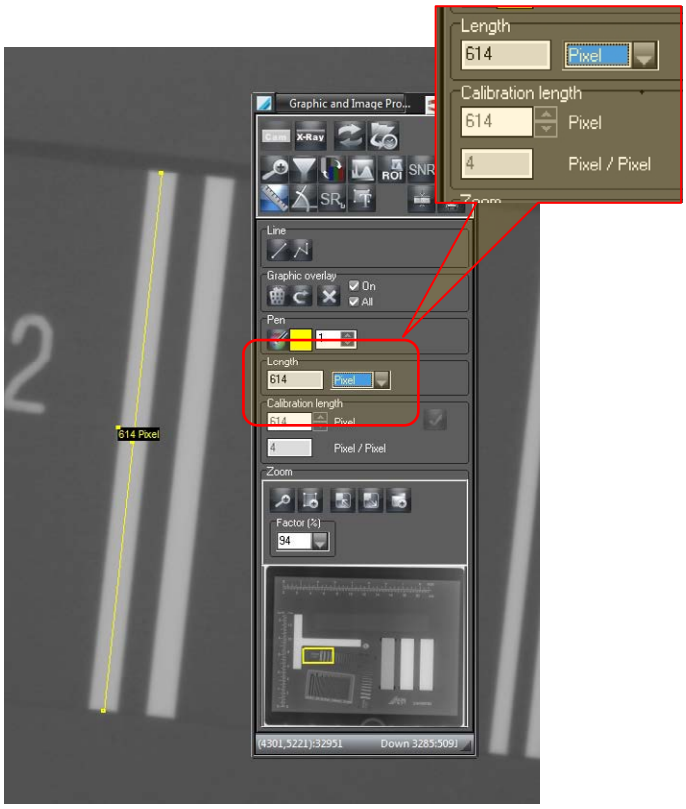
The basic spatial resolution is determined using two duplex wire image quality indicators (IQIs) according to ISO 19232-5. The duplex wire IQIs shall be positioned at an angle of approximately 5° to the laser scan direction and 5° to the imaging plate transport direction. The SR_b should be determined using multiple single line profiles that give a total width of 60% of the Duplex Wire IQI width.

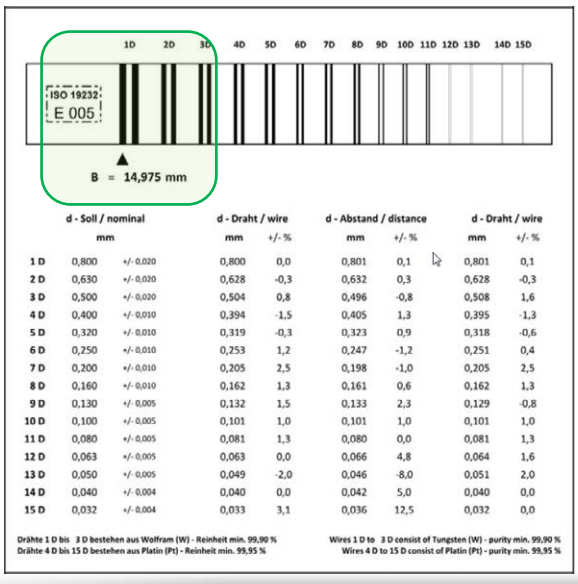


Note: The CR Phantom must be centered on the rigid cassette and parallel to the cassette edges.

Zoom into the Duplex Wire IQI (Ref. B) and use the length measurement tool to measure the approximate width. The nominal (real) width of the IQI is 14.975 mm according to the DW measurement protocol sheet. The measured width in the example below is 15 mm which corresponds to 614 pixels (use the dropdown menu to change to pixel units).







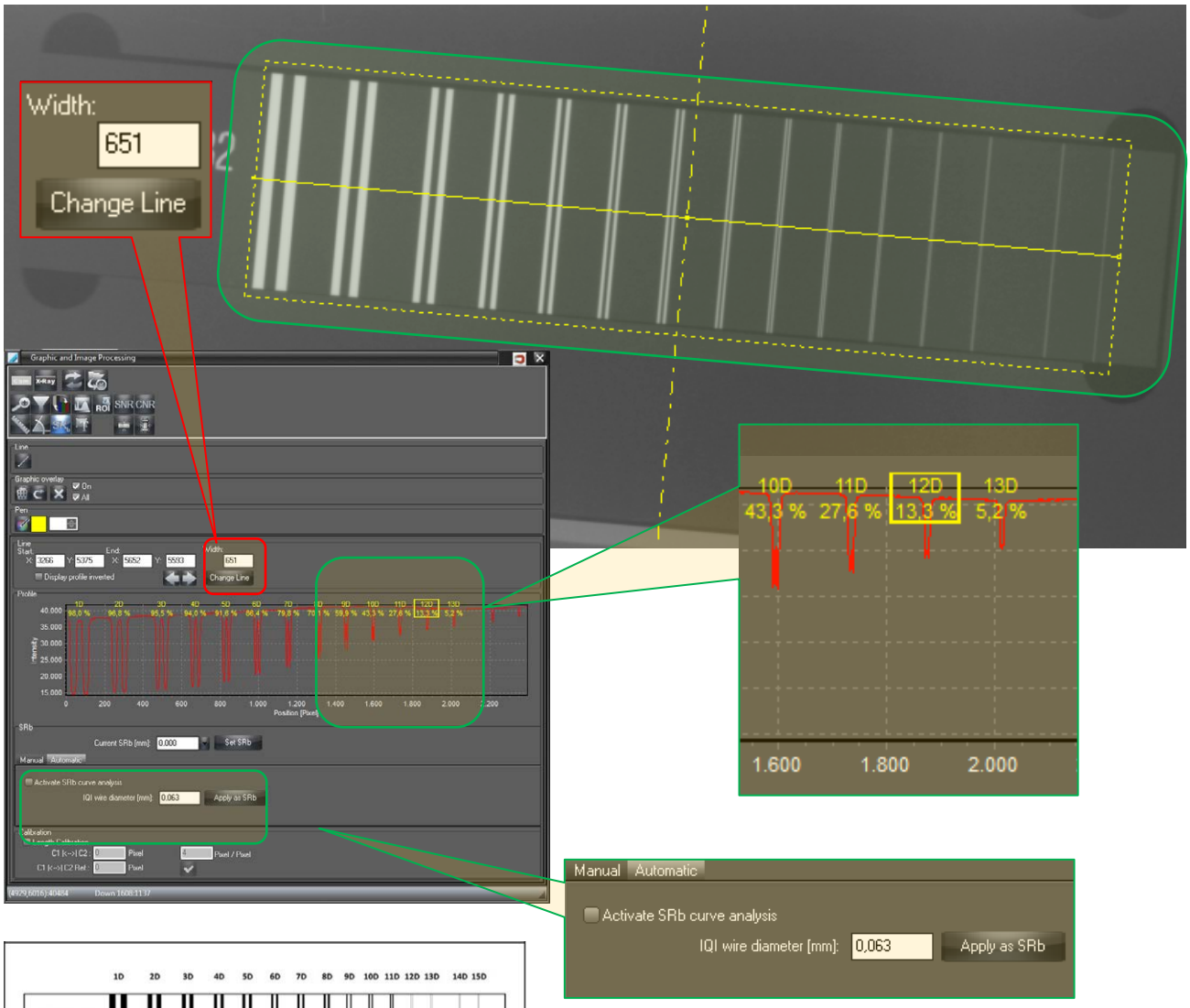
60% line profile width:

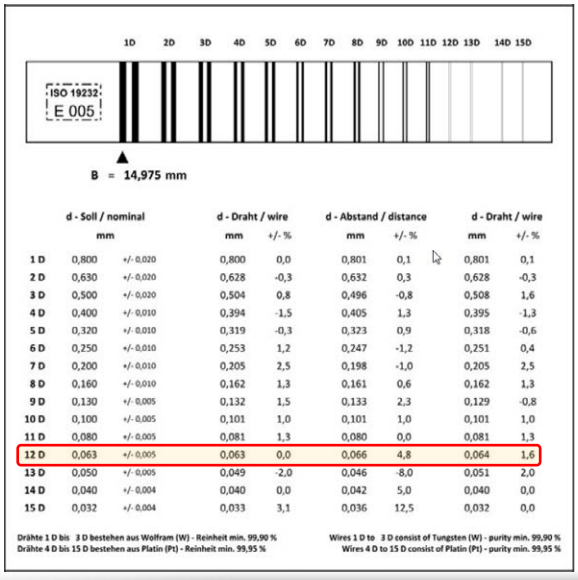
614/100*60 = 368.4

Line Profile Width: 369 pixels

Zoom into the Duplex Wire IQI (Ref. B) and use the line profile measurement tool (SR_b) to measure the basic spatial resolution. Measurement of the SR_b must be performed in both the laser and transport scan directions using multiple single line profiles to completely cover the Duplex Wire IQI width (e.g. 651 lines is required in the below example).

Laser scan direction:





	d - Soll / nominal mm		d - Draht / wire mm	+/- %	d - Abstand / distance mm	+/- %	d - Draht / wire mm	+/- %
1 D	0,800	+/- 0,020	0,800	0,0	0,801	0,1	0,801	0,1
2 D	0,630	+/- 0,020	0,628	-0,3	0,632	0,3	0,628	-0,3
3 D	0,500	+/- 0,020	0,504	0,8	0,496	-0,8	0,508	1,6
4 D	0,400	+/- 0,010	0,394	-1,5	0,405	1,3	0,395	-1,3
5 D	0,320	+/- 0,010	0,319	-0,3	0,323	0,9	0,318	-0,6
6 D	0,250	+/- 0,010	0,253	1,2	0,247	-1,2	0,251	0,4
7 D	0,200	+/- 0,010	0,205	2,5	0,198	-1,0	0,205	2,5
8 D	0,160	+/- 0,010	0,162	1,3	0,161	0,6	0,162	1,3
9 D	0,130	+/- 0,005	0,132	1,5	0,133	2,3	0,129	-0,8
10 D	0,100	+/- 0,005	0,101	1,0	0,101	1,0	0,101	1,0
11 D	0,080	+/- 0,005	0,081	1,3	0,080	0,0	0,081	1,3
12 D	0,063	+/- 0,005	0,063	0,0	0,066	4,8	0,064	1,6
13 D	0,050	+/- 0,005	0,049	-2,0	0,046	-8,0	0,051	2,0
14 D	0,040	+/- 0,004	0,040	0,0	0,042	5,0	0,040	0,0
15 D	0,032	+/- 0,004	0,033	3,1	0,036	12,5	0,032	0,0

Drähte 1 D bis 3 D bestehen aus Wolfram (W) - Reinheit min. 99,90 %
Drähte 4 D bis 15 D bestehen aus Platin (Pt) - Reinheit min. 99,95 %

Wires 1 D to 3 D consist of Tungsten (W) - purity min. 99,90 %
Wires 4 D to 15 D consist of Platin (Pt) - purity min. 99,95 %

SR_b (laser scan direction):

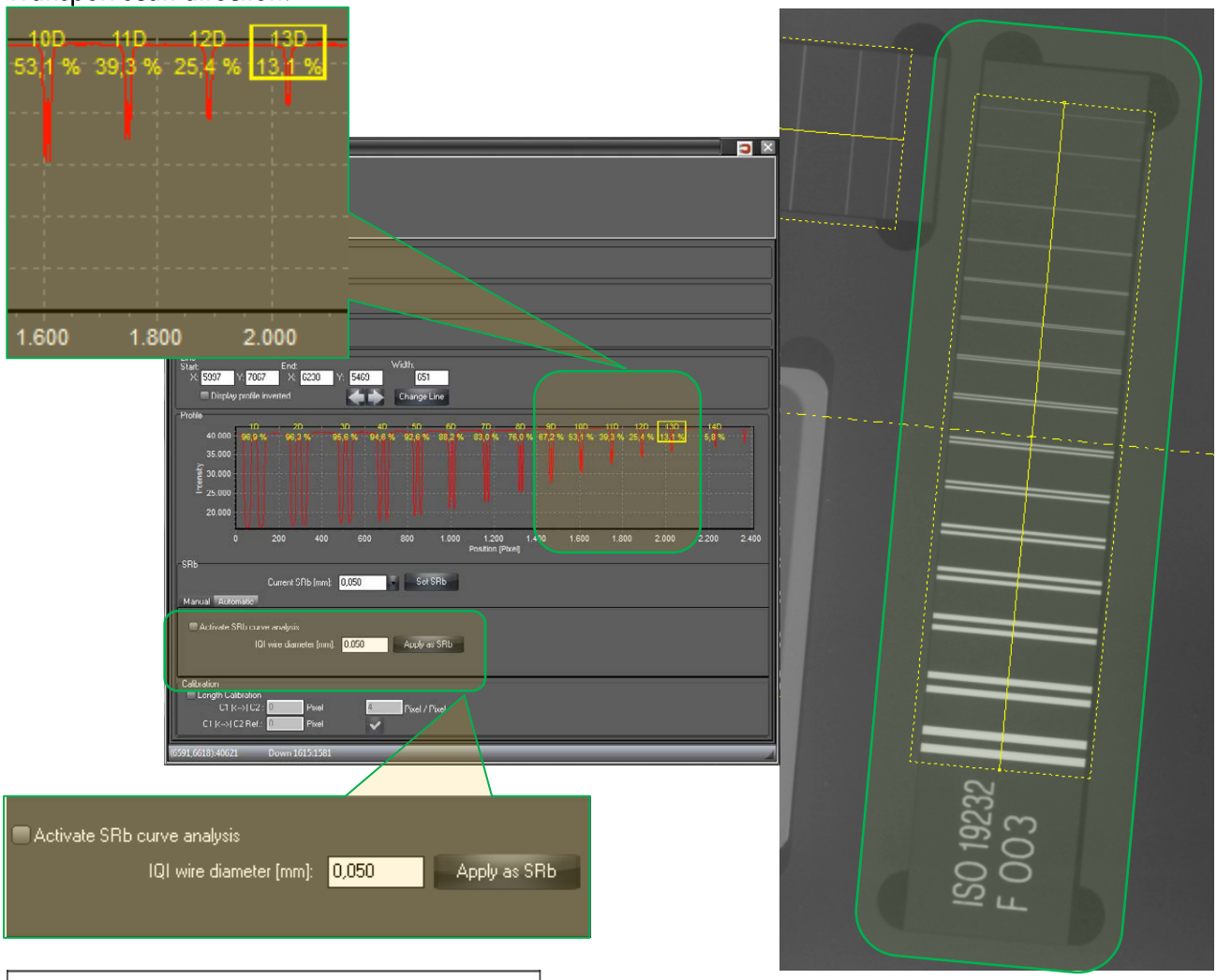
DW11 ≥ 20%

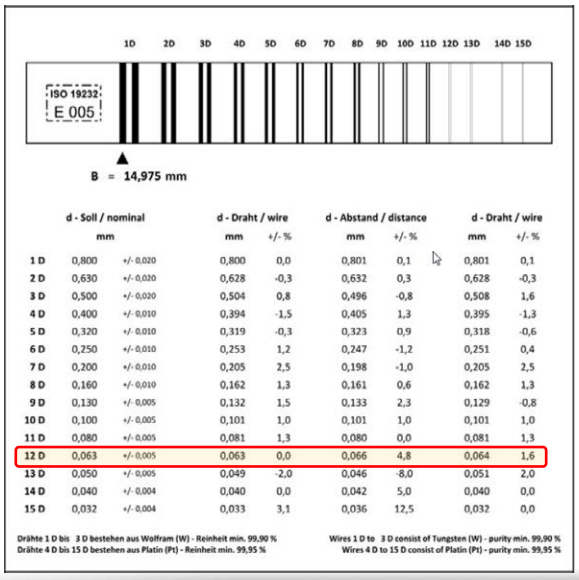
DW12 = 63 µm , 13.4 % (rounded 60µm)

II. Test procedure
2. Basic Spatial Resolution

Zoom into the Duplex Wire IQI (Ref. B) and use the line profile measurement tool (SR_b) to measure the basic spatial resolution. Measurement of the SR_b must be performed in both the laser and transport scan directions using multiple single line profiles to completely cover the Duplex Wire IQI width (e.g. 651 lines is required in the below example).

Transport scan direction:





	d - Soll / nominal mm		d - Draht / wire mm	+/- %	d - Abstand / distance mm	+/- %	d - Draht / wire mm	+/- %
1 D	0,800	+/- 0,020	0,800	0,0	0,801	0,1	0,801	0,1
2 D	0,630	+/- 0,020	0,628	-0,3	0,632	0,3	0,628	-0,3
3 D	0,500	+/- 0,020	0,504	0,8	0,496	-0,8	0,508	1,6
4 D	0,400	+/- 0,010	0,394	-1,5	0,405	1,3	0,395	-1,3
5 D	0,320	+/- 0,010	0,319	-0,3	0,323	0,9	0,318	-0,6
6 D	0,250	+/- 0,010	0,253	1,2	0,247	-1,2	0,251	0,4
7 D	0,200	+/- 0,010	0,205	2,5	0,198	-1,0	0,205	2,5
8 D	0,160	+/- 0,010	0,162	1,3	0,161	0,6	0,162	1,3
9 D	0,130	+/- 0,005	0,132	1,5	0,133	2,3	0,129	-0,8
10 D	0,100	+/- 0,005	0,101	1,0	0,101	1,0	0,101	1,0
11 D	0,080	+/- 0,005	0,081	1,3	0,080	0,0	0,081	1,3
12 D	0,063	+/- 0,005	0,063	0,0	0,066	4,8	0,064	1,6
13 D	0,050	+/- 0,005	0,049	-2,0	0,046	-8,0	0,051	2,0
14 D	0,040	+/- 0,004	0,040	0,0	0,042	5,0	0,040	0,0
15 D	0,032	+/- 0,004	0,033	3,1	0,036	12,5	0,032	0,0

Drähte 1 D bis 3 D bestehen aus Wolfram (W) - Reinheit min. 99,90 %
Drähte 4 D bis 15 D bestehen aus Platin (Pt) - Reinheit min. 99,95 %

Wires 1 D to 3 D consist of Tungsten (W) - purity min. 99,90 %
Wires 4 D to 15 D consist of Platin (Pt) - purity min. 99,95 %

SR_b (transport direction):

DW12 ≥ 20 %

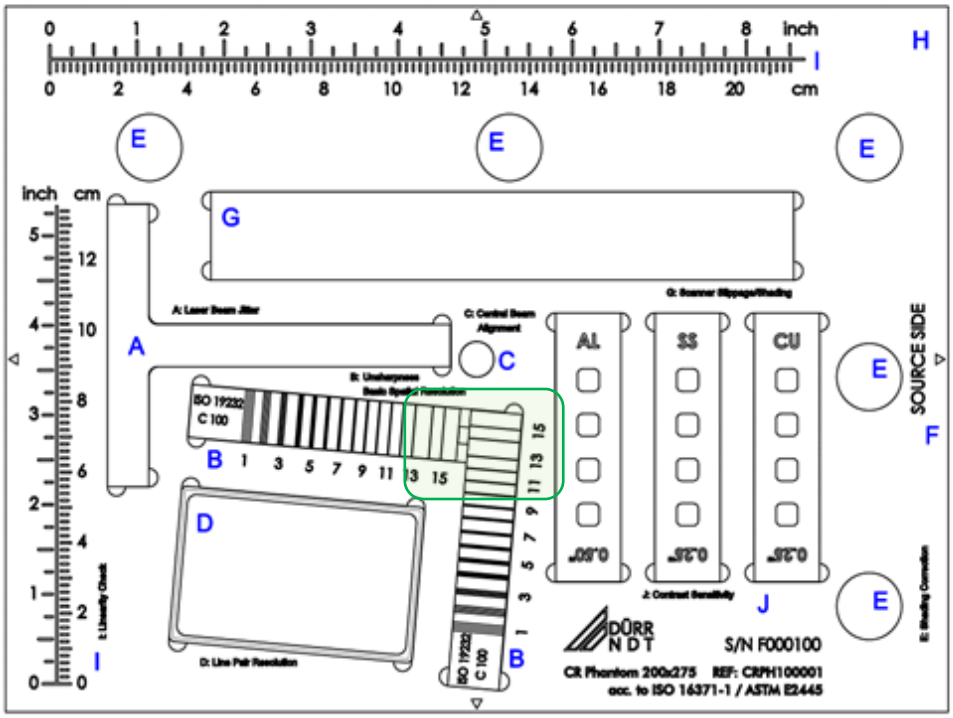
DW13 = **50 µm , 13.1 %**

<u>Enter the result in the CR Phantom report :</u>

(SR_b in µm , %)

SR_b (laser direction) = 63 µm , 13.4 %
SR_b (transport direction) = 50 µm , 13.1 %

PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**
Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	



Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
C	BAM-Schnecke	Zentralstrahlausrichtung	BAM Snail	Central Beam Alignment
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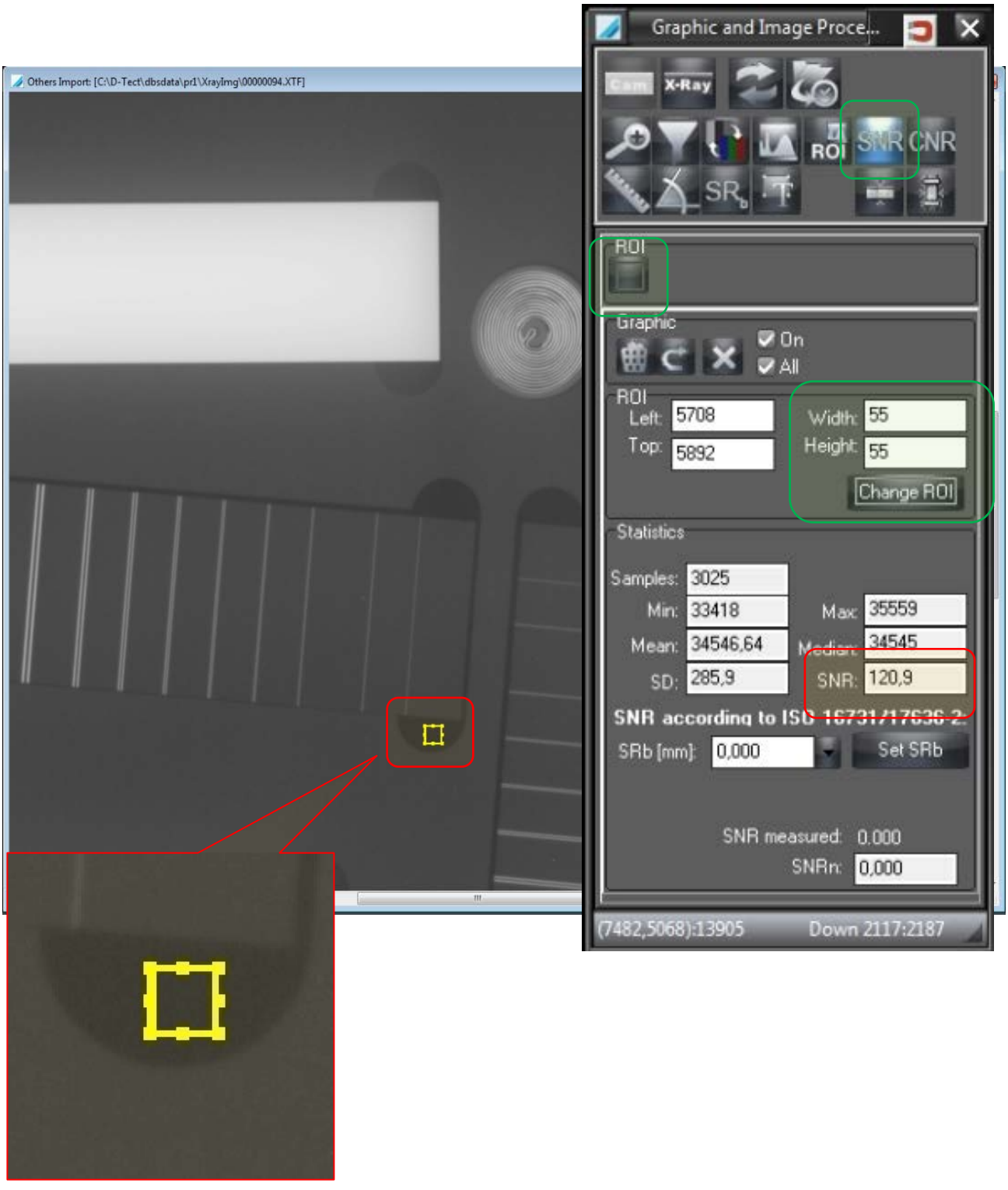
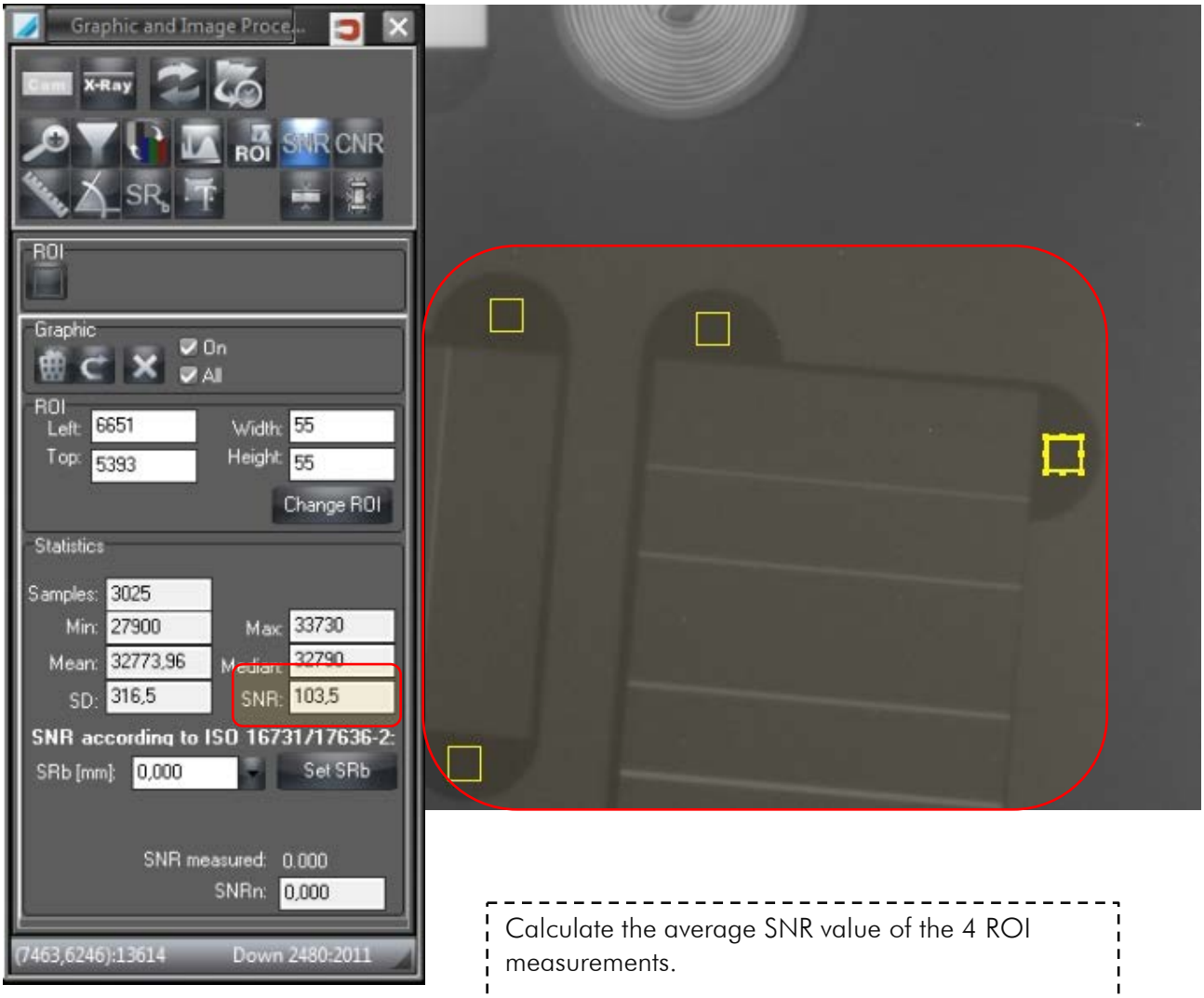
G	homogener Al-Streifen	Abtastschlupf, Bildinhomogenität	homogeneous AL Strip	Scanner Slippage, Shading
H	PMMA-Platte	Trägerplatte	Lucite Plate	Carrier Plate
I	cm/inch Lineal	Geometrische Verzerrung	cm/inch Ruler	Linearity Check
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity

Zoom into the area near the BAM snail and open the statistics function (SNR) in the toolbox. As shown below, place a ROI rectangle at the mounting hole of the duplex wire IQI.

Change the ROI size so the rectangle fits into the homogenous area (e.g. 55x55 pixels).



Measure the SNR in the 4 mounting holes and calculate the average of these 4 measurements.



Calculate the average SNR value of the 4 ROI measurements.

Example: (SNR1+SNR2+SNR3+SNR4) / 4

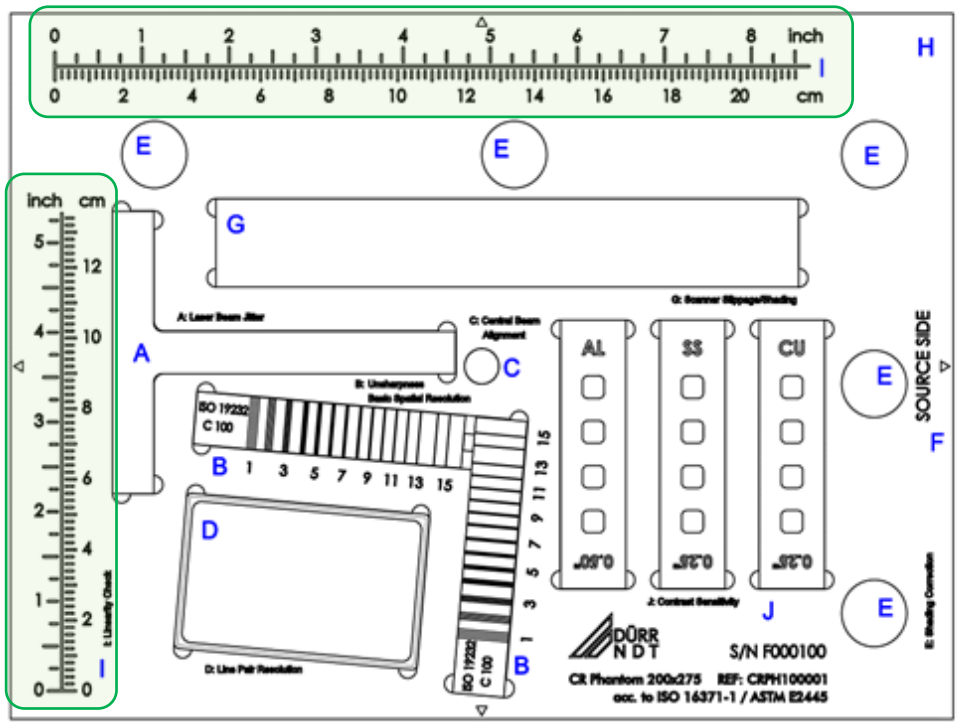
(120.9+117.6+117.2+103.5) / 4

= 115

Enter the result in the CR Phantom report:

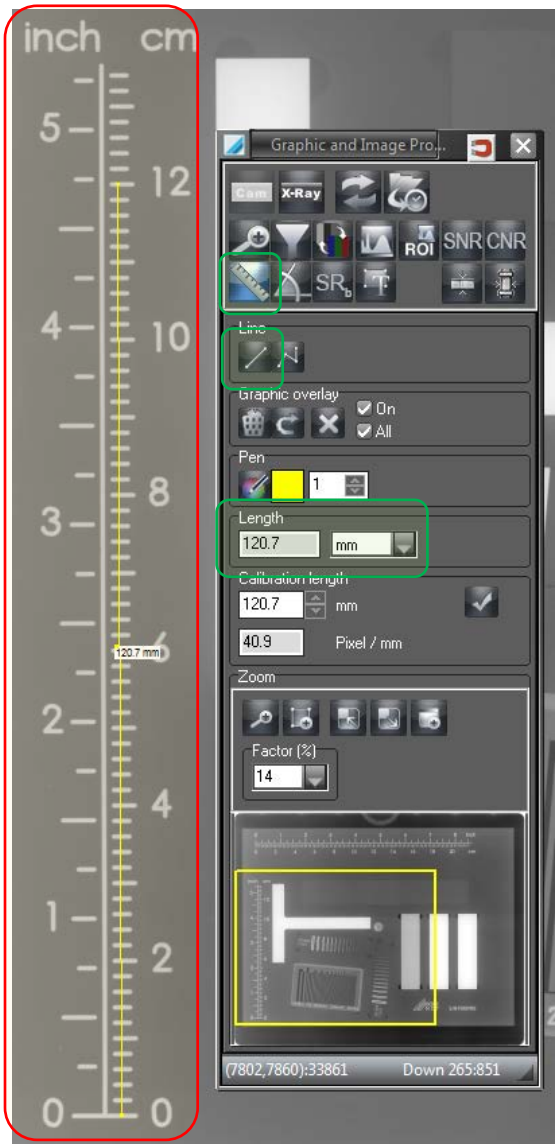
Signal-to-noise ratio = 115

PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**
Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	



Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
C	BAM-Schnecke	Zentralstrahlausrichtung	BAM Snail	Central Beam Alignment
D	Linienpaar-BPK	Linienpaarauflösung	Line Pair IQI	Line Pair Resolution
E	EL, EC, ER Messstellen	Bildinhomogenität	EL, EC, ER Measuring Points	Shading Correction
F	Markierung Kassettenposition	Kassettenpositionierung	Cassette Positioning Locator	Positioning of Cassette
G	homogener Al-Streifen	Abtastschlupf, Bildinhomogenität	homogeneous AL Strip	Scanner Slippage, Shading
H	PMMA-Platte	Trägerplatte	Lucite Plate	Carrier Plate
I	cm/inch Lineal	Geometrische Verzerrung	cm/inch Ruler	Linearity Check
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity

Using the measurement tool (ruler) in D-Tect, both the horizontal (transport direction, 24 cm IP length) and vertical (laser direction, 30 cm IP length) rulers are measured.



Measure with the measurement tool (ruler) in D-Tect, the cm/inch Ruler (Ref. I) in both the laser scan direction (120 mm) and in the transport scan direction (200 mm).

Example:

((Measured * 100) / Actual) - 100 = X.XX %

In the laser scan direction, 200.5 mm is measured:

((200.5 mm * 100) / 200mm) – 100% = 0.25 %

In the transport scan direction, 120.7 mm is measured:

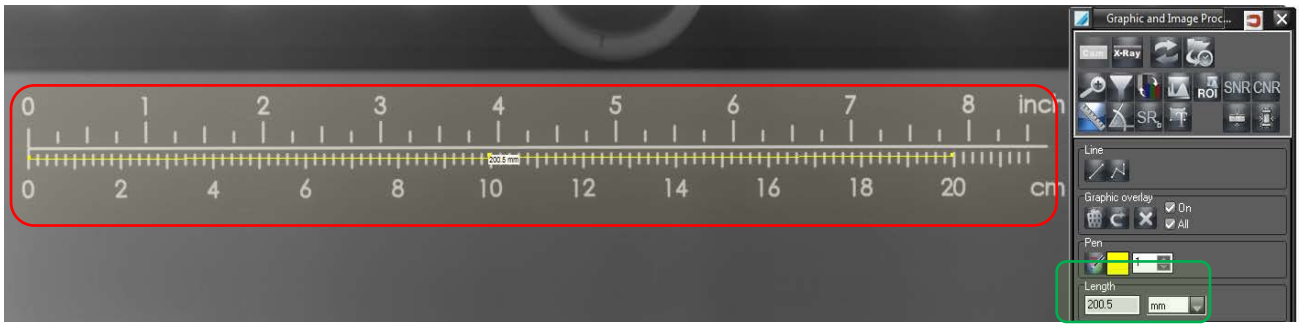
((120.7 mm * 100) / 120mm) – 100% = 0.58 %

Enter the result in the CR Phantom report :

(Geometric distortions in %)

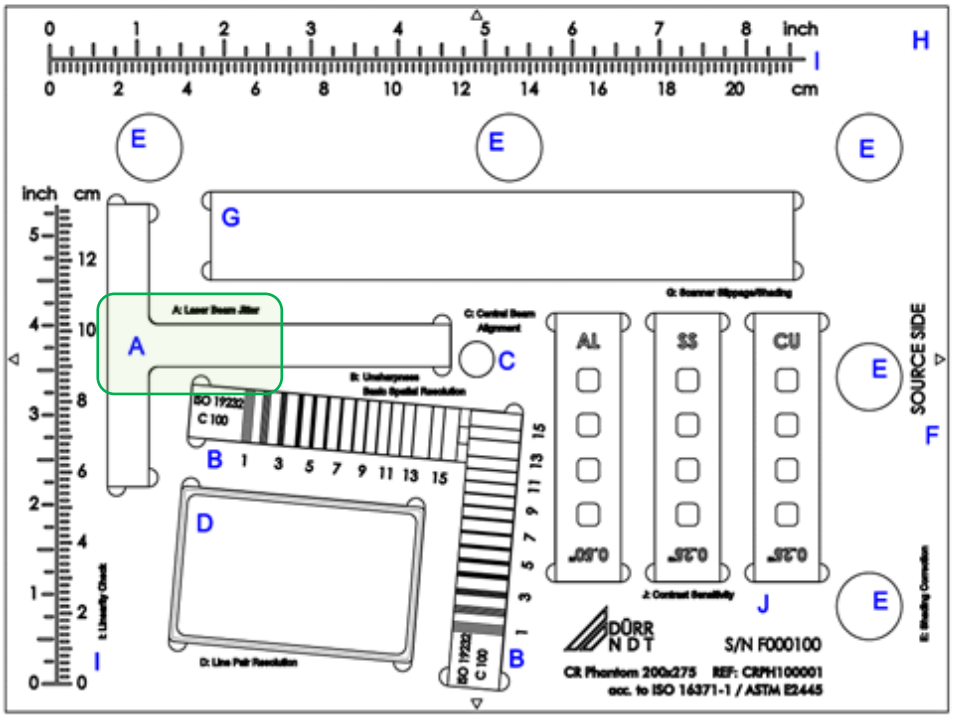
The measured spatial non-linearity shall be **less than 2 %** for both plate directions.

Geometric distortion (laser direction) = 0.25 %
Geometric distortion (transport direction) = 0.58 %



PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**

Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	



Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
C	BAM-Schnecke	Zentralstrahlausrichtung	BAM Snail	Central Beam Alignment
D	Linienpaar-BPK	Linienpaarauflösung	Line Pair IQI	Line Pair Resolution
E	EL, EC, ER Messstellen	Bildinhomogenität	EL, EC, ER Measuring Points	Shading Correction
F	Markierung Kassettenposition	Kassettenpositionierung	Cassette Positioning Locator	Positioning of Cassette
G	homogener Al-Streifen	Abtastschlupf, Bildinhomogenität	homogeneous AL Strip	Scanner Slippage, Shading
H	PMMA-Platte	Trägerplatte	Lucite Plate	Carrier Plate
I	cm/inch Lineal	Geometrische Verzerrung	cm/inch Ruler	Linearity Check
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity

The brass T-target (Ref. A) can be used to assess whether there is laser beam jitter in the laser direction (this serves as a laser/electronics check). The procedure is as follows:

1. Firstly, zoom with a magnification factor of 200% on the edge of the T-target (**Fig. 1 on next page**).
2. Change the histogram windowing for higher image contrast (**Fig. 2 on next page**).
3. Zoom up to highest zoom factor if necessary (**Fig. 3 on next page**).

The following example shows the edge of the T-target gauge (Ref. A) without any laser jitter effect (Fig. 1). No shifted pixel lines are visible (Fig. 2) and only slight PV differences are visible with histogram windowing adjustment (Fig. 3).

To obtain the image view in Fig. 2, histogram windowing must be used to maximize the displayed contrast (see red arrow).

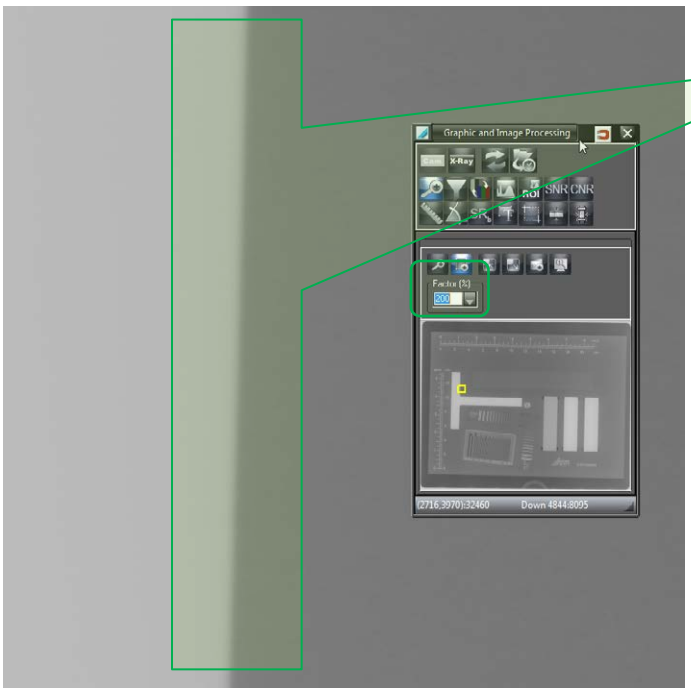
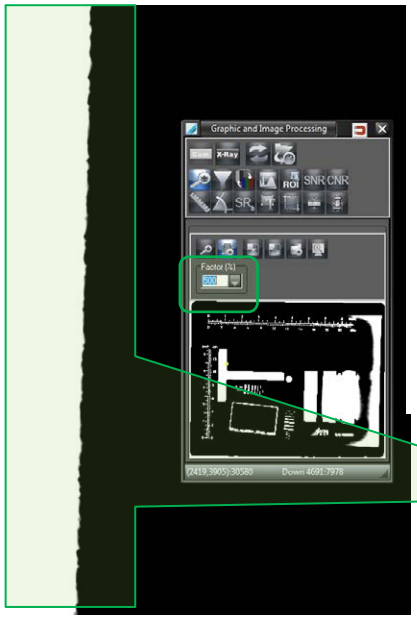


Fig. 1: Original image (at 200% zoom)

Fig. 2: Image (at 200% zoom)



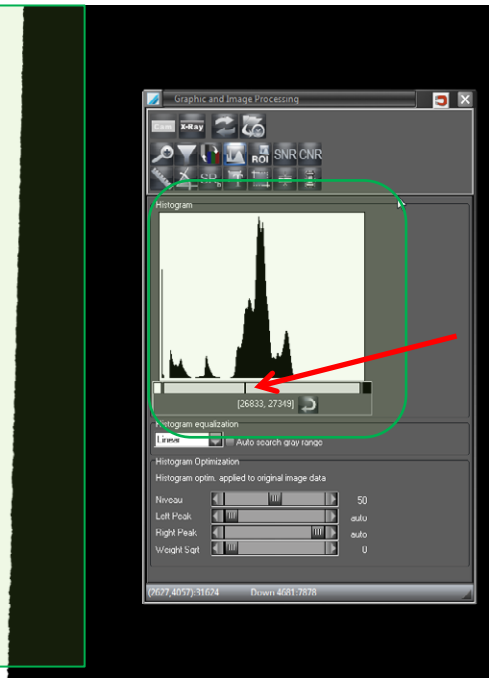


Fig. 3: Image (at 500% zoom)

The following example shows the laser jitter effect at the edge of the T-target gauge. If laser jitter occurs during the scan, the shifted pixel line will cause a "saw tooth" pattern to be visible in the image.

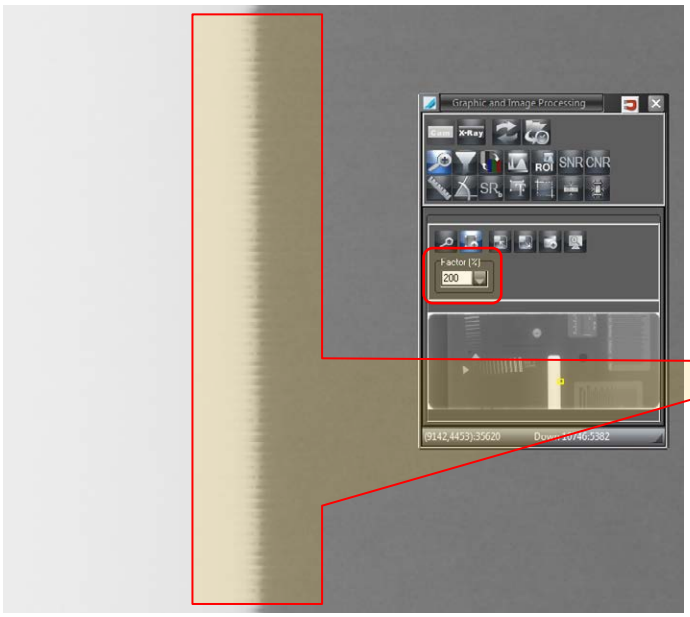
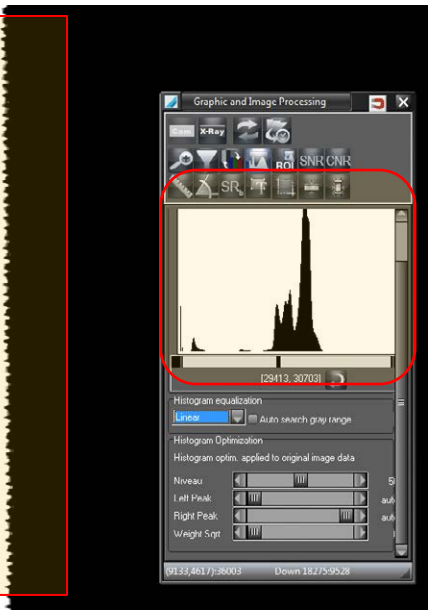


Fig. 1: Original image (at 200% zoom)

Fig. 2: Image (at 200% zoom)



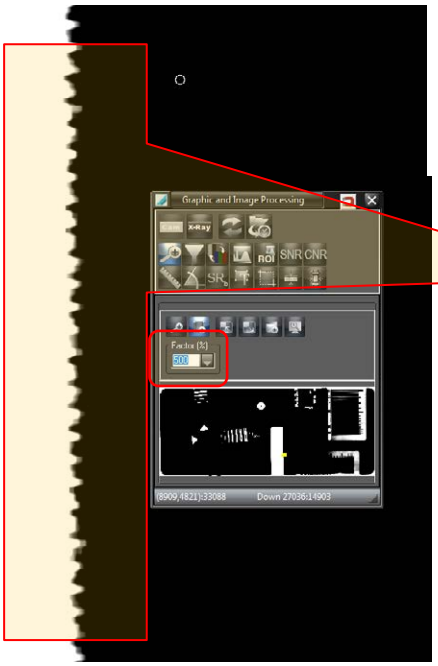
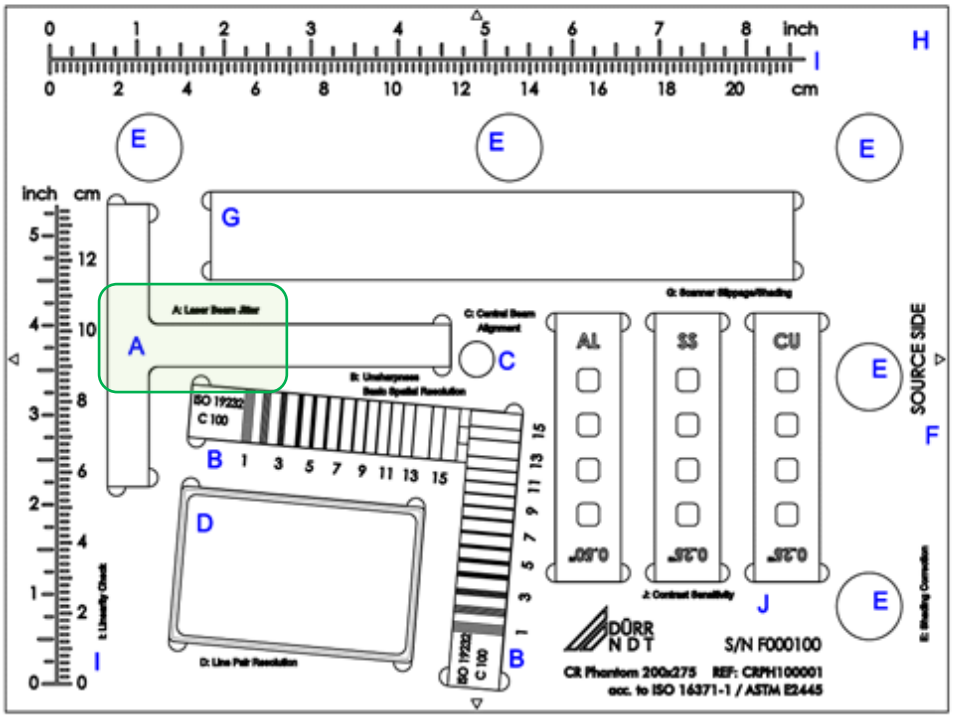


Fig. 3: Image (at 500% zoom)

Enter the result in the CR Phantom report :

Jitter: Yes / No

PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**
Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	

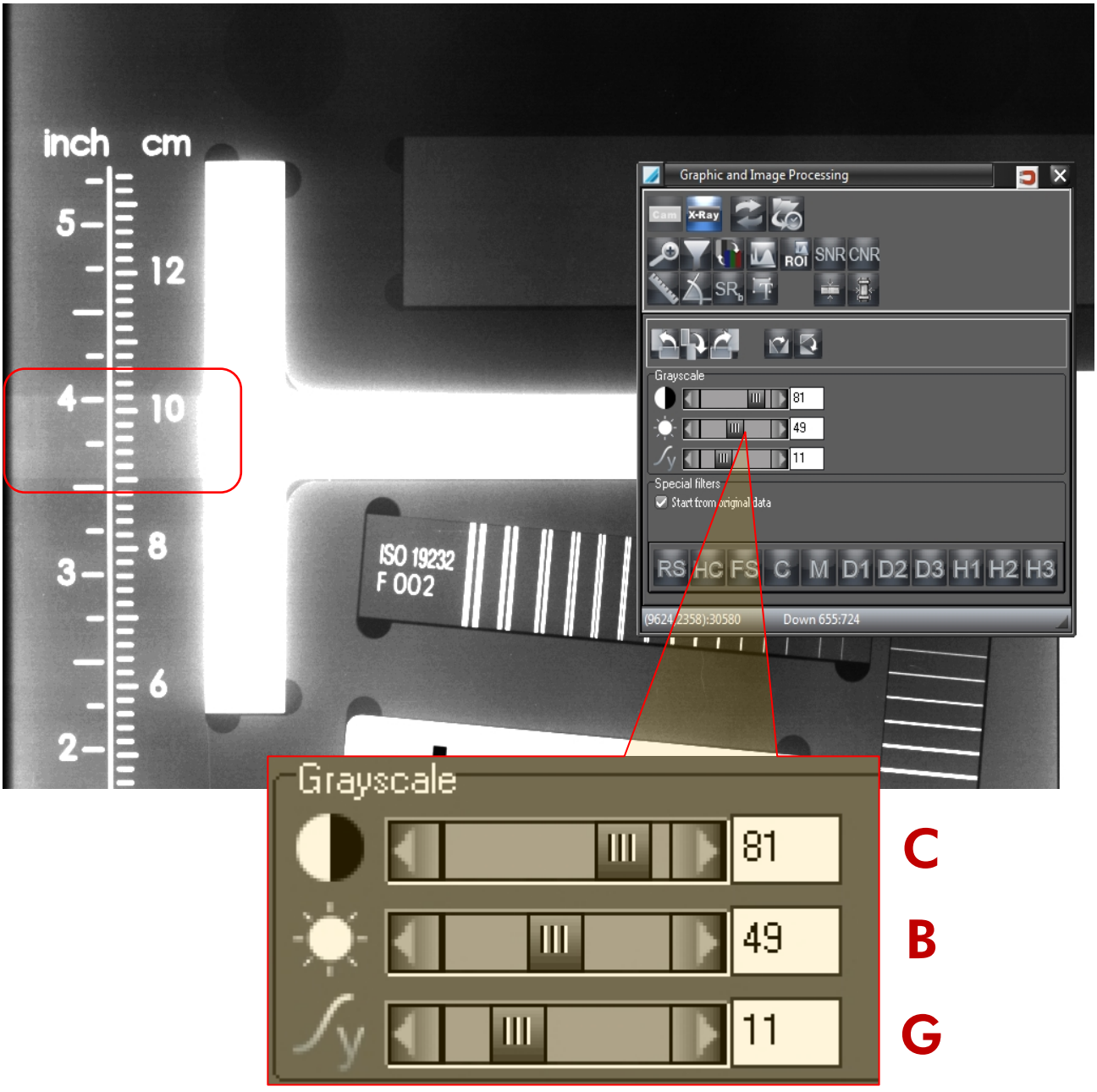


Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
C	BAM-Schnecke	Zentralstrahlausrichtung	BAM Snail	Central Beam Alignment
D	Linienpaar-BPK	Linienpaarauflösung	Line Pair IQI	Line Pair Resolution
E	EL, EC, ER Messstellen	Bildinhomogenität	EL, EC, ER Measuring Points	Shading Correction
F	Markierung Kassettenposition	Kassettenpositionierung	Cassette Positioning Locator	Positioning of Cassette
G	homogener Al-Streifen	Abtastschlupf, Bildinhomogenität	homogeneous AL Strip	Scanner Slippage, Shading
H	PMMA-Platte	Trägerplatte	Lucite Plate	Carrier Plate
I	cm/inch Lineal	Geometrische Verzerrung	cm/inch Ruler	Linearity Check
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity

Zoom in on the T-target (Ref. A) and adjust the Contrast/Brightness/Gamma (CBG) settings (e.g. C=81, B=49, G=11) until any "blooming" effect is visible.

Blooming or PMT non-linearity is a deviation from a linear response of the PMT at high light input values or from step changes in light.

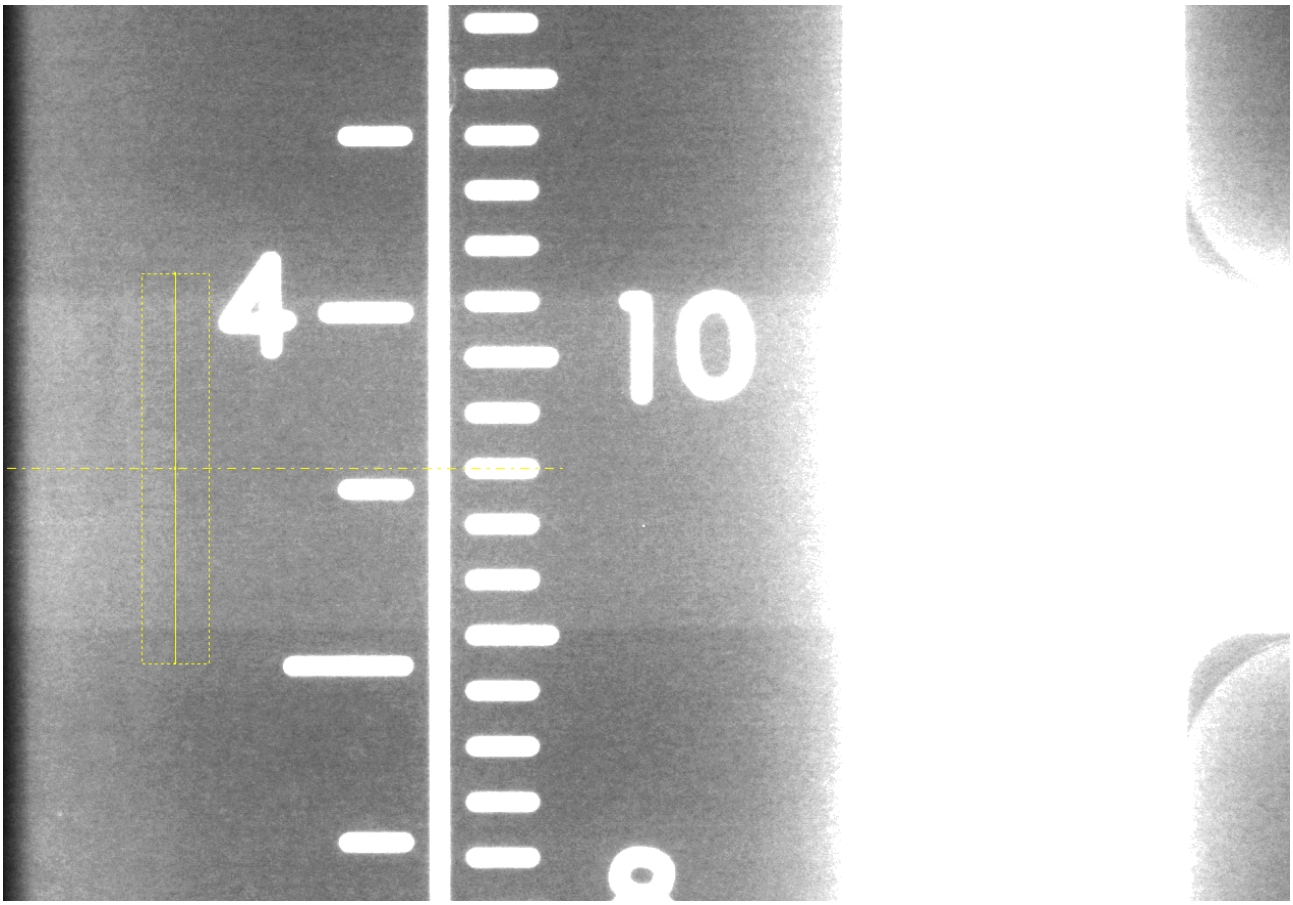
At high light input values the PMT may under-respond, the PMT may over-shoot or undershoot in response to a step change in light.



Use the D-Tect line profile tool to measure the PV difference over the "blooming´" area adjacent to the brass T-Target (Ref. A).

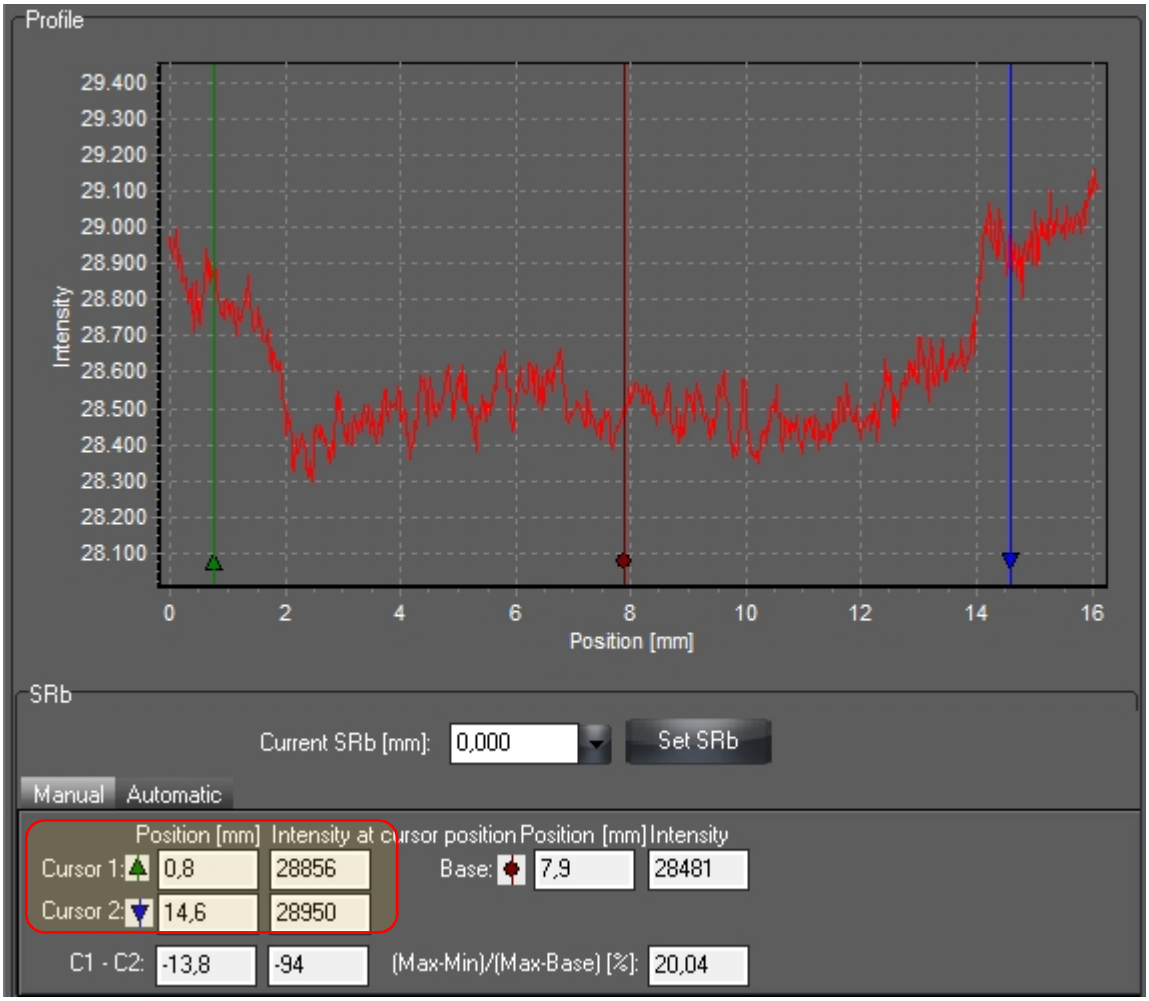
Change the line profile width from 21 pixels to 101 pixels.

Refer to example image below:



Use the D-Tect line profile tool ("SR_b" icon in the toolbox) and select the tab: "Manual"

1. Position the 1st marker (green) at approximately the average intensity of the non-blooming area in the left of the line profile. Record this PV. This is measurement point C1 (28856 PV).
2. Position the 2nd marker (blue) at approximately the average intensity of the non-blooming area in the right of the line profile. Record this PV. This is measurement point C2 (28950 PV).
3. The 3rd marker (red) should positioned at the average base signal level (28481 PV).



Enter the result in the CR Phantom report :

Blooming in %

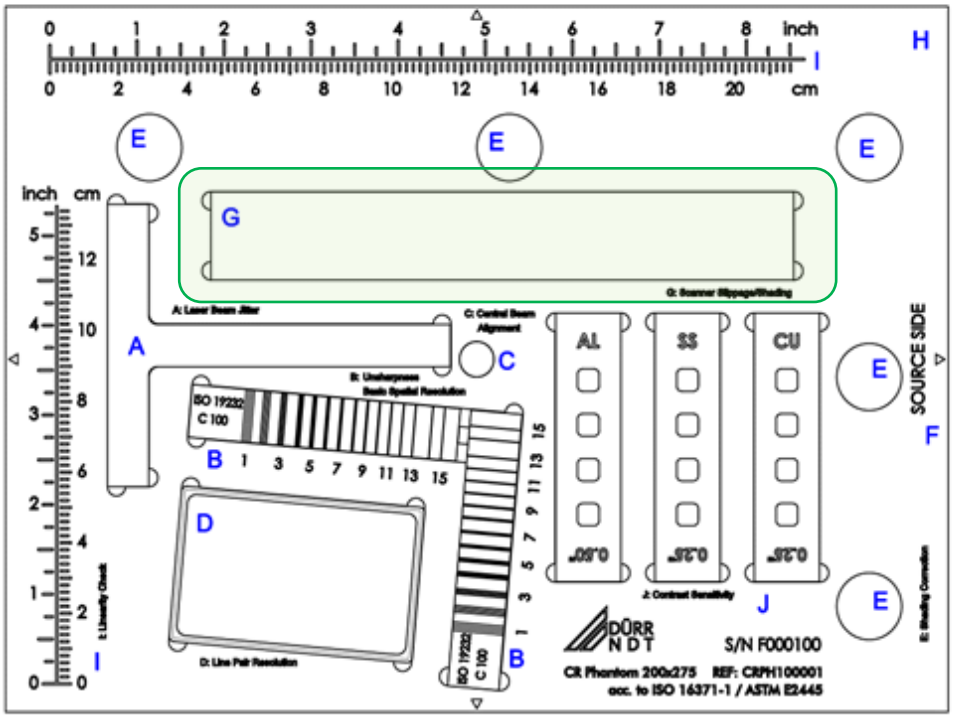
(no acceptance criteria)

The average of the non-blooming area (C1 and C2) is then compared with the blooming area (Base):

Example:
((((C1 + C2) / 2) / Base) * 100) - 100 = X.XX %

((((28856 + 28950) / 2) / 28481) * 100) – 100 = 1.48 %

PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**
Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	

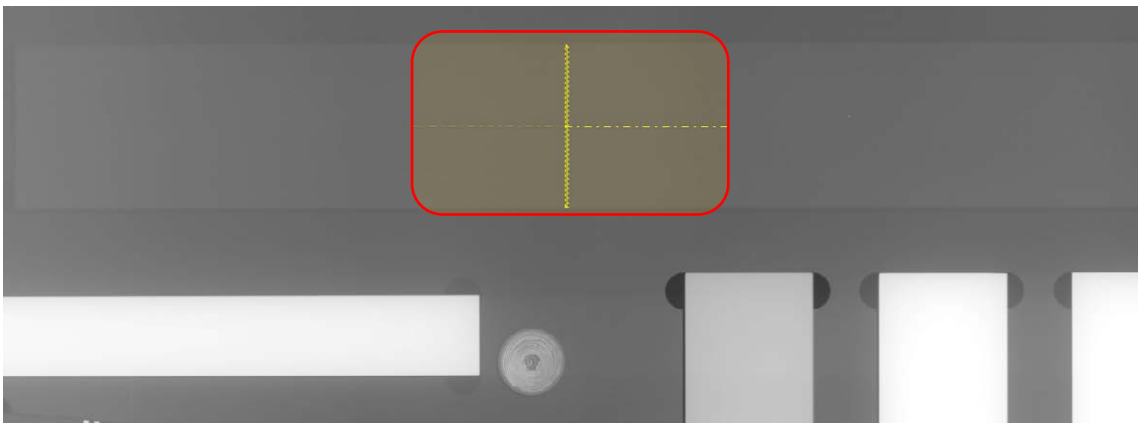


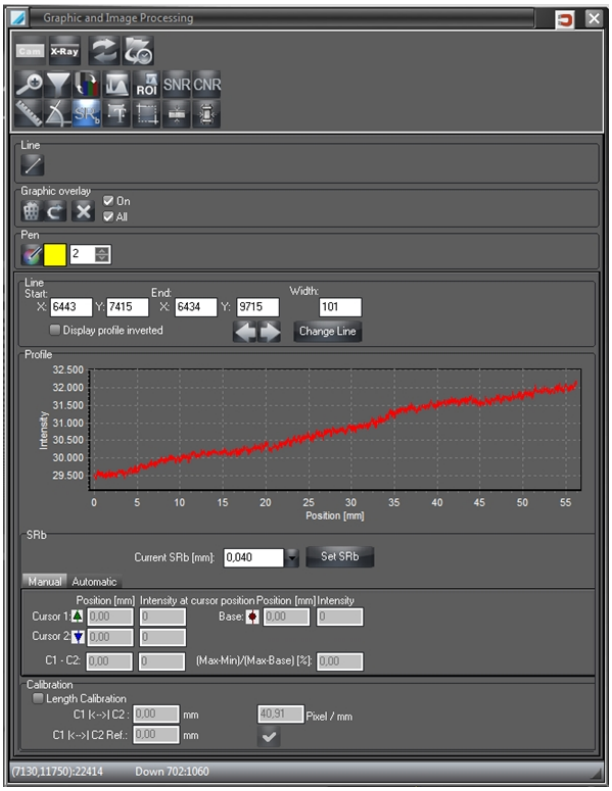
Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
C	BAM-Schnecke	Zentralstrahlausrichtung	BAM Snail	Central Beam Alignment
D	Linienpaar-BPK	Linienpaarauflösung	Line Pair IQI	Line Pair Resolution
E	EL, EC, ER Messstellen	Bildinhomogenität	EL, EC, ER Measuring Points	Shading Correction
F	Markierung Kassettenposition	Kassettenpositionierung	Cassette Positioning Locator	Positioning of Cassette
G	homogener Al-Streifen	Abtastschlupf, Bildinhomogenität	homogeneous AL Strip	Scanner Slippage, Shading
H	PMMA-Platte	Trägerplatte	Lucite Plate	Carrier Plate
I	cm/inch Lineal	Geometrische Verzerrung	cm/inch Ruler	Linearity Check
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity

Slipping of the imaging plate during transport can cause distortion in image homogeneity due to different grayscale intensities (PV) between consecutive read lines. If no slippage is present, the deviation between the line intensities shall be less than or equal to the noise.

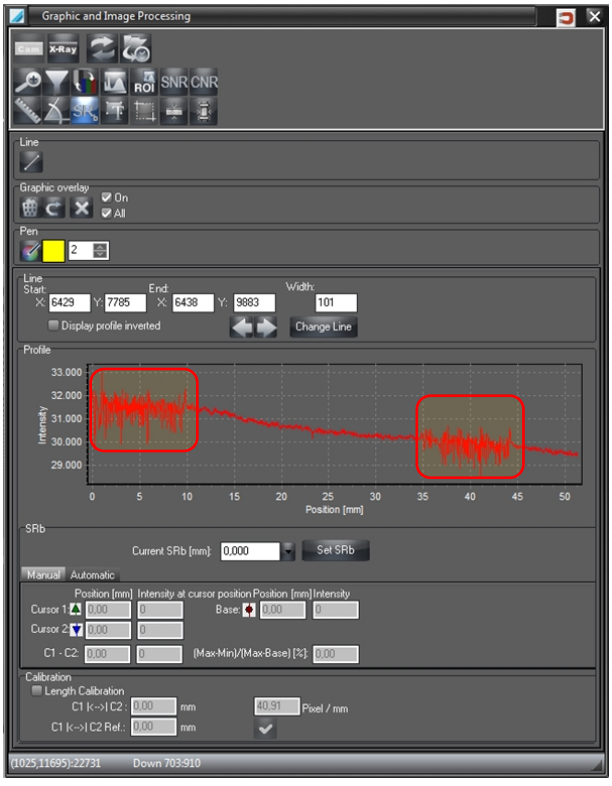
To detect scanner slippage, draw a line profile in the Al strip (Ref. G) in the transport direction (as shown below). Change the profile measurement width from 21 to approximately 101 lines and then check the profile curve for any indications of slippage.

Examples:





Scanner slipping: **No**



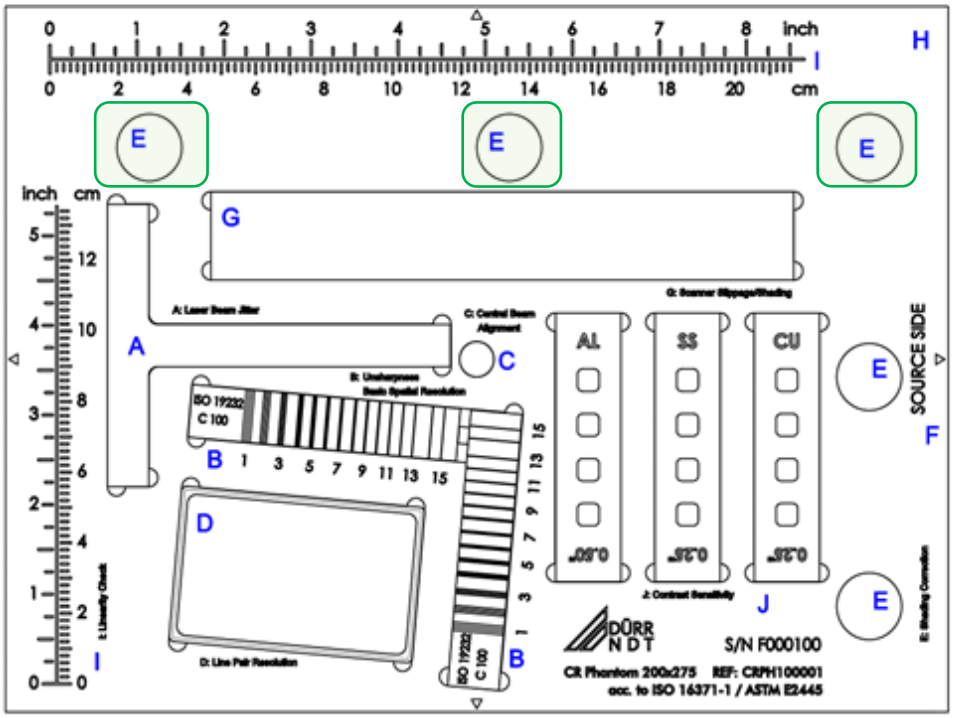
Scanner slipping: **Yes**

<u>Enter the result in the CR Phantom report :</u>

Accepted criteria: No

PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**

Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	

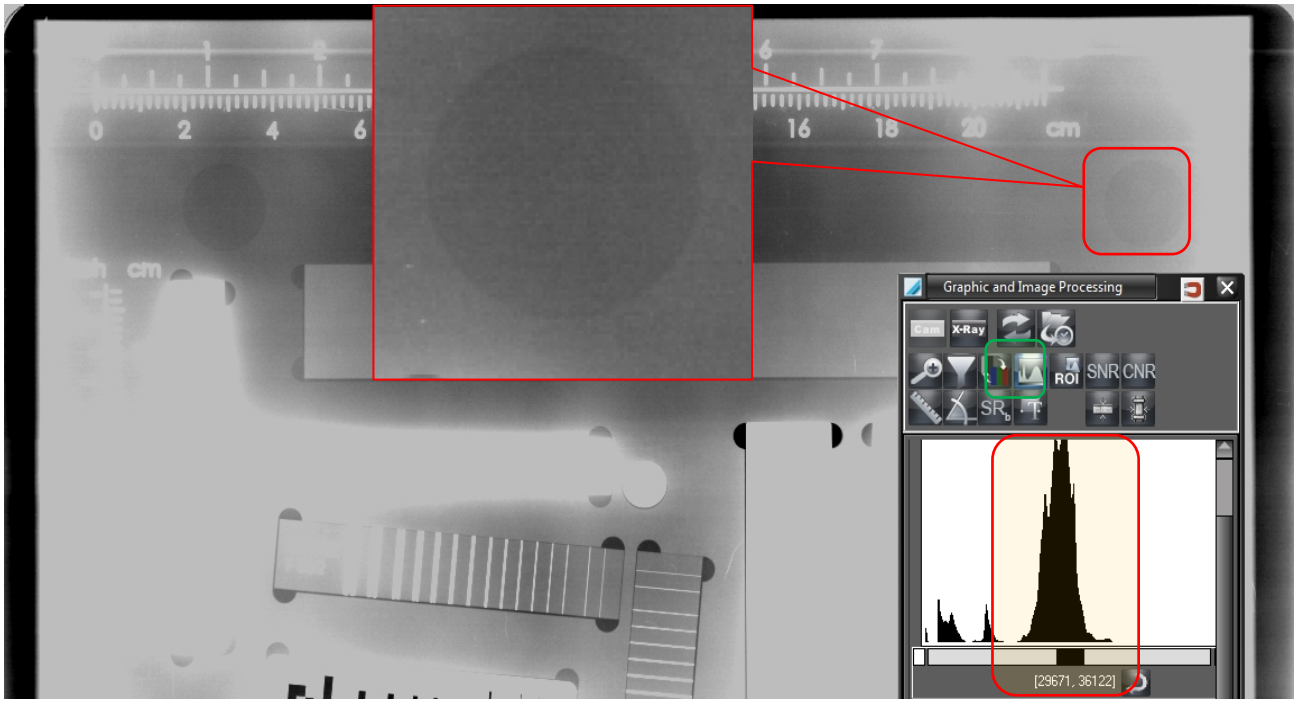


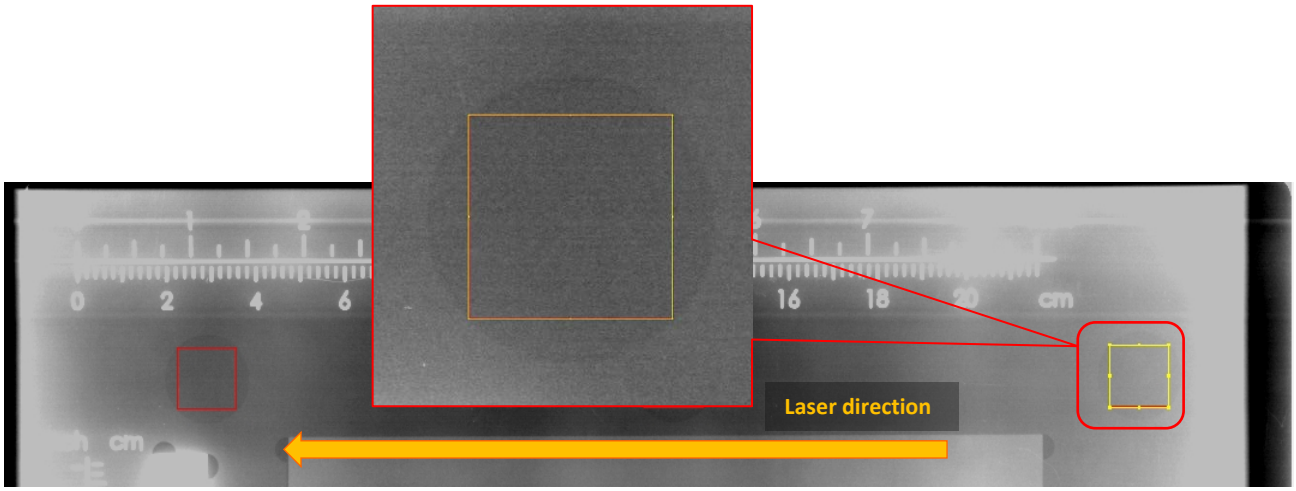
Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
C	BAM-Schnecke	Zentralstrahlausrichtung	BAM Snail	Central Beam Alignment
D	Linienpaar-BPK	Linienpaarauflösung	Line Pair IQI	Line Pair Resolution
E	EL, EC, ER Messstellen	Bildinhomogenität	EL, EC, ER Measuring Points	Shading Correction
F	Markierung Kassettenposition	Kassettenpositionierung	Cassette Positioning Locator	Positioning of Cassette
G	homogener Al-Streifen	Abtastschlupf, Bildinhomogenität	homogeneous AL Strip	Scanner Slippage, Shading
H	PMMA-Platte	Trägerplatte	Lucite Plate	Carrier Plate
I	cm/inch Lineal	Geometrische Verzerrung	cm/inch Ruler	Linearity Check
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity

Gauge E: EL -> Left EC -> Center ER -> Right

Use the histogram tool and set a window (i.e. grayscale interval) in order to show the target area (circle) clearly.

Then zoom in on each target area so that the SNR ROI rectangle can be positioned precisely.

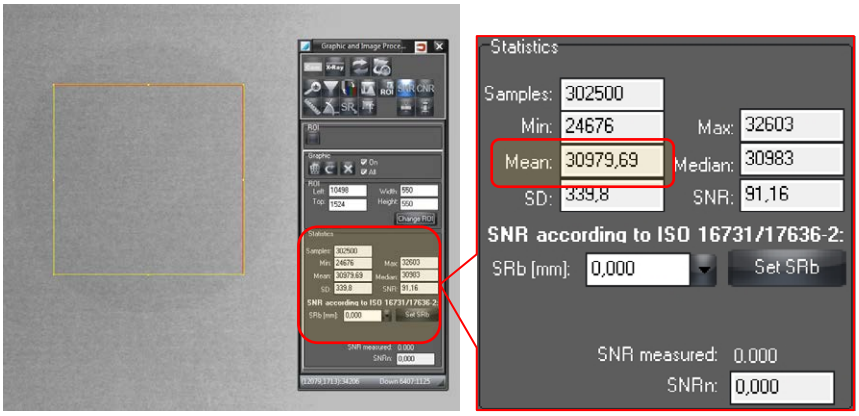




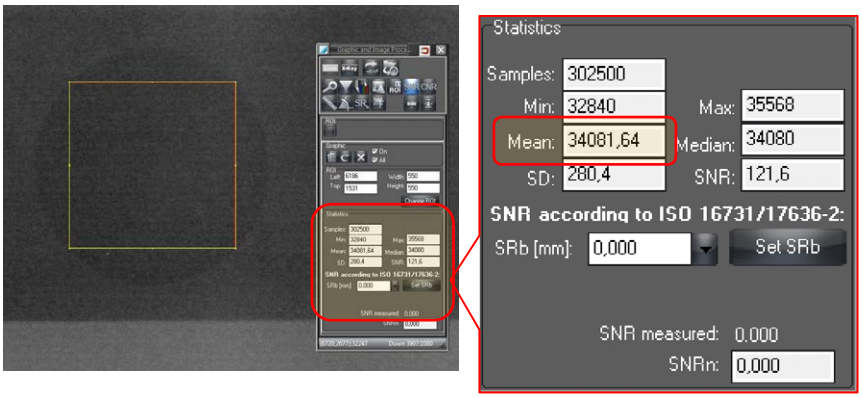
Use the SNR tool to measure the PV in the target areas (Ref. E) EL, EC & ER in the laser direction. This is detailed graphically on the following page. In summary:

1) Using the SNR tool, create a ROI in each of the three targets (Ref. E).
2) Change the ROI width and the height values manually so that it fits within the target area circle (e.g. 550 pixel width and height). For consistency, it is also recommended to always use the same ROI size for subsequent measurements in the future.
3) Record the **Mean** PV (as shown in the Statistics box) for each area (EL, EC and ER).

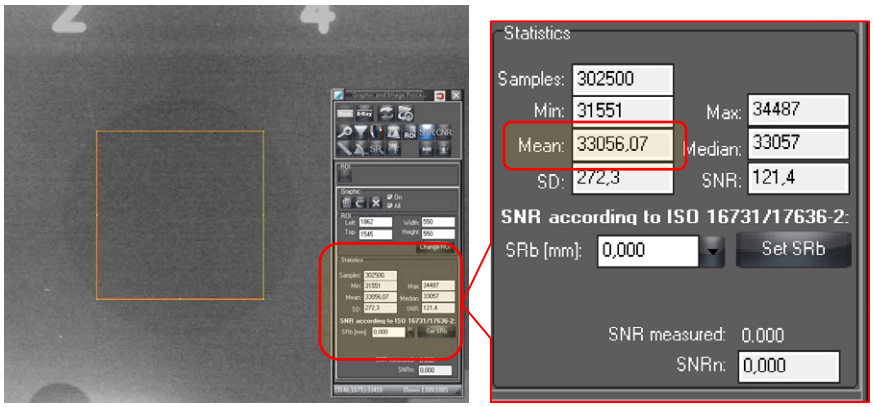
The measured PV difference between EL and EC, and ER and EC <u>should be within ± 15 %</u>



The measured mean PV in ER (right): **30980**



The measured mean PV in EC (center): **34082**



The measured mean PV in EL (left): **33056**

Example:
Shading is evaluated by calculating the PV difference between EC and ER, as well as between EC and EL:

((ER * 100) / EC) - 100 = % ((30980*100) / 34082) - 100 = -9.1 %
((EL * 100) / EC) - 100 = % ((33056*100) / 34082) - 100 = -3.0 %

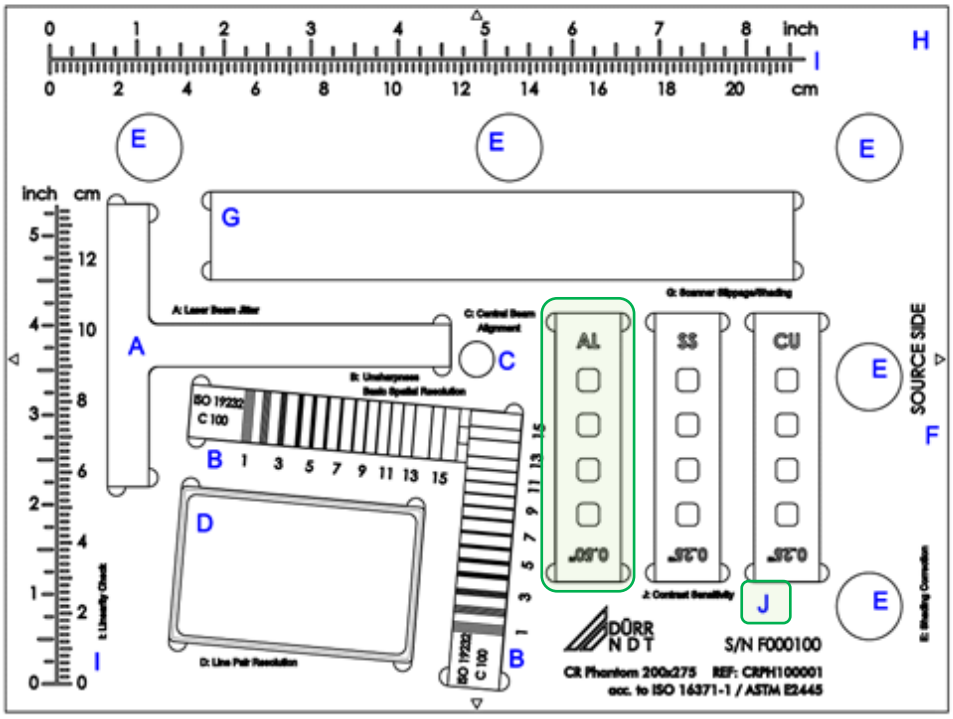
Enter the result in the CR Phantom report : Scanner shading in % (both values)

II. Test procedure

9. Contrast Sensitivity

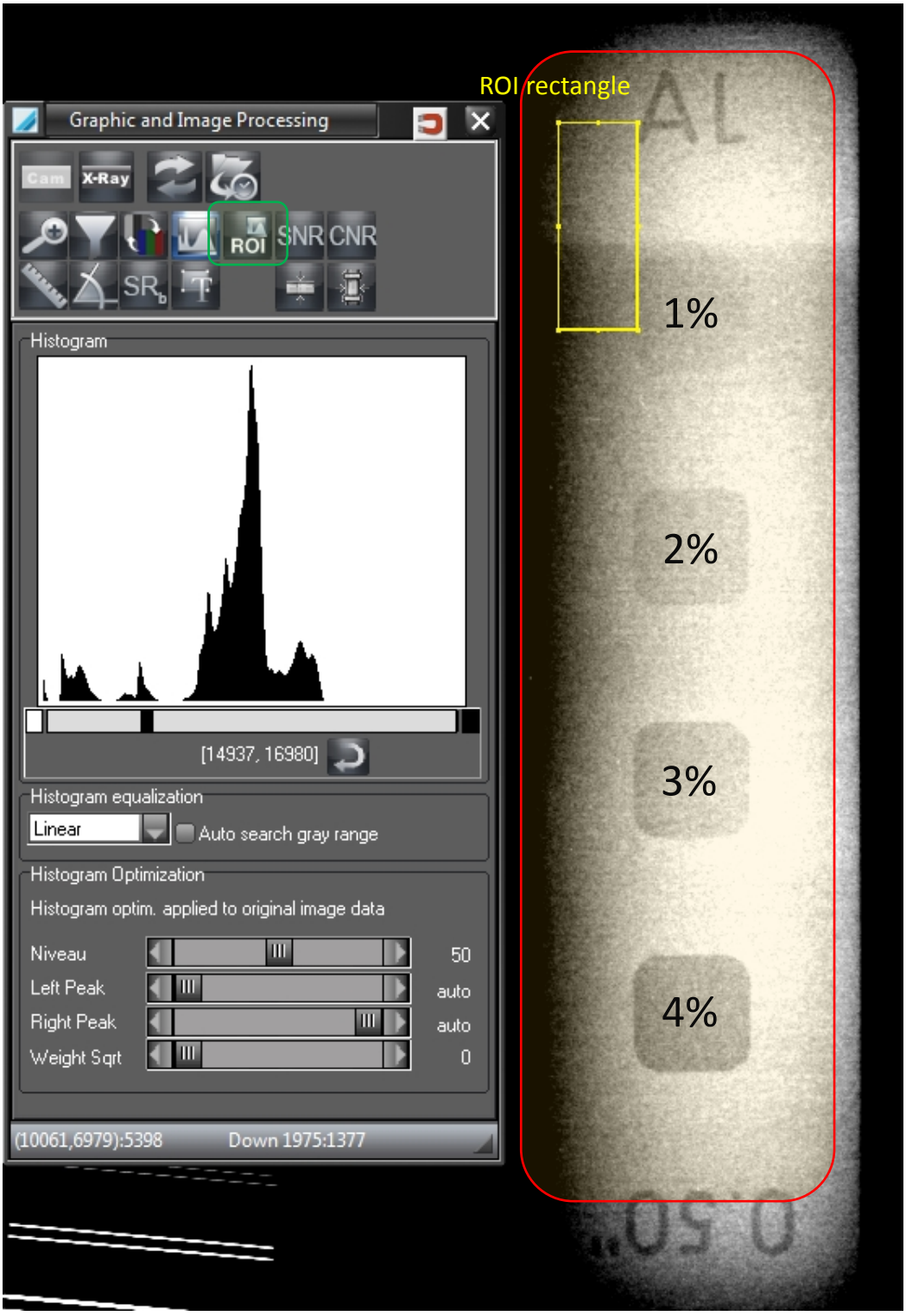
– Low energy (90 kV)

PRÜFBERICHT Nr. / Datum		nach:	**ISO 16371-1**
TEST REPORT No. / Date	**08.03.2019**	according to:	**ASTM E2445**
Prüfobjekt	CR-Phantom 275 x 200 mm - nach ISO 16371-1	Serien-Nr.	**J 000160**
Test Object	CR Phantom 275 x 200 mm - according to ASTM E2445	Serial No.	



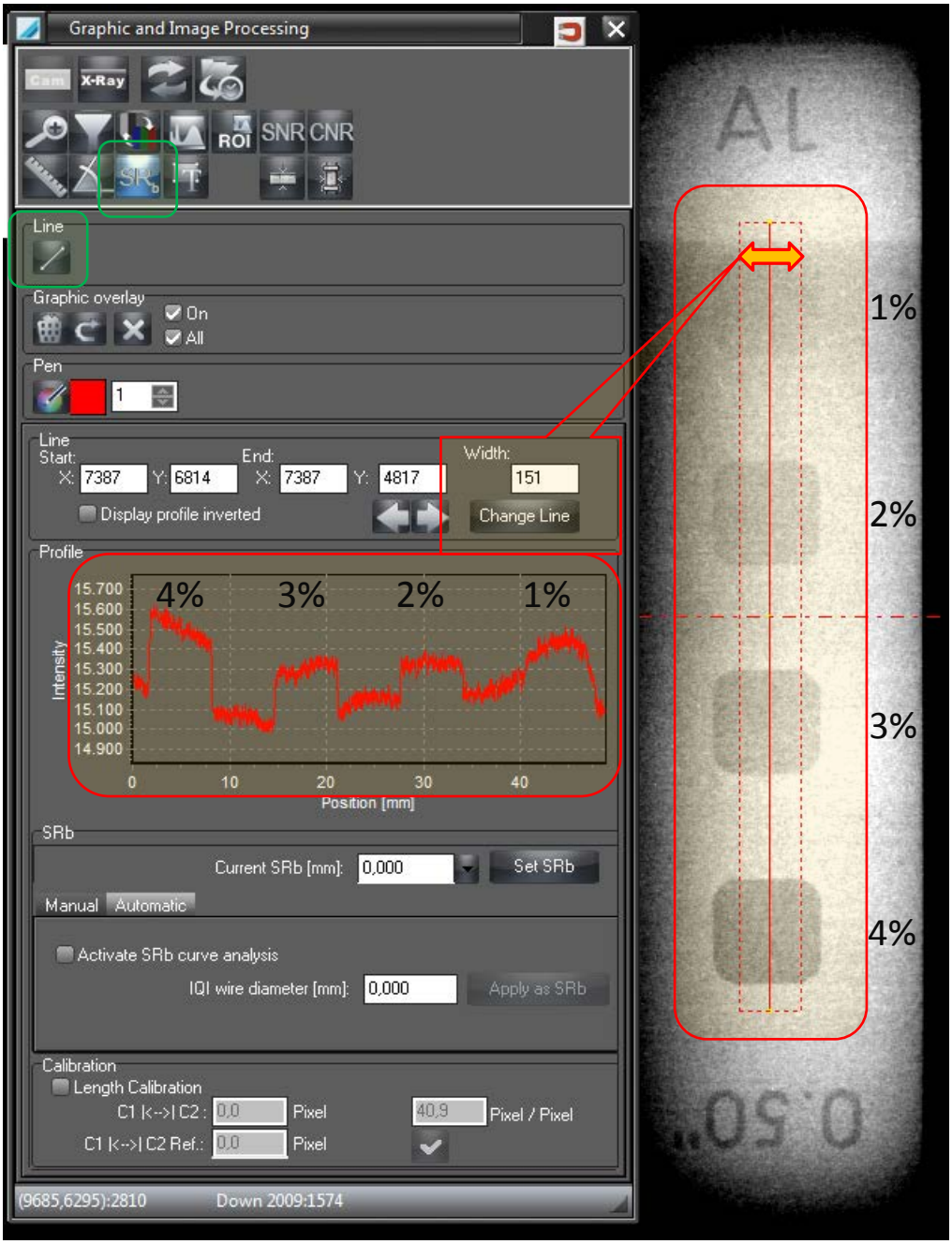
Nr.	CR Prüfkörper	Prüfungen	CR Quality Indicators	Tests
A	T-Target - Messing	Laserabtaststabilität, MÜF-Test, Überstrahlung	T-target - Brass	Laser Beam Jitter, MTF Check, Blooming (Flare)
B	Doppeldraht-BPK 15D - HiRes	Basis-Ortsauflösung, Unschärfe	Duplex Wire Type IQI 15D - HiRes	Basic Spatial Resolution, Unsharpness
C	BAM-Schnecke	Zentralstrahlausrichtung	BAM Snail	Central Beam Alignment
D	Linienpaar-BPK	Linienpaarauflösung	Line Pair IQI	Line Pair Resolution
E	EL, EC, ER Messstellen	Bildinhomogenität	EL, EC, ER Measuring Points	Shading Correction
F	Markierung Kassettenposition	Kassettenpositionierung	Cassette Positioning Locator	Positioning of Cassette
G	homogener Al-Streifen	Abtastschlupf, Bildinhomogenität	homogeneous AL Strip	Scanner Slippage, Shading
H	PMMA-Platte	Trägerplatte	Lucite Plate	Carrier Plate
I	cm/inch Lineal	Geometrische Verzerrung	cm/inch Ruler	Linearity Check
J	Kontrastempfindlichkeits-BPK	Kontrastempfindlichkeit	Contrast Sensitivity Gauge	Contrast Sensitivity

Zoom into the Al contrast sensitivity gauge (Ref. J) and place a ROI rectangle (region of interest histogram) over the Al contrast sensitivity gauge as shown in the example image below. This allows the four contrast indicators to be easily viewed.



Draw a profile line, starting from bottom to top, over all four contrast indicators and set the line width to cover approximately 60% of the contrast indicator size (e.g. 151 pixel lines). For a contrast indicator to be evaluated as "resolved", the indicator signal must be clearly defined against the signal noise level – this can be judged by the presence of a "shoulder" with sharp straight-line transitions in the profile.

Note: For higher X-ray energies, the copper (Cu) or stainless steel (SS) contrast gauge should be evaluated instead.

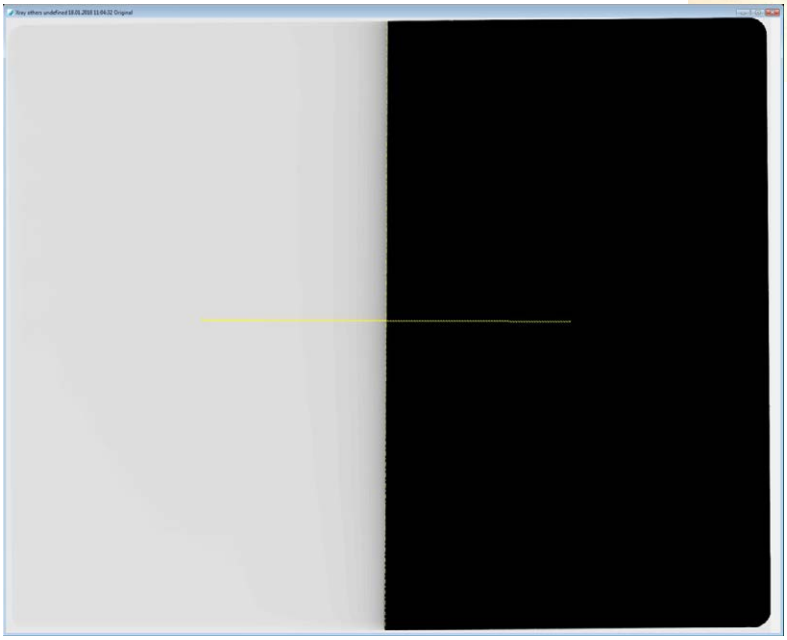


Enter the result in the CR Phantom report :

Contrast sensitivity aluminium (Al): 2% step resolved
Contrast sensitivity copper (Cu): N/A
Contrast sensitivity stainless steel (SS): N/A

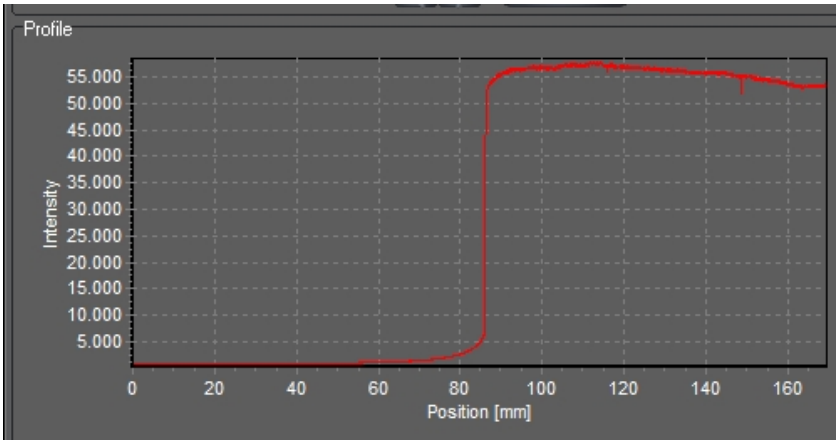
For the erasure test, 50% of the imaging plate should be shielded during exposure in order to produce an image with an almost saturated area (~60000 PV) and an almost unexposed area (~1000 PV).

Example: Rigid cassette with 50% lead shielding

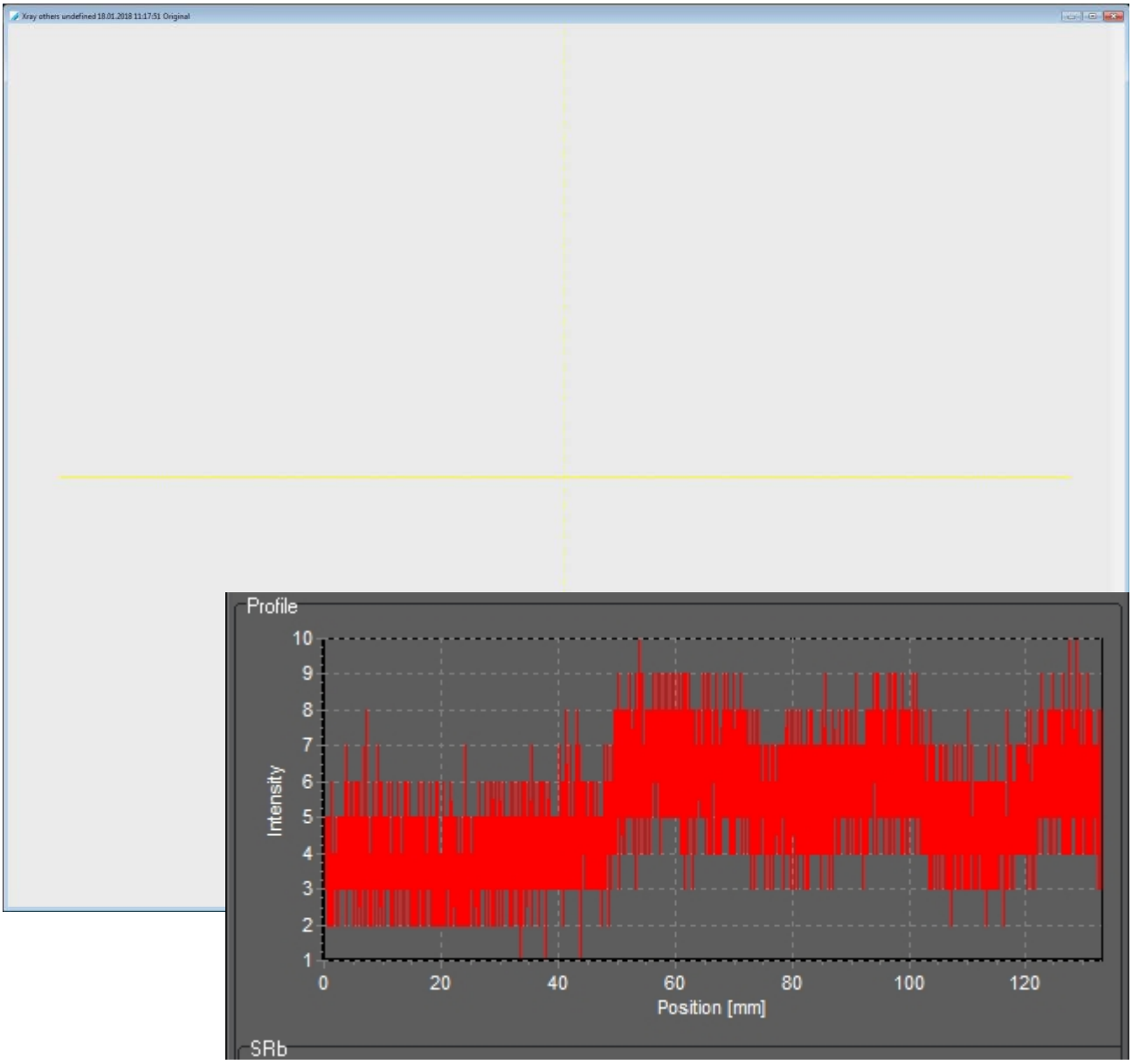


Example: Resulting scanned image

Example: Resulting line profile



Next, re-scan the same imaging plate (this imaging plate should now be erased due to the previous erasure). The example below shows the expected image and the line profile for an erased IP.



The measured pixel values shall not exceed 1 % of the maximum grayscale value.

Example:
For 16-bit system with a maximum 65535 PV, the result shall not exceed 655 PV.

(10 * 100) / 65536 = 0.015 %

Enter the result in the CR Phantom report :
(Erasure in %)

