REPORTS OF PRACTICAL ONCOLOGY AND RADIOTHERAPY 15 (2010) 145–152

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Technical note

Basic tests in mammography as a tool in quality improvement

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ARTICLE INFO

Article history:
Received 14 April 2010
Received in revised form
12 August 2010
Accepted 19 August 2010

Keywords:
Mammography
Basic tests
Quality control
Densitometer
Sensitometer

ABSTRACT

Background: Mammography is a radiological diagnostic method which relies on an X-ray examination of breasts and is a process involving the use of low-dose amplitude-X-rays (usually around 0.7 mSv). Combining the use of small doses and high quality images requires extensive quality protocols, part of them being included in regulations adopted by the Minister of Health.

Aim: The aim of this study was to check the usefulness and efficacy of selected quality tests associated with mammography.

Material/methods: The study was performed in the mammography service of the Greater Poland Cancer Centre in Poznan. Following equipment was used: densitometer, sensitometer, mammographic scales, electronic scales, thermometer, hygrometer, PMMA plates, Europhantom, screen film contact phantom, viewing boxes and magnifying glasses. The methods were based on basic mammography tests. Quality control in mammography demands: clean darkroom, marked and clean cassettes, clean viewing boxes with homogenous light.

Results: The results of the "Development Process" test show that each sensitometer has to be used with an appropriate densitometer. Phantoms with abnormal structures cannot be used to "AEC System – Solidity exposure" test. "Compression – The force of compression" test may only be carried out with suitable scales and compressible material. Analysis of rejected films shows that the main reasons for rejection were wrong collimation and underexposure.

Conclusion: Every quality control in mammography provides essential information about the functioning of a laboratory. Apart from recommended standard sterility, it should be remembered that equipment should always be adjusted and repaired.

Mammography is a radiological diagnostic method which relies on an X-ray examination of breasts and is a process involving the use of low-dose amplitude-X-rays (usually around 0.7 mSv). The aim of mammography is to detect very small abnormalities in the breast tissue before they develop into breast cancer, typically through detection of characteristic masses and/or microcalcifications.

Mammography is a very sensitive diagnostic method that requires very precise equipment and qualified medical personnel to perform the examination. Combining the use of

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doi:10.1016/j.rpor.2010.08.004

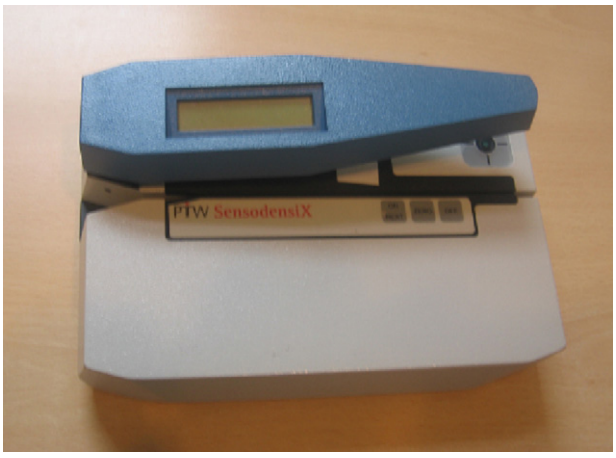

Fig. 1 – Sensitometer Sensix PTW Freiburg.

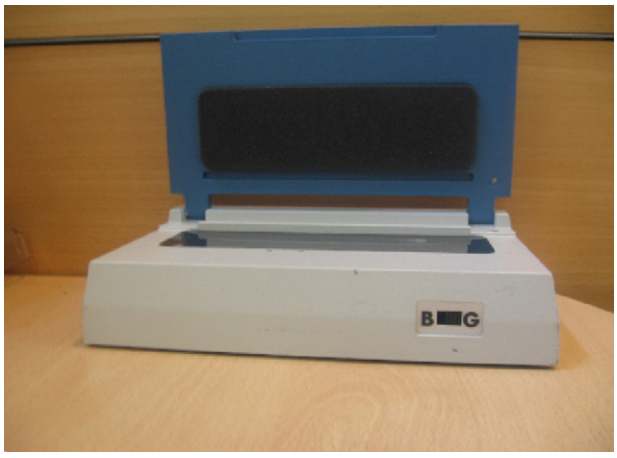

Fig. 2 – Densitometer SensodensiX PTW Freiburg.

small doses and high quality images requires extensive quality protocols,[1,2] part of them being included in regulations or recommendations adopted by legal scientific organisations.[1,3,4]

1. Aim

The aim of this study was to check the usefulness and efficacy of selected quality tests associated with mammography.

2. Equipment and methods

2.1. *Equipment*

The study was performed in the mammography service of the Greater Poland Cancer Centre in Poznan. The following equipment was used: densitometer, sensitometer, mammographic scales, electronic scales, thermometer, hygrometer, PMMA plates, Europhantom, screen film contact phantom, viewing boxes, and magnifying glasses. The manufacturers and serial numbers are shown in Table 1.

A densitometer was used to measure the optical density of exposed films. This study used three densitometers by three different manufacturers. The use of each of the three densitometers was tested with each of the three sensitometers. The sensitometers were used to ensure that the delicate chemical balance needed to process films remains consistent. The sensitometer generates a consistent exposure time and is considered constant. The sensitometer must be set to match the colour spectrum of the test film used (in mammography it is usually green).[11,12] Figs. 1 and 2 show the sensitometer and densitometer used in the study.

3. Methods

3.1. *Basic mammography tests*

Quality control in mammography demands clean darkroom, marked and clean cassettes, and clean viewing boxes with homogenous light. It is important to choose a suitable kind of film, chemical reagent, developer and parameters of the

Table 1 – The apparatus used in the Greater Poland Cancer Centre for basic tests in mammography.

	Apparatus	Manufacturer	Serial number
1.	Sensitometer	PTW Freiburg SensiX	T51003-5206
2.	Sensitometer	PTW Freiburg SensiX	T51003-3536
3.	Sensitometer	Pehamed	4987
4.	Densitometer	PTW Freiburg SensodensiX auto Cal	T52004
5.	Densitometer	Pehamed	N1031
6.	Densitometer	PTW Freiburg SensodensiX	T52004-N 1167
7.	Mammographic scales	Soehnle	775507TH00946
8.	Mammographic scales	Nuclear Associates	18-241-44-26
9.	Electronic scales	Rinstrum	EWP 0201 27/2006
10.	Theromometer	Testo	31618309/604
11.	Theromometer	Testo	I-33-02-012 06021293
12.	Hygrometer	Thermohygro	–
13.	PMMA plates	PTW Freiburg	–
14.	Europhantom	PTW Freiburg	T 42024-0109
15.	Screen film contact phantom	PTW Freiburg	T 42022-0020
16.	Viewing box	BAKMED	I-48-44-065
17.	Magnifying glass	Hama	–

development process and films storage. Equally significant for the QA process is the choice of a suitable thermometer and densitometer, development and reading of sensitograms, establishment of a control method, and setting of a reference value and tolerance limit. The darkroom was cleaned at the beginning of each workday, before any films were handled or processed. A darkroom should be as free as possible of any dust or dirt that could result in artefacts in the image. A daylight processor for mammography largely eliminates artefacts that occur in the process of film handling. If the darkroom and the processor were shared rather than dedicated to mammography, mammography quality standards would still have to be maintained by quality control technicians. Keeping the darkroom clean was very important in quality control because it was the main source of problems. Humidity in the darkroom was around 40–60%.

All the cassettes and screen-films in the mammographic laboratory were marked. All the cassettes and screen-films were cleaned once a week. Films were usually kept in temperature lower than 25 °C and humidity between 40% and 60%. A digital thermometer was used in the mammographic laboratory. At the beginning of quality control tests, it was essential to assign a reference value and tolerance limit to control parameters.[2]

Four tests were made to verify quality control in mammography Unit. The first test was that of "Process development". Three different sensitometers were used: PTW Freiburg SensiX 5206, PTW Freiburg SensiX 3536, Pehamed 4987, and three different densitometers: PTW Freiburg SensodensiX auto Cal 0600, Pehamed 1031, PTW Freiburg SensodensiX 1167. The study applied the mammograph GE Diamond, the developer AGFA Mamoray Compact Plus and a film by AGFA. Five measurements were made for each measurement set. The optical density was measured and recorded in 21 boxes. Each line in the table corresponds to one measurement. There are five lines with measurements. The mean optical density was derived from five measurements. These measurements were also used to calculate the standard deviation to show the difference between results. The temperature of the developer in each measurement was set at 34 °C.

The next test was that of AEC System – Solidity exposure. It involved eight different phantoms and three sensitometers: 0600, 1031, and 1167. The third test checked the compression force. Two compression paddles (small and large) were used in this test to measure the force of compression. Three mammographic scales were used (one of them was bigger and covered the whole bucky). A small compression paddle and three scales were used during the first test. Three measurements were made with additional compressible material and three without it. The test used Phantom 4.5 cm PMMA, Mode Auto kV and the AEC detector was located in the position closest to the chest wall. The density was +0.

The fourth test was the "Analysis results of rejected films". 5980 mammogram films were analysed from April 2006 to April 2009. The Mammogram films were divided into three types of projection: oblique projection left or right, targeted projection, and cranio-caudal projection. The reasons for film rejection were: collimation, overexposure, underexposure, patient motion, artefacts, fog, wrong identification, and others.

Table 2 – The results of the development process with the use of sensitometer 4987 and densitometer 1031.

	Field number																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	0.18	0.18	0.18	0,18	0.19	0.20	0.22	0.28	0.43	0.82	1.60	2.39	3.05	3.50	3.75	4.02	4.18	4.28	4.37	4.38	4.38
	0.18	0.18	0.18	0,18	0.20	0.20	0.22	0.28	0.43	0.82	1.59	2.39	3.03	3.51	3.82	4.04	4.18	4.29	4.38	4.38	4.38
	0.18	0.18	0.18	0.19	0.20	0.20	0.22	0.28	0.45	0.84	1.62	2.44	3.07	3.51	3.82	4.05	4.19	4.28	4.36	4.38	4.38
	0.19	0.19	0.19	0.20	0.20	0.20	0.22	0.28	0.45	0.83	1.61	2.42	3.06	3.53	3.82	4.05	4.20	4.30	4.38	4.38	4.38
	0.18	0.18	0.18	0.18	0.20	0.20	0.22	0.27	0.43	0.81	1.59	2.38	3.02	3.50	3.79	4.01	4.15	4.25	4.34	4,37	4.37
Mean optical density	0.18	0.18	0.18	0.19	0.20	0.20	0.22	0.28	0.44	0.83	1.60	2.40	3.05	3.51	3.80	4.03	4.18	4.28	4.37	4.38	4.38
Standard deviation	0.004	0.004	0.004	0.008	0.004	0.00	0.00	0.004	0.010	0.010	0.012	0.023	0.019	0.011	0.028	0.016	0.017	0.018	0.015	0.004	0.004

Table 3 – The results of the development process with the use of sensitometer 4987 and densitometer T 52004-N0600.

Field number																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Mean optical density																				
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Standard deviation																				
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4. Results

4.1. *Test no. 1: Process of development*

The results of this test show that each sensitometer should be used with an appropriate densitometer. The sensitometer 4987 has to be used to measure mammograms which are exposed to the densitometer 1031. When used with an inappropriate densitometer, all the optical density levels were incorrectly indicated at 0.16. To measure the optical density, 15 films were used. The films were divided into three groups as there were three different measurement sets. The nine results thus received prove that all the three measurement sets provide the same results, but only if each sensitometer is used with an adequate densitometer. In Tables 2 and 3, five measurements made with the samesensitometer but different densitometer are shown in five rows. The other tables with results are shown in Appendix A.

4.2. *Test no. 2: AEC System – Solidity exposure*

The test results show that all the three densitometers provide the same levels of optical densities. The optical density measured for phantom 7 was higher than 1.80, because this phantom contains structures which imitate abnormal structures in female breast. Therefore, this phantom may not be used in this type of tests. The other phantoms performed their functions correctly. The optical density of received films was in the range of 1.3–1.8. The results are showed in Table 4.

4.3. *Test no. 3: Compression – The force of compression*

Three measurements were made with additional compressible material and three without it. In the case of the measurements without additional compressible material, the nominal values of the force of compression were at the same level of 20 kg. For scales 2 and 3 they were too high, exceeding 20 kg. The force of compression measurement values for scales 2 and 3 were two times higher than the standard value: 55 kg and 49.5 kg, respectively. In the case of measured and nominal values of the force of compression with additional compressible material, results were out of limit for scales 2. The second test was made with a large compression paddle. In this case, also when scales 2 and 3 were used, the results were different from the standard levels. The value of the force of compression measured with phantom on scales 2 was about 8 kg higher than the limit value of 20 kg. In the other case, measured and nominal values of the force of compression were within the limit. The results of this test are presented in Tables 5 and 6.

4.4. *Test no. 4: Analysis of rejected films*

5980 mammogram films were analysed from April 2006 to April 2009. 32 films were replayed and accounted for 0.54% of all films. The main reasons for rejecting films in left or right oblique projection were wrong collimation and underexposure. In the case of targeted mammogram films, the main reason for rejection was wrong collimation. Other reasons for rejection, together with collimation, applied to

Table 4 – The results of AEC System test – Solidity exposure.

Item	Phantom	High voltage [kV]	Exposure time [mA s]	Densitometer		
				T 52004-N0600	N 1031	T-49-031-013
1	Large rectangular plexi plates	25	173	1.52	1.50	1.45
2	Small rectangular plexi plates	24	66	1.54	1.53	1.55
3	Rectangular plexi plate with circular-shapes	26	82	1.52	1.46	1.52
4	Semicirrcural plexi plate	26	87	1.45	1.42	1.42
5	Square plexi plate	24	83	1.48	1.45	1.45
6	Small square plexi plate	26	76	1.45	1.41	1.47
7	ACR Phantom	25	82	1.87	1.8	1.90
8	Europhantom	27	74	1.52	1.47	1.55
Mean		25.38	90.38	1.54	1.51	1.54

Table 5 – Test results of "Compression test – The force of compression" with the use of small compression paddle.

Mammographic scales	EWP0201	18-241-4426	SOEHNLE
Without additional compressible material			
Nominal force of compression [kg]	18.0	23.5	21.5
Measured force of compression [kg]	19.6	55.0	49.4
Force of compression after 1 min [kg]	18.9	53.8	47.8
With additional compressible material			
Nominal force of compression [kg]	X	12.0	12.5
Measured force of compression [kg]	X	29.8	13.3
Force of compression after 1 min [kg]	X	28.2	12.6

Table 6 – Test results of Compression test – The force of compression with the us of a large compression paddle.

Mammographic scales	EWP0201	18-241-4426	SOEHNLE
Without compressible material			
Nominal force of compression [kg]	13.50	25.00	22.50
Measured force of compression [kg]	15.06	26.00	23.80
Force of compression after 1 min [kg]	17.70	35.60	21.90
With compressible material			
Nominal force of compression [kg]	13.50	11.50	11.00
Measured force of compression [kg]	15.06	28.00	12.45
Force of compression after 1 min [kg]	17.70	11.50	11.90

CC projection. Other factors did not influence the results (Table 7).

5. Discussion

The analysis of quality control tests shows that routine control of medical equipment is necessary when conducting quality control tests in mammography. Accurate quality control guarantees high quality of conducted examinations, and consequently, a correct diagnosis of the patient on the basis of resulting mammograms. For the assessments to be consistent, the same assessment image criteria, e.g. density, should be measured at one reference point, i.e. 6 cm from the chest. It is also necessary to use a correctly illuminated viewing box, keep the same evaluation conditions, and use a magnifying glass as in the case of analysis of mammographic images. The room where mammograms are performed should be dimmed by cutting off additional outside light. A correct use of densitometer and sensitometer sets is essential, as well as working in compliance with manufacturer's recommendations, otherwise results may be misleading. The choice of a suitable sensitometer enables a quality control to be conducted in conditions of irradiation close to those of clinical examinations. It is important to set a reference level and acceptable tolerance range at the beginning of a quality control program in a mammographic laboratory. Values received while measuring parameters of a correctly functioning system during routine work serve as reference levels.

As shown by the examination results, all the three densitometers in the Greater Poland Cancer Centre measured the optical density equally. The examination results show clearly that the densitometer 4987 is the only one to be used to measure the density of mammographic film irradiated by the sensitometer 1031. To carry out basic quality control tests, it is recommended to use a sensitometer and densitometer by the same manufacturer. A failure to follow manufacturer's recommendations may result in erroneous interpretation of the results. Using the above mentioned sensitometer with another densitometer proved wrong as all the results achieved were at the same level of 0.16. All the three sets of sensitometers and densitometers show similar levels and fall within the range of standard quantities. To carry out AEC System test, it is highly important to avoid using a phantom featuring various hidden structures imitating irregularities in female breasts. Other phantoms can be freely used in the test. The use of matching phantoms is essential as each test requires a different phantom. To measure the strength of compression, it is recommended to use digital scales which should be set in the place of breast placement during clinical research. The outcome is similar for a rolled towel used as a phantom. It allows an actual measurement. Regular scales are not recommended for this test as they are not precise enough. While carrying out quality control tests, it is also essential to pay attention to the

Table 7 – Results of rejected films analysis.

Projection	Collimation	Overexposure of film	Underexposure of film	Patient motion	Artefacts	Fog	Identification	Other
Oblique projection left or right	2	1	2	–	–	–	–	–
Targeted	3	–	–	–	–	–	–	1
CC (cranial-caudal view)	7	1	5	2	–	–	–	8

possibility of artefacts appearing in mammograms. Artefacts are likely to distort the information about the object under examination. The main reason for artefacts to appear may be the darkroom. Artefacts can be caused by external conditions (diagnostic equipment) or mistakes made by people conducting quality control tests and clinical examinations. Artefacts can be observed on the entire area of the picture. Most dangerous are those appearing in the area of a diagnosed organ and blurring the image. When similar to anatomic structures to be detected, they create the risk of wrong decisions, thus lowering the efficacy of the examination.

6. Conclusion

All the three measurement sets used in the test development process provide the same results but only with a properly matched sensitometer and densitometer.

The "AEC System – Solidity exposure" test has to be carried out with a phantom which is intended for this test. Using unsuitable phantom can deliver misleading results. Phantoms containing structures which resemble abnormal structures in female breast near the measurement point may not be used.

The "Compression – The force of compression" test may only be carried out with suitable scales and compressible material.

The analysis of rejected films shows that the main reason for rejection of films was wrong collimation and underexposure.

Appendix A.

See Tables 8–14.

Table 8 – Results of the development process with the use of sensitometer T 51003-5206 and densitometer T 52004-N0600.

Box number																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.18	0.17	0.18	0.18	0.18	0.18	0.20	0.26	0.43	0.83	1.53	2.28	2.96	3.42	3.75	3.99	4.15	4.26	4.34	4.43	4.52
0.17	0.17	0.18	0.18	0.18	0.18	0.21	0.27	0.44	0.86	1.58	2.34	3.01	3.46	3.79	4.02	4.18	4.28	4.36	4.45	4.55
0.16	0.16	0.16	0.17	0.18	0.18	0.20	0.26	0.43	0.84	1.57	2.34	3.02	3.46	3.78	4.03	4.18	4.28	4.36	4.45	4.46
0.16	0.16	0.16	0.17	0.18	0.18	0.20	0.26	0.43	0.84	1.56	2.34	3.01	3.47	3.79	4.02	4.17	4.28	4.36	4.45	4.55
0.16	0.16	0.17	0.17	0.18	0.18	0.20	0.27	0.44	0.86	1.59	2.34	3.01	3.46	3.79	4.01	4.15	4.25	4.34	4.43	4.52
Mean optical density																				
0.17	0.82	0.34	0.17	0.18	0.18	0.20	0.26	0.43	0.85	1.57	2.33	3.00	3.45	3.78	4.01	4.17	4.27	4.35	4.44	4.52
Standard deviation																				
0.009	0.005	0.010	0.005	0.000	0.000	0.004	0.005	0.005	0.013	0.023	0.027	0.024	0.019	0.017	0.015	0.015	0.014	0.011	0.011	0.037

Table 9 – Results of the development process with the use of sensitometer T 51003-5206 and densitometer T 49-031-013.

Box number																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.18	0.18	0.18	0.18	0.18	0.20	0.22	0.28	0.44	0.85	1.58	2.35	3.01	3.45	3.78	4.00	4.15	4.26	4.35	4.43	4.52
0.18	0.18	0.18	0.18	0.18	0.20	0.22	0.28	0.46	0.89	1.64	2.42	3.07	3.51	3.83	4.05	4.20	4.31	4.39	4.48	4.57
0.18	0.18	0.18	0.18	0.18	0.19	0.22	0.28	0.45	0.88	1.63	2.43	3.09	3.51	3.82	4.05	4.20	4.31	4.39	4.47	4.48
0.18	0.18	0.18	0.18	0.18	0.19	0.22	0.28	0.45	0.87	1.63	2.41	3.09	3.52	3.83	4.04	4.19	4.31	4.39	4.47	4.48
0.18	0.18	0.18	0.18	0.18	0.20	0.22	0.28	0.46	0.89	1.65	2.42	3.08	3.50	3.82	4.03	4.16	4.27	4.35	4.43	4.45
Mean optical density																				
0.18	0.18	0.18	0.18	0.18	0.20	0.22	0.28	0.45	0.88	1.63	2.41	3.07	3.50	3.82	4.03	4.18	4.29	4.37	4.46	4.50
Standard deviation																				
0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.008	0.017	0.027	0.032	0.033	0.028	0.021	0.021	0.023	0.025	0.022	0.024	0.046

Table 10 – Results of the development process with the use of sensitometer T 51003-5206 and densitometer T N 1031.

Box number																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Mean optical density																				
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Standard deviation																				
0.000	0.000	00.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 11 – Results of the development process with the use of sensitometer 4987 and densitometer T-49-031-013.

Box number																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Mean optical density																				
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Standard deviation																				
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 12 – Results of the development process of the use of sensitometer T 51003-3536 and densitometer T 49-031-013.

Box number																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.17	0.17	0.18	0.18	0.18	0.18	0.20	0.24	0.38	0.72	1.36	2.16	2.96	3.49	3.84	4.06	4.22	0.17	0.17	0.18	0.18
0.18	0.18	0.18	0.18	0.18	0.18	0.20	0.24	0.38	0.71	1.37	2.17	2.95	3.49	3.83	4.06	4.21	0.18	0.18	0.18	0.18
0.18	0.18	0.18	0.18	0.18	0.19	0.20	0.25	0.40	0.74	1.38	2.18	2.97	3.51	3.85	4.07	4.22	0.18	0.18	0.18	0.18
0.18	0.18	0.18	0.19	0.18	0.19	0.20	0.25	0.40	0.74	1.38	2.18	2.98	3.55	3.88	4.09	4.24	0.18	0.18	0.18	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.21	0.25	0.40	0.73	1.38	2.19	2.97	3.52	3.86	4.08	4.23	0.19	0.19	0.19	0.19
Mean optical density																				
0.18	0.18	0.18	0.18	0.18	0.19	0.20	0.25	0.39	0.73	1.37	2.18	2.97	3.51	3.85	4.07	4.22	0.18	0.18	0.18	0.18
Standard deviation																				
0.007	0.007	0.004	0.005	0.004	0.005	0.004	0.005	0.011	0.013	0.009	0.011	0.011	0.025	0.019	0.013	0.011	0.007	0.007	0.004	0.005

Table 13 – The results of the development process with the use of sensitometer T 51003-3536 and densitometer T 52004-N0600.

Box number																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.16	0.16	0.16	0.17	0.18	0.18	0.2	0.24	0.37	0.69	1.34	2.14	2.91	3.45	3.83	4.05	0.16	0.16	0.16	0.17	0.18
0.17	0.18	0.18	0.18	0.18	0.18	0.2	0.24	0.37	0.69	1.34	2.15	2.9	3.46	3.82	4.05	0.17	0.18	0.18	0.18	0.18
0.18	0.18	0.18	0.18	0.18	0.18	0.2	0.24	0.39	0.71	1.36	2.16	2.92	3.48	3.85	4.07	0.18	0.18	0.18	0.18	0.18
0.18	0.18	0.18	0.18	0.18	0.18	0.2	0.24	0.38	0.71	1.36	2.14	2.92	3.51	3.87	4.07	0.18	0.18	0.18	0.18	0.18
0.18	0.18	0.18	0.18	0.18	0.18	0.2	0.24	0.37	0.7	1.36	2.15	2.91	3.48	3.85	4.06	0.18	0.18	0.18	0.18	0.18
Mean optical density																				
0.17	0.18	0.18	0.18	0.18	0.18	0.20	0.24	0.38	0.70	1.35	2.15	2.91	3.48	3.84	4.06	0.17	0.18	0.18	0.18	0.18
Standard deviation																				
0.009	0.009	0.009	0.004	0.000	0.000	0.000	0.000	0.009	0.010	0.011	0.008	0.008	0.023	0.019	0.010	0.009	0.009	0.009	0.004	0.000

Table 14 – Results of the process of developing with the use of sensitometer T 51003-3536 and densitometer N 1031.

Box number																				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Mean optical density																				
0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Standard deviation																				
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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