The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2166-Handout

College on Medical Physics. Digital Imaging Science and Technology to Enhance Healthcare in the Developing Countries

13 September - 1 October, 2010

Basics of Fluoroscopic X-ray Equipment Quality Control

Slavik Tabakov
King's College London
United Kingdom

8.1 BASICS OF FLUOROSCOPIC X-RAY EQUIPMENT QUALITY CONTROL

8.1.1 Tasks

Quality Control (QC) of all contemporary fluoroscopic X-ray equipment relates to assessment of its imaging chain, assuming that the X-ray tube and generator have been already tested and perform well. This QC is based on understanding the functioning of the image chain, importing test images (through test objects) and assessing the qualities of these test images.
Approximate time for performing the task - 2 days (2 X-ray hours) - most of this task is based on in-class reading and observation.
The fluoroscopic X-ray equipment should only be used under the supervision of an approved member of the staff.
Measurement of the Conversion factor of the II is optional and must be performed only by qualified service engineer.

8.1.2 Competencies Addressed

Understanding and measuring the parameters of fluoroscopic X-ray equipment; Understanding the concepts of image test objects and their practical use.

8.1.3 Equipment and Materials

Block diagrams of fluoroscopic X-ray equipment.
Information and images from several types of image test objects.
A set of image test objects (minimum: edge phantom, spatial resolution phantom, contrast resolution phantom - overall image quality phantom).
Copper plate 1 mm thick and with surface about 150 x 150 mm.
Tape measure.
Dosimeter with flat ionisation chamber.
Oscilloscope.
(Photometer - optional).

8.1.4 Procedures and Measurements

8.1.4.1 Familiarisation with Block Diagrams of Fluoroscopic X-ray Equipment

Study the Block diagram of a fluoroscopic X-ray unit and identify it's basic parts and their interrelation.
Study the block diagram of the Image Intensifier and identify it's parts.
Comment on different types of luminifors used in II.
Study the block diagram of the TV video camera and identify it's parts.
Comment on different types of TV camera tubes.
Study the concepts of II Conversion factor and Contrast ratio.
If possible, discuss with the certified local service engineer the possibility to observe measurement of II Conversion factor [$cd/m^{2}.\mu Gy/s$] for two II image field sizes. For the purpose it is necessary to:
a) Open the output screen of the II; b) Attenuate the X-ray output with 0.5 mm Cu; c) Select the kV at approx. 75 kV; d) Adjust the II input dose rate to

approx. 1-10 μGy/s; e) Measure the corresponding II output luminance [cd.m^{-2}] with the photometer.

8.1.4.2 Familiarisation with Different Types of Image Test Objects

Study the images of several types of test objects.

Study the parameters of these test objects.

Use the table given below (based on real measurements) to draw the contrast-detail diagram using the test object for overall imaging assessment [min. visible contrast] as a function of the [corresponding detail size].

Row (for TO10)	**Detail size** diameter		Detail number and **limiting contrast** with II field size (using Leeds Test Object TO10 with ABC system on)				
	[mm]	II image field = 30cm		II image field = 23cm		II image field = 17cm	
		80kV	0.2mA	80kV	0.6mA	80kV	1.2mA
A	**11.1**	6	**0.032**	6	**0.032**	6	**0.032**
B	**7.9**	6	**0.032**	6	**0.032**	6	**0.032**
C	**5.6**	6	**0.032**	6	**0.032**	6	**0.032**
D	**4**	6	**0.045**	6	**0.045**	6	**0.045**
E	**2.8**	5	**0.066**	6	**0.045**	6	**0.045**
F	**2**	5	**0.066**	5	**0.066**	5	**0.066**
G	**1.4**	4	**0.16**	6	**0.086**	6	**0.086**
H	**1**	3	**0.23**	4	**0.16**	5	**0.123**
J	**0.7**	2	**0.35**	3	**0.23**	4	**0.16**
K	**0.5**	1	**0.93**	3	**0.5**	4	**0.35**
L	**0.35**	0	**0.99**	1	**0.93**	3	**0.5**
M	**0.25**	0	**0.99**	0	**0.99**	1	**0.93**

Using the data in the table, calculate the threshold detection index H_T where $H_T = [C_T(A).A^{1/2}]$. C_T is the threshold contrast for each detail A, and $A^{1/2}$ is the square root of the area of this detail A.

Plot the threshold detection index function $H_T = F[A^{1/2}]$.

8.1.4.3 Familiarisation with the Concepts of II Image Brightness and Contrast and with Video Signal Assessment.

Connect the oscilloscope to the signal from the II TV camera - either at the special output of TV monitor or with a T-junction BNC connector (remember to terminate the TV signal chain (normally with 75 ohm special terminator).

Set the oscilloscope parameters to 0.2 V and 10 μs/per division (TV signal measurements).

Use X-ray beam with 1 mm Cu attenuation and place the Step-wedge phantom (in case of Leeds test objects - Gray scale TOGS) as close as possible to the II, observe the set contrast and brightness and mark the proper position of the TV monitor contrast and brightness knobs.

Record the maximal amplitude of the video signal and measure the II entrance dose rate for this reference image.

If possible, change the TV monitor brightness and contrast in order to lose visibility of one step from the wedge.
If possible, switch off the automatic brightness control (ABC) system and adjust the X-ray parameters of the fluoroscopy system until the step is again visible.
Record again the maximal amplitude of the video signal and measure the II entrance dose rate for this new image.
Replace the Step-wedge phantom with the Edge-phantom (in case of Leeds test objects - TOE1) or simply cover half of the II input with a piece of lead (2 mm Pb) with a sharp edge, in order to have the image separated to two vertical areas - black and white.
Select the appropriate II entrance dose rate (according to the manufacturers specifications) - normally this is in the region of 0.2 - 10 μGy/s.
Measure (at least for two II field sizes) the specific parts of the video signal, given on the figure, and record them in the table:

Video signal parameter	[mV] @ II size….	[mV] @ II size….
Sync. pulse/ blanking		
Blanking/black level		
Loss of contrast (black)		
Camera noise (black) P-Pmax		
Blank/white ampl.		
Camera & quantum noise (white) P-P		
Vignetting slope		
Dose rate mR/min		
kVp/mA		

8.1.5 Calculations

8.1.5.1 Familiarisation with Block Diagrams of Fluoroscopic X-ray Equipment
Compare the characteristics of two TV camera tubes - Vidicon and Plumbicon.

8.1.5.2 Familiarisation with Different Types of Image Test Objects
Compare the Contrast-detail Characteristic with the Normal values given in the Reference (IPSM Report 32).
Compare and comment on the two different Contrast-detail functions.

8.1.5.3 Familiarisation with the concept of II Image Brightness and Contrast and with Video Signal Assessment
Compare the difference in video signal amplitude and II entrance dose rate for a screen with adjusted and mis-adjusted contrast and brightness.
Compare the noise on the video signal in both of the above cases.
Compare and comment on the difference in video signals for two different II image field sizes.

8.1.6 Observations, Interpretations, Conclusions

Comment on the effectiveness of the Fluoroscopic X-ray Equipment and explain why the patient dose during fluoroscopy is greater than that in radiography.

Comment on the possible areas of application of the different TV camera tubes.

Observe the plotted contrast-detail functions and comment on their dependence on II image field size.

Describe a video signal with NOT-Acceptable parameters.

8.1.7 References

IPSM Report 32 - part II - X-ray Image Intensifier Television Systems

M.Thompson, ,J. Hall, M.Hattaway, S.Dowd, Imaging Science and Protection Saunders Co, 1994

M.Tortorici, Concepts in Medical Radiographic Imaging, Saunders Co, 1992

Technical and Physical Parameters for Quality Assurance in Medical Diagnostic Radiology, BIR Report 18, 1989

S.Armstrong, Physics of Radiology, Clinical Press, 1990

Verification

Signature and date by the trainer:

Name of the Trainee:_____

Comments:_____

_____

_____

Date:_____Trainer's sign:_____

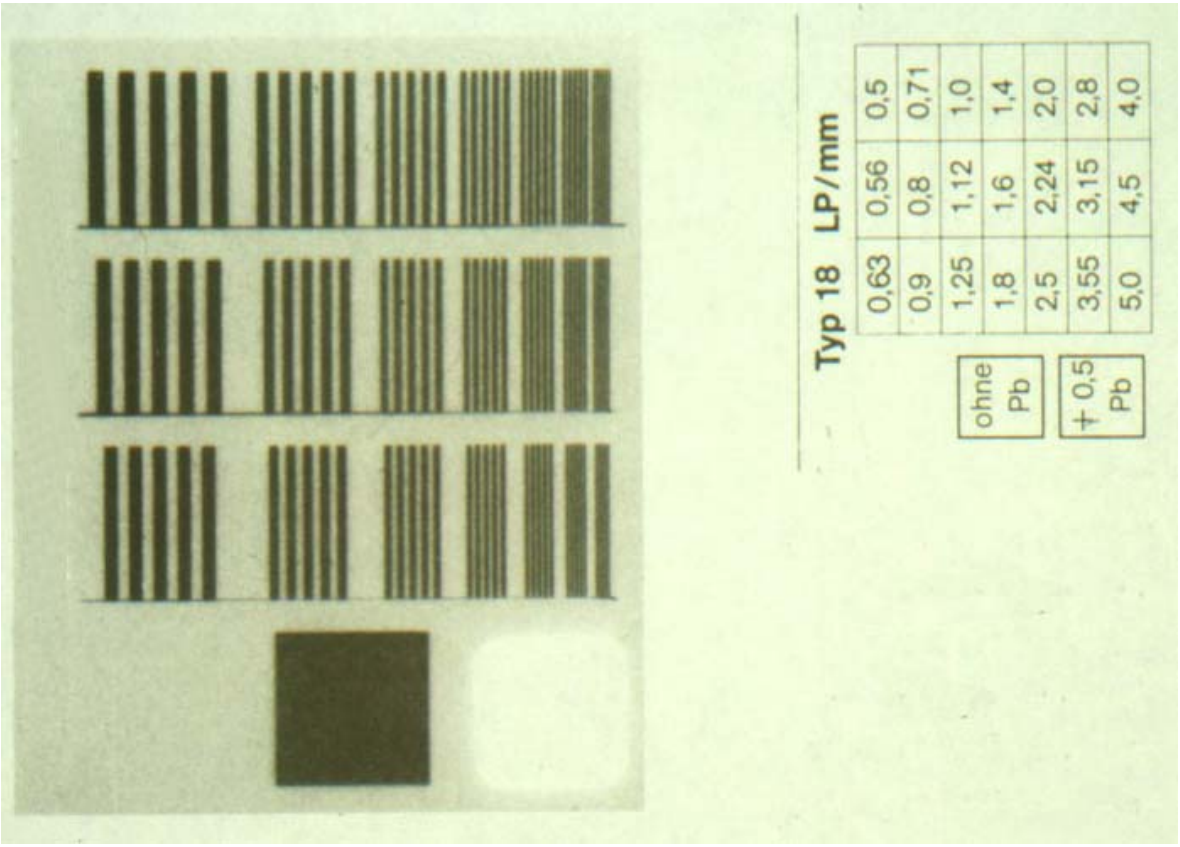
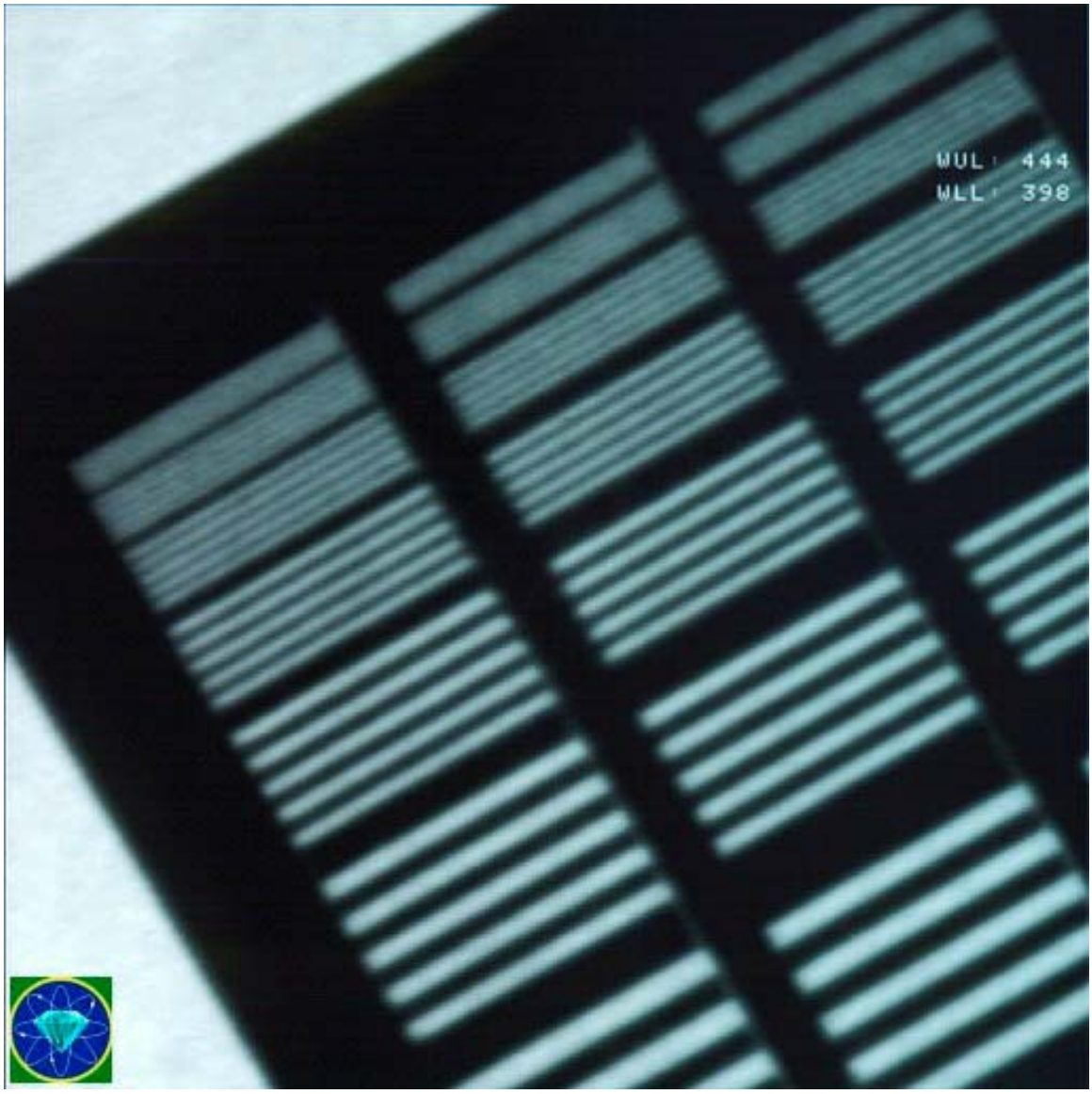
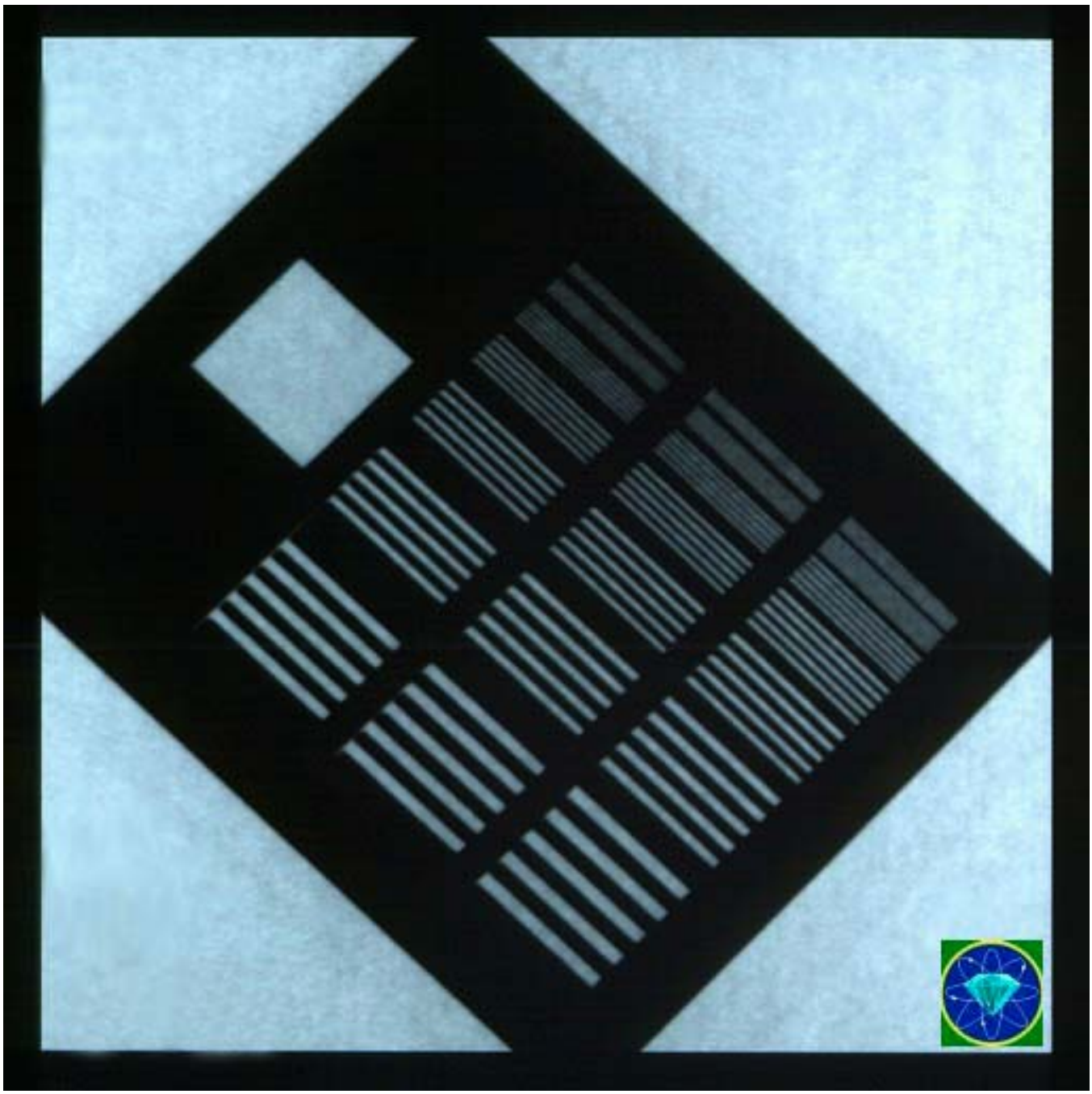
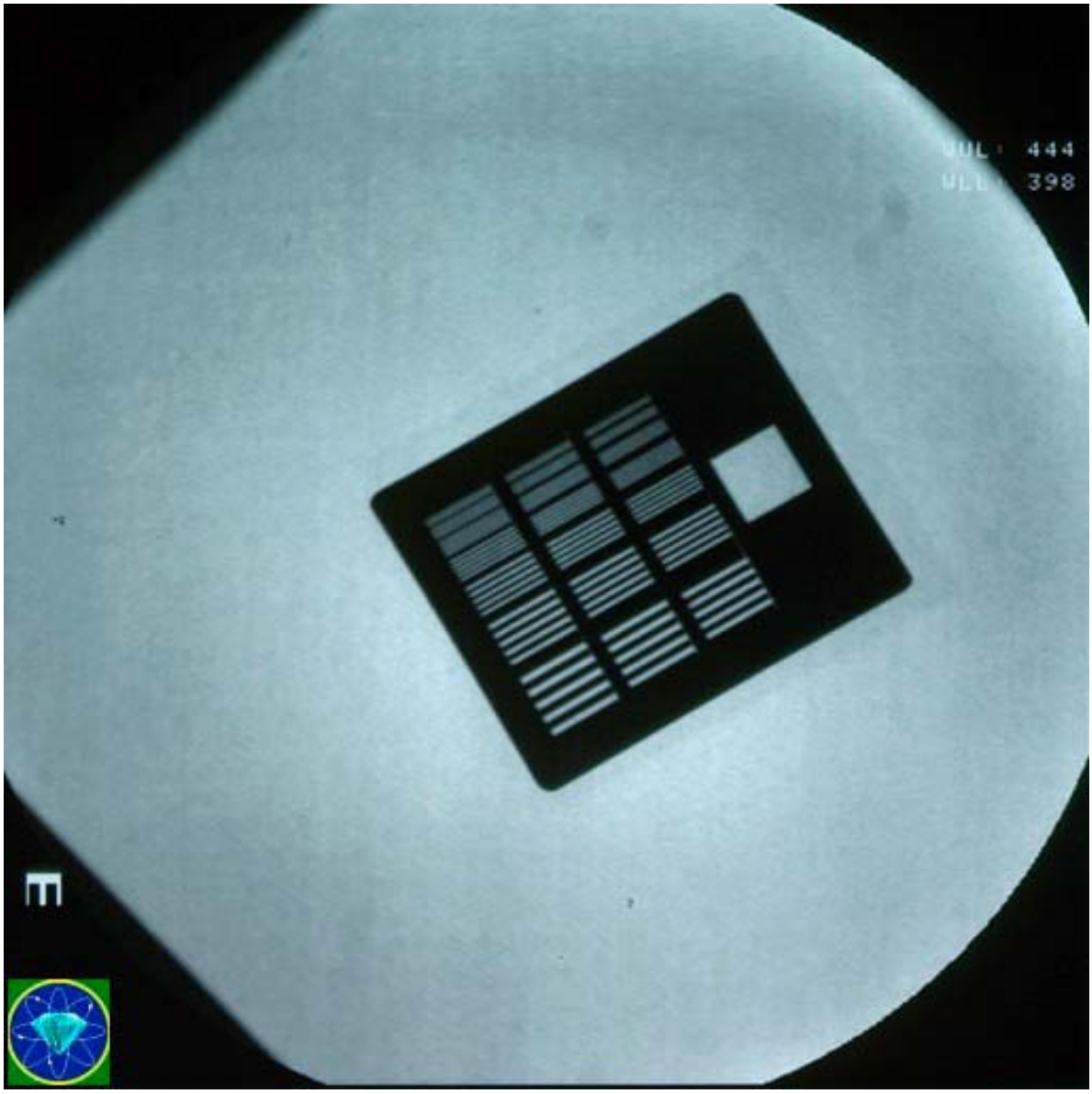


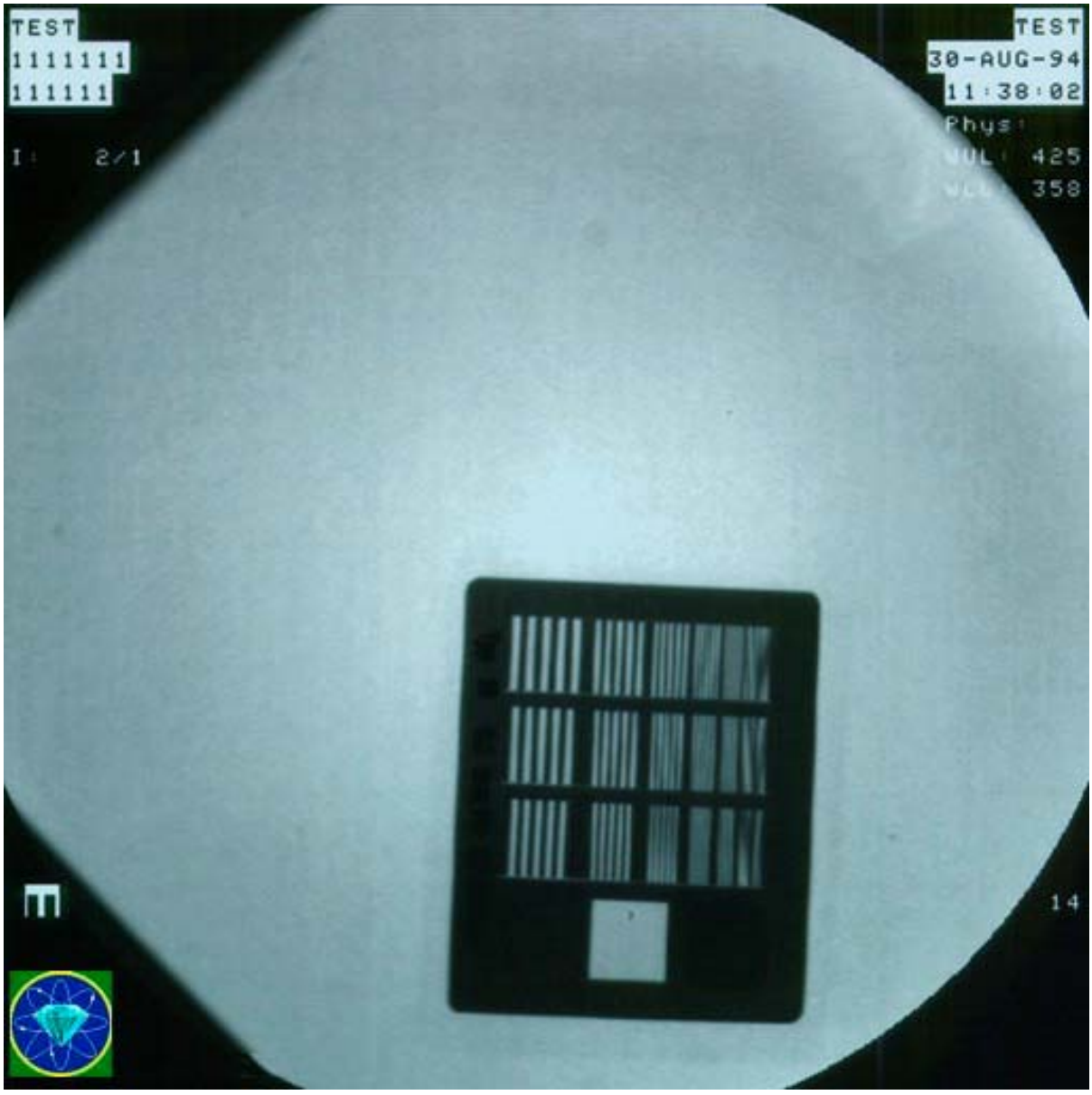
Table 8.3.5 High Spatial Contrast Resolution

Field Size	Read/Set kV	Read/Set mA	group No	lp/mm


WUL: 444
WLL: 398




444
398


TEST
1111111
111111
I: 2/1
TEST
30-AUG-94
11:38:02
Phys:
VUL: 425
VCL: 358
14

Row (for TO10)	**Detail size** diameter		Detail number and **limiting contrast** (using Leeds Test Object TO10 with ABC on) II image field =				
	[mm]	II - good qual. object	contrast	II - poor quality object	contrast	object	contrast
A	**11.1**						
B	**7.9**						
C	**5.6**						
D	**4**						
E	**2.8**						
F	**2**						
G	**1.4**						
H	**1**						
J	**0.7**						
K	**0.5**						
L	**0.35**						
M	**0.25**						

Row (for TO10)	**Detail size** diameter [mm]	II image field =	Detail number and **limiting contrast** (using Leeds Test Object TO10 with ABC on) II image field =		II image field =		
		30cm object	contrast	23cm object	contrast	17cm object	contrast
A	**11.1**						
B	**7.9**						
C	**5.6**						
D	**4**						
E	**2.8**						
F	**2**						
G	**1.4**						
H	**1**						
J	**0.7**						
K	**0.5**						
L	**0.35**						
M	**0.25**						

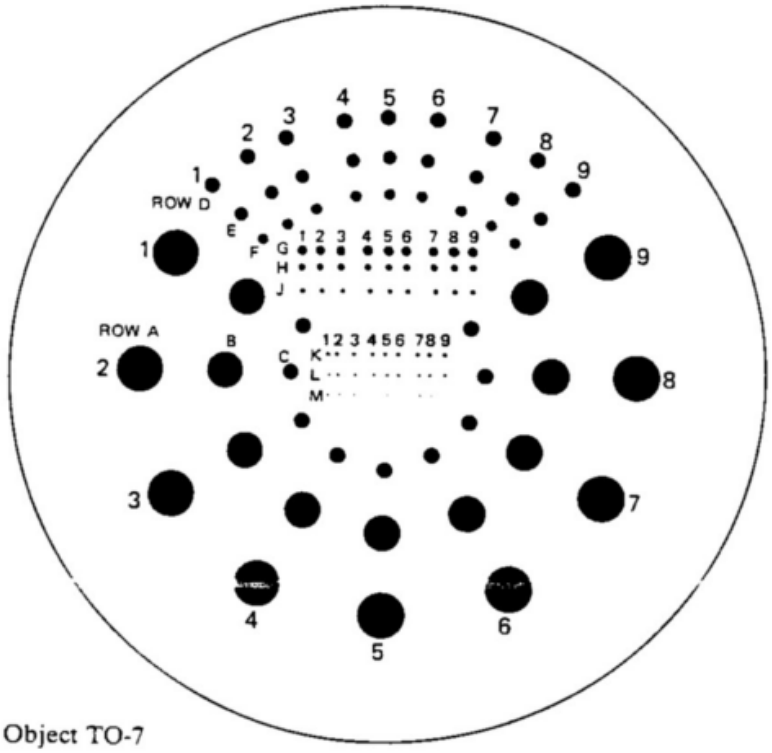
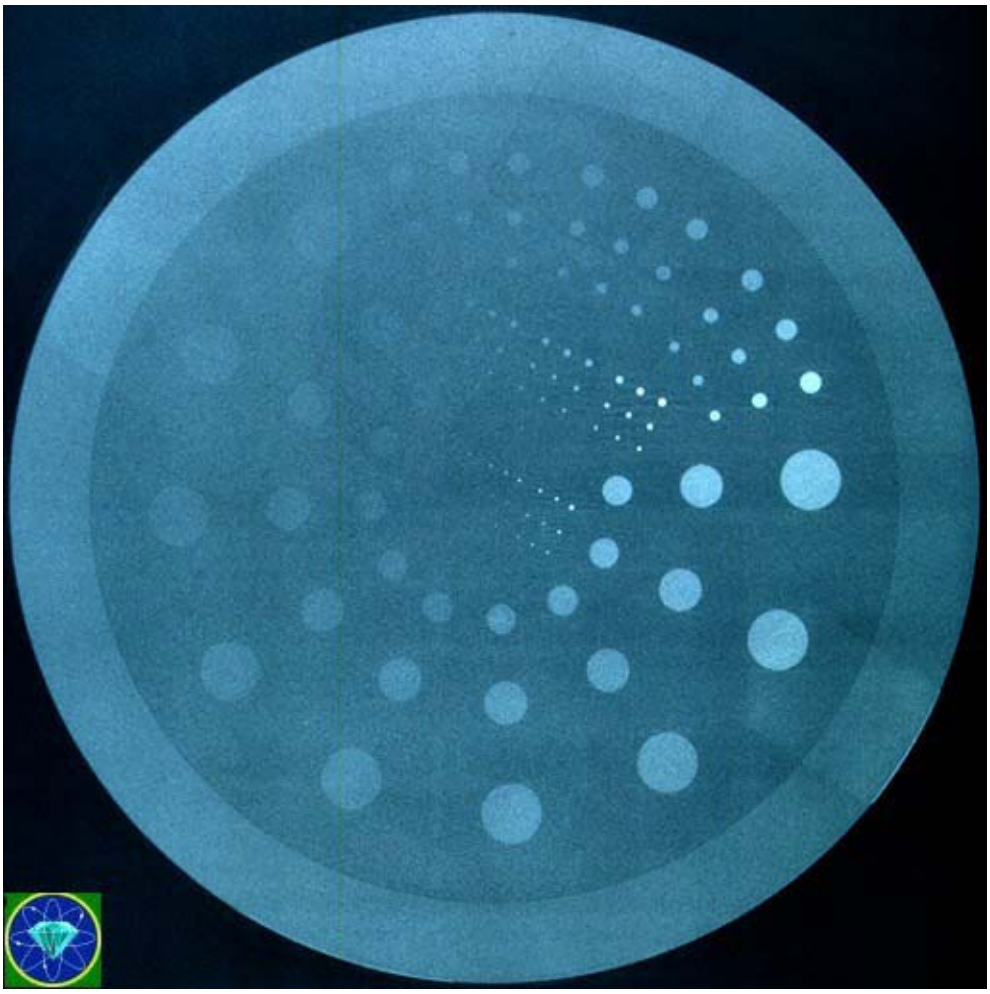
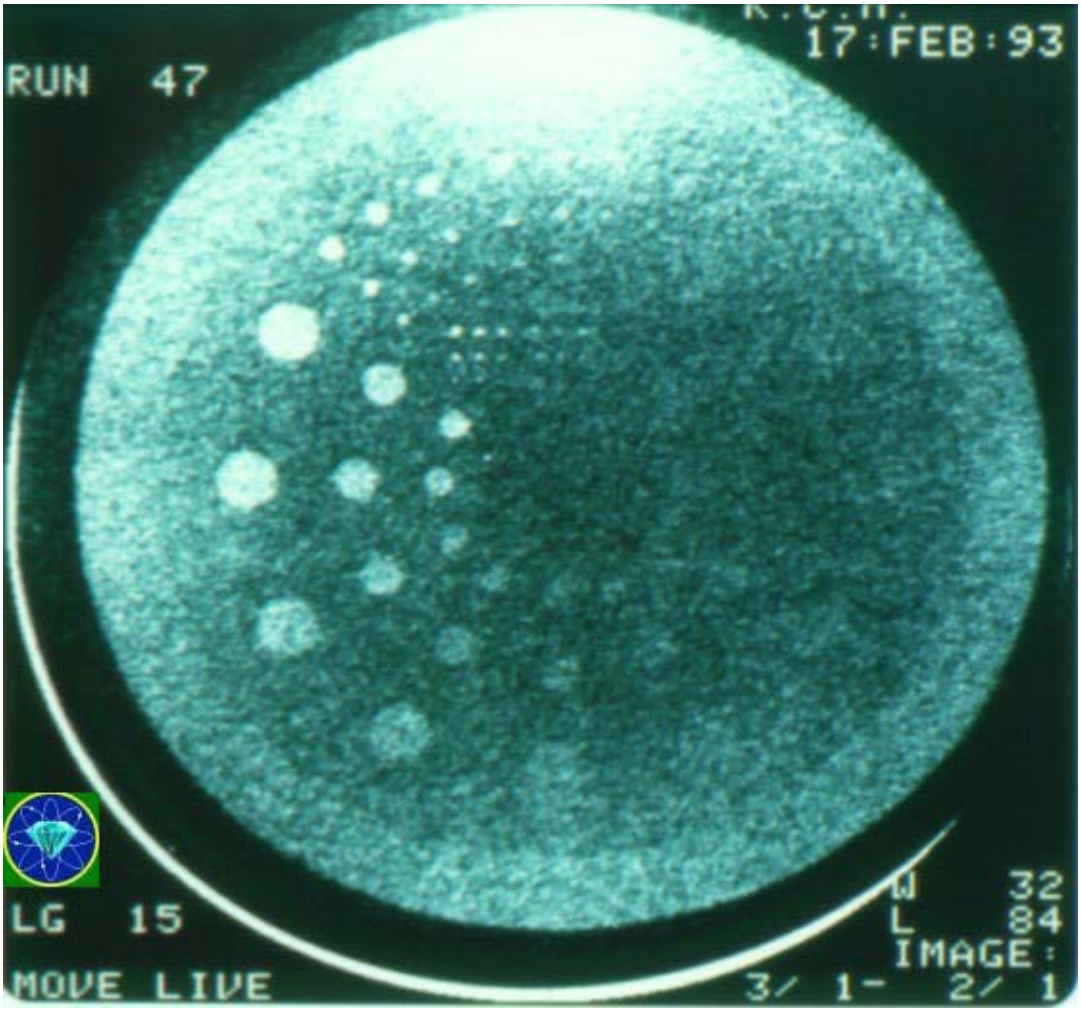


Figure 5. Test Object TO-7

Table 3. Description of Test Object TO-7
X-ray contrasts for each row (A to M) containing 9 discs

Row	Dia. mm	Disc number 1	2	3	4	5	6	7	8	9
A	11.1	.16	.125	.088	.063	.044	.022	.016	.011	.0075
B	7.9	.16	.125	.088	.063	.044	.022	.016	.011	.0075
C	5.6	.16	.125	.088	.063	.044	.022	.016	.011	.0075
D	4.0	.23	.16	.125	.088	.063	.044	.022	.016	.011
E	2.8	.23	.16	.125	.088	.063	.044	.022	.016	.011
F	2.0	.23	.16	.125	.088	.063	.044	.022	.016	.011
G	1.4	.50	.34	.23	.16	.125	.088	.063	.044	.022
H	1.0	.50	.34	.23	.16	.125	.088	.063	.044	.022
J	0.7	.50	.34	.23	.16	.125	.088	.063	.044	.022
K	0.5	.95	.68	.50	.34	.23	.16	.125	.088	.063
L	0.35	.95	.68	.50	.34	.23	.16	.125	.088	.063
M	0.25	.95	.68	.50	.34	.23	.16	.125	.088	.063




17:FEB:93
RUN 47
LG 15
W 32
L 84
IMAGE:
MOVE LIVE
3/ 1- 2/ 1