

# Examination Radiographs and Master Reports for the Industrial Sectors 6 and 7

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**Abstract:** The qualification and certification of NDT personnel in the following industrial sectors: number 6 - metal manufacturing, and number 7 - pre and in-service testing of equipment, plant and structure (combining product sectors: c-casting, f - forging, t - pipes and tubes, w – welded products, and wp - wrought products) [1], involves a wider scope of training and examination. An example of the examination radiographs and master reports in industrial sectors 6 and 7 has been presented in the paper. The radiographs and related master sheets comprise: i) in the sector 6, the welded specimen (product sector “w”) composed of casting (product sector “c”) and pipe (product sector “t”), and in the sector 7, the specimen consisting of pipe with sediment and corrosion attack.

## Introduction

The qualification and certification of NDT personnel who performs non destructive testing in the industrial sectors 6 – “metal manufacturing”, and 7 – “pre and in-service testing of equipment, plant and structure” (combining product sectors c, f, t, w and wp) [1] requires the adequate radiographs and related master reports for RT(2) practical examination. Level 2 operators are sometimes faced against interpretation of radiographs of different products (sector 6) or related to in-service induced anomalies (sector 7) [2].

## 1. Industrial sector 6 – metal manufacturing

### 1.1 Test specimen and RT instruction

In Fig.1 is shown the radiographic testing instruction (test sheet) for a test specimen in form of weld seam (sector “w”) joining steel pipe (“t”) and steel casting (“c”) [3]. The outer diameter of pipe and wall thickness are  $\varnothing 610 \times 10$  mm respectively. The radiographs have been performed using Ir-192 source and D5 Agfa film (RT testing class “A” – standard sensitivity).

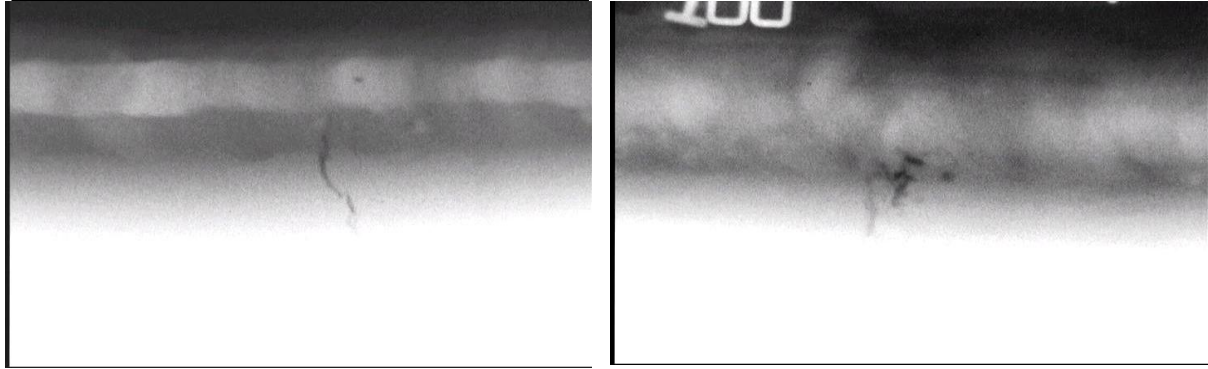
### 1.2 Examination radiograph and master report

In Fig. 2 are presented two radiographs of the reported specimen. The master report for one of these radiographs has been proposed in the Fig. 3 and 4.



179

187



a)

b)

Fig. 2. Radiographs of the welded joint of pipe  $\phi$  610 x 10 mm to valve (steel casting)

For interpretation of the radiographs shown in Fig.2, the knowledge of welding and casting imperfections is indispensable. The transversal crack visible on the radiograph “a”, localised mostly in casting (designation “D” for casting and “102” for welding), has been probably initiated by thermal cycle of welding. Similar crack on radiographs “b” is accompanied with non-metallic inclusions or pores or shrinkage in casting (designation “B” or “A” or “C” respectively). In the weld itself, there are some pores (2011), the biggest probably in root pass. The examination radiographs should be as unambiguous as possible in sense of “master” interpretation, in order to reduce the uncertainty of interpretation by examinees. For this reason, only radiograph “a” has been considered as suitable for examination purposes and described in master report (Fig. 3, 4 ).

## 2. Industrial sector 7 – pre and in-service testing of equipment, plant and structure

### 2.1 Test specimen and RT instruction

Test instruction for radiographic inspection of a water desalination steel pipeline ( $\phi$  170 x 10 mm) with deposit and corrosion attack [4] has been presented in the Fig.5. The radiographs has been performed using Ir-192 source and Kodak A film. There are no standard requirements for this kind of test. Therefore, RT testing class “A” of normal sensitivity ( or below) has been accepted.

### 2.2 Examination radiograph and master report

The master report and copy of the examination radiograph typical for in-service inspection (sector 7) are shown in Fig. 6 and Fig 7 .

1. Kind of product : circumferential butt weld joining pipe to body of valve (casting), arc welding – covered electrode (111)												
2. Material : pipe: carbon steel; body of valve: steel casting												
3. Dimensions : outer diameter $\phi$ 610 mm, wall thickness $s = 10$ mm ; weld type „V”, one side welding; examined length of weld $L = 1885$ mm.												
4. Method, technique of test:		Arrangement : panoramic (EN 1435, Fig. 5)			Source: Ir <sup>192</sup> , 2,8x2,8mm, 2,5TBq		Film: D5, rollpack		Screens Pb 0,027/0,027	SFD: 305 mm		
		Number of exposures: 1			Number and dimension of films for each exposure: 1 (6 x 200 cm)							
		Test class : A			Quality Level: C (ISO EN 5817)			Acceptance level: (*) 2 (EN 12517)				
5.	EXAMINATION RESULTS: preliminary VT and radiographic testing RT report											
Ordinal number	Designation of specimen, material (see legend below)	Designation of radiograph	Arrangement ( fig. No. EN 1435)	Density of radiograph	Penetrated /tested thickness (mm)	Readings: IQI number, test class (A, B)	MASTER REPORT OF IMPERFECTIONS / IN-SERVICE ANOMALIES			Evaluation (*)		Re- mar- ques
							FOR WELDS : designation (symbol) ; coordinates [x, y, z]; length [ l =.....mm], accumulated length [ $\Sigma l$ =.....mm] ; FOR CASTINGS : designation (symbol) ; coordinates, severity level (if applicable); FOR IN-SERVICE INDUCED ANOMALIES: name(symbol); coordinates, characteristic dimension(s) (ex. length,width,area)			...EN 12517....	..acc. level.2..	
						Results of preliminary VT	imperfections welds acc. to EN ISO 6520-1	imperfections castings acc. to EN 12681	In-service induced anomalies	no relevant imperfections	Imperfections acceptable	non acceptable
							100 - cracks 200 – cavities, (pores) 300 – solid inclusions 401 – lack of fusion 402 – lack of penetration 5013 – shrinkage groove 515 – root concavity 504 – excess penetration other imperfections	A- Gas porosity B- Sand and slag inclusions C <sub>1</sub> - Shrinkage type C1 C <sub>2</sub> - Shrinkage type C2 C <sub>3</sub> - Shrinkage type C3 D - Crack E – Hot tears F - Insert other imperfections	P- cracks U – material / thickness reduction U <sub>k</sub> – corrosion U <sub>e</sub> – erosion U <sub>z</sub> - wear O-deposit other anomalies			
1	SOR V <sub>obw</sub> CS	RT- Z34L Co- ord. 179- 187	No. 5 pa- no- ra- mic	2 <u>0,2<sup>#</sup></u> pkt.	10	W13 A (***) <u>0,2<sup>#</sup></u> pkt.	n=1,5 b=20 p <sub>max</sub> =1 conca- vity (**)	★ 102; X =183-4 cm; l > 20mm (in casting & weld), $\Sigma l > 20$ mm <u>0,4<sup>#</sup> pkt.</u>  2011 or 3012; X = 185cm; l =1 mm, $\Sigma l = 1$ mm <u>0,2<sup>#</sup>pkt.</u>	★ D or E; X=183-4 cm <u>0,6<sup>#</sup> pkt.</u>			X  <u>0,6<sup>#</sup></u> pkt.

CS – carbon steel; SS – stainless steel; Al – aluminium; S - weld; O – casting; R – pipe; B – plate; V, X, K type of weld; T – T-joint

Sk<sub>wp</sub> – weld of “internal” nozzle; Sk<sub>na</sub> – weld of “external” nozzle

(\*) – different acceptance criteria for the group of radiographs or individual radiographs can be used in one examination set of radiographs

(\*\*\*) – In case the IQI is not visible on the reported radiograph, the IQI number should be given in the exam paper, and image quality class estimated by the examinee.

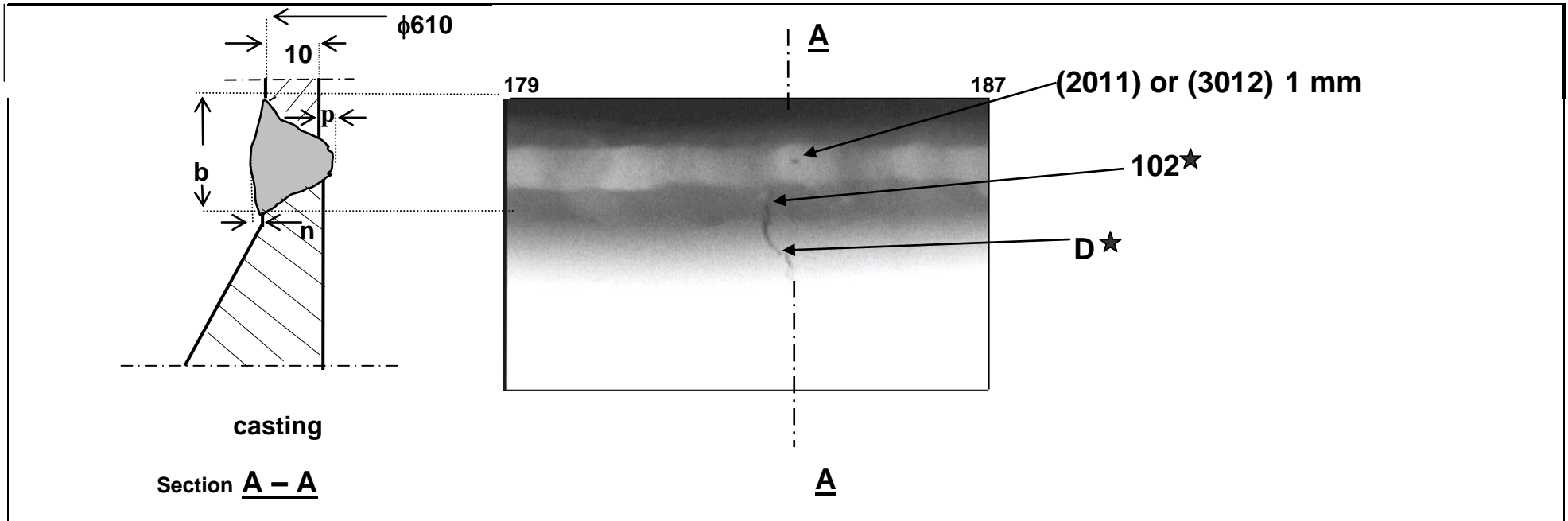
... # pkt. – grading points – max. 2,2 pkt (points) for each evaluated radiograph !

24 rdg. x 2,2 pkt = 52,8 pkt (points) + max. 2,2 pkt (points) for general presentation of the test rapport (examiner authority) = max. 55 (conform to Table D1 PN-EN 473).

★ - interpretation elements “mandatory for candidates to report”; failing will be awarded zero marks for the radiograph interpreted.

Fig. 3. Proposal of Master Sheet (page 1 of 2) for the examination radiograph shown in Fig. 2a (sector number 6)

**COPY OR SCHEMATIC ILLUSTRATION OF RADIOGRAPH**  
with indication(s) / imperfection(s) mandatory for candidate to report



★ - imperfection(s) mandatory for candidates to report. Failing will be awarded zero marks for the radiograph(s) interpreted.

**MASTER SHEET PREPARED BY:**

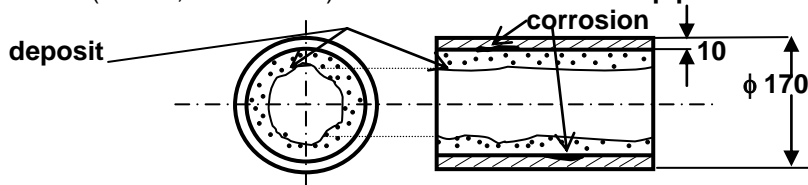
FIRST INTERPRETER NAME : CERTIFICATE:	DATE : SIGNATURE :	SECOND INTERPRETER NAME : CERTIFICATE:	DATE : SIGNATURE:
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Validation : Date.....

.....  
NAME.....Cert. RT3 No. ....

Fig. 4. Proposal of Master Sheet (page 2 of 2) for the examination radiograph - sector number 6

TEST SPECIMEN (sketch, dimensions): See water desalination pipeline



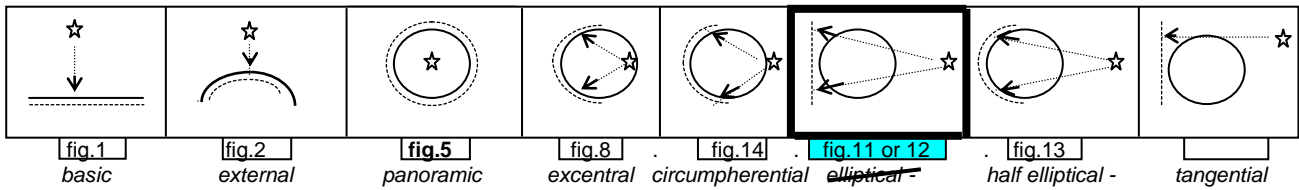
Material: **pipe-carbon steel; deposit – water stone**

TEST PURPOSE : **in service inspection of deposit and corrosion**

QUALITY LEVEL : **na.** TEST CLASS : **„A” or below** ACCEPTANCE LEVEL: **to be determined**

TEST ARRANGEMENT (Fig. numbers acc. to PN-EN 1435),

MARK ARRANGEMENT/ TEST TECHNIQUE APPLIED :



nbr of exposures  
for 1 area : 2  
(examined object)

nbr of films/cassettes  
for 1 exposure,  
sizes: 1, 10x24 cm

RX or gamma unit  
(type): **Gamma TIF**

PROTECTION AGAINST  
SCATTERED RADIATION:

Filter before object: **NO**

collimator: **YES** Mask: **NO**

Filter between object and cassette: **NO** Screen behind cassette: **1 mm Pb**

TEST PARAMETERS:

SOURCE kind, dimensions, activity [TBq] [kV, mA] [mm]	FILM, SCREENS kind, thickness, front / back [mm]	THICKNESS OF TESTET MATERIAL min / max		EFFEC- TIVE DIMEN- SION OF SOURCE [mm]	D I S T A N C E [mm]			EXPO- SURE  TIME [sec], [min]	DEVELO- PMENT autom., manual chemicals [°C] [min]
		penetrated [mm]	evaluated [min]		„b” defect - film	„f <sub>min</sub> ” source – object	„SFD” source – film: min/applied		
<b>Ir-192</b> <b>2 TBq</b> <b>3 x 2</b> <b>mm</b>	<b>Kodak</b> <b>A</b> <b>0,1/0,1</b> <b>Pb</b>	<b>2x10 Fe</b> <b>+deposit /</b> <b>≈ 80 Fe</b>	<b>2x10 Fe</b> <b>+deposit /</b> <b>≈ 80 Fe</b>	<b>3,0</b>	<b>85</b> <b>(½ ext.</b> <b>diam. of</b> <b>pipe)</b>	<b>class A</b> <b>EN 444</b> <b>b = 85</b> <b>f<sub>min</sub>=450</b>	<b>450 + 85</b> <b>= 535 /</b> <b>935</b>	<b>6,5 min</b>	<b>manual</b> <b>20°C</b> <b>5 min</b>

Enlargement: **measured on radiograph, ≈ 6%** ; Ext. diam. real = 170 mm, on radiograph ≈ 180 mm

Requested image quality.: **not specified**

Film density D (min): **about 2,0**

IQI: **6 ISO 12 Fe**

source side : **---**

film side: **X (F)**

Film interpretation: **RT Level 2;** according to: **client requirements** ; quality/accept.level: **weld : na.**

<i>Prepared: M. Dobrowolski, RT-3</i> (signature,date)	<i>Verified:</i> (signature,date)	<i>Operator: M. Dobrowolski</i> (signature,date)
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Fig. 5. RT – test instruction ( sector number 7)

1. Kind of product : Sea water desalination pipeline														
2. Material : Pipe: carbon steel / sediment – water deposit														
3. Dimensions : pipe outer diameter $\phi$ 170, wall thickness s = 10 mm;														
4. Method, technique of test: (in-service inspection)		Arrangement : perpendicular (EN 1435, Fig. 12)			Source: Ir <sup>192</sup> , 3x2 mm, 2,0 TBq		Film: KODAK A		Screens Pb 0,1 / 0,1	SFD: 935 mm				
		Number of exposures: 2 (90°)			Number and dimension of films for each exposure: 1 (10 x 24 cm)									
		Test class : A, <A			Quality Level: -----			Acceptance level: (*) see remarks						
5.	EXAMINATION RESULTS: preliminary VT and radiographic testing RT report													
Ordinal number	Designation of specimen, material (see legend below)	Designation of radiograph	Arrangement ( fig. No. EN 1435)	Density of radiograph	Penetrated /tested thickness (mm)	Readings: IQI number, test class (A, B)	Results of preliminary VT	MASTER REPORT OF IMPERFECTIONS / IN-SERVICE ANOMALIES FOR WELDS : designation (symbol) ; coordinates [x, y, z]; length [ l =.....mm], accumulated length [ $\Sigma$ l=.....mm] ; FOR CASTINGS : designation (symbol) ; coordinates, severity level (if applicable); FOR IN-SERVICE INDUCED ANOMALIES: name(symbol); coordinates, characteristic dimension(s) (ex. length,width, area)			Evaluation(*) ...see remarks...			Re- mar- ques
								imperfections welds acc. to EN ISO 6520-1	imperfections castings acc. to EN 12681	In-service induced anomalies	no relevant imperfections	Imperfections acceptable	Imperfections non acceptable	
	Pipe with de-posit	RT/7 RTG -1	No. 12	$\approx$ 2 0,2# pkt.	20 Fe + de-posit / 80 Fe	W9 <A (***) 0,2# pkt.	no indications	not applicable			1.★ "O" – deposit, thick-ness=25-40 mm; 1,0# pkt 2. U <sub>k</sub> under deposit, h $\approx$ up to 20% thickness of the pipe wall "t"; 0,2# pkt	X 0,6# pkt.	Acc. limits O<10 mm; U<10 % t	

CS – carbon steel; SS – stainless steel; Al – aluminium; S - weld; O – casting; R – pipe; B – plate; V, X, K type of weld; T – T-joint ; Sk<sub>wp</sub> – weld of "internal" nozzle; Sk<sub>na</sub> – weld of "external" nozzle;

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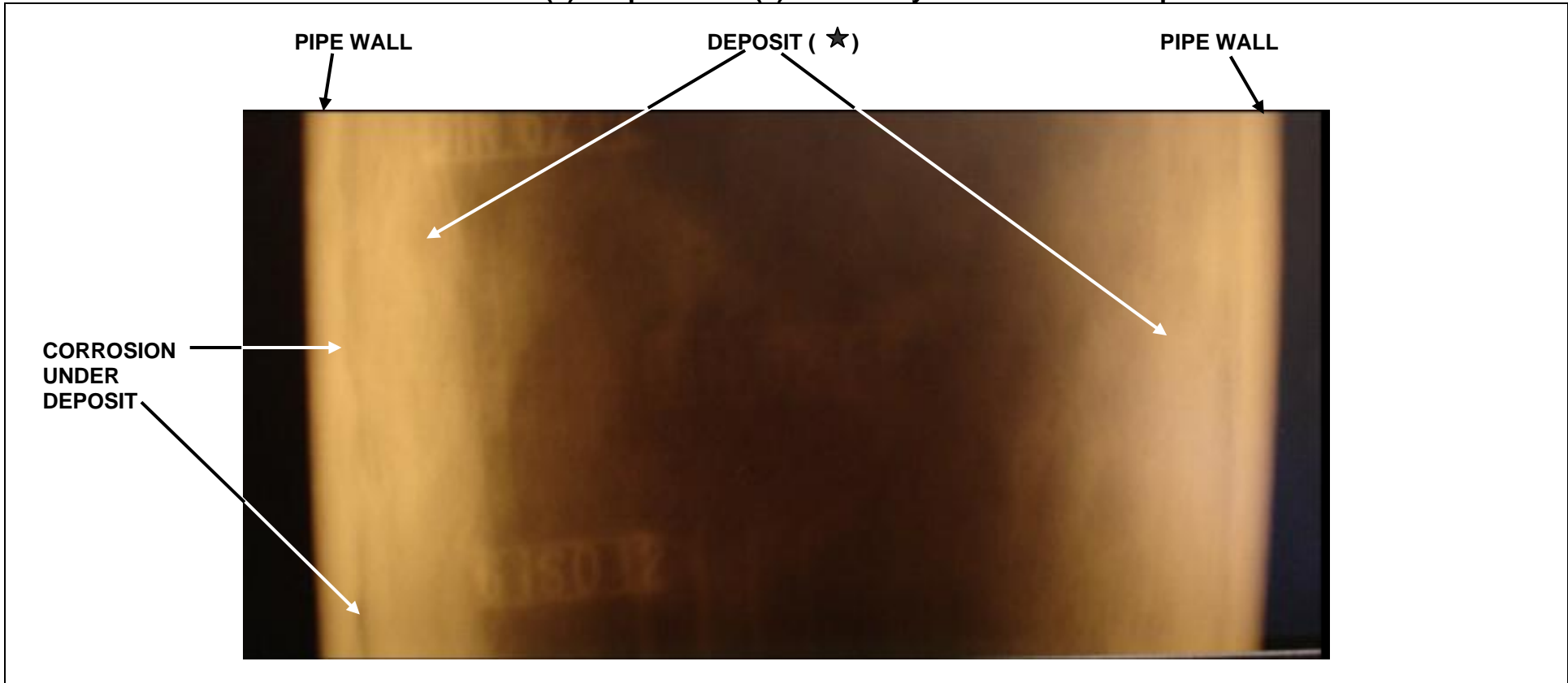
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★ - interpretation elements "mandatory for candidates to report"; failing will be awarded zero marks for the radiograph interpreted.

Fig. 6. Proposal of Master Sheet for examination radiograph – page 1 of 2 (sector number 7)



**COPY OR SCHEMATIC ILLUSTRATION OF RADIOGRAPH  
with indication(s) / imperfection(s) mandatory for candidate to report**



**★ - imperfection(s) mandatory for candidates to report. Failing will be awarded zero marks for the radiograph(s) interpreted.**

INTERPRETER 1, NAME : CERTIFIKATE NBR:	DATE : SIGNATURE :	INTERPRETER 1, NAME : CERTIFIKATE NBR:	DATE : SIGNATURE :
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VALIDATION : Date.....  
*name* .Cert. RT3 nr. ....

Fig. 7. Proposal of Master Sheet for examination radiograph – page 2 of 2 (sector number 7)



### 3. Grading

#### 3.1 General principle

For RT practical examination, the test specimen need not contain discontinuities since these will be exhibited on the radiographs for interpretation [1]. Therefore, during the practical radiographic examination RT-2, the part 3 of practical examination “the detection and reporting of the discontinuities, their characterisation (position, orientation, dimension, and type) and evaluation against code, standard, specification or procedure criteria” is managed through the interpretation of 12 or 24 radiographs [1].

#### 3.2 Weighting factors

The weightings factors (marks) for each radiograph interpreted by the candidate under RT-2 examination are presented in the Table 1 below.

Table 1. Film interpretation weighting factors / marks

Part of practical examination / activity	Maximal marks [%]		
	Acc.to EN 473 Level 2	JCO UDT-CERT practice	
		12 radiographs	24 radiographs
<b>PART 3: Detection of discontinuities and reporting</b>			
a) Detection of mandatory reportable discontinuities	15	12 x <b>1,2</b> = 14,4	24 x <b>0,6</b> = 14,4
b) Characterisation (type, position, orientation, apparent dimensions etc.)	15	12 x <b>1,2</b> = 14,4	24 x <b>0,6</b> = 14,4
c) Level 2 evaluation against code, standard, specification or procedure criteria	15	12 x <b>1,2</b> = 14,4	24 x <b>0,6</b> = 14,4
d) Redaction of the test report	10	11,8	11,8
d1) Reading density and IQI		12 x <b>0,8</b> = 9,6	24 x <b>0,4</b> = 9,6
d2) general reporting (examiner authority)		2,2	2,2
<b>TOTAL</b>	<b>55</b>	<b>55%</b>	<b>55%</b>

### References

- [1] PN-EN 473:2000 – Non destructive testing - Qualification and certification of NDT personnel - General principles
- [2] TC138 WI 099–, „NDT-Recommendation for discontinuities-types in test specimens for examination” 2003
- [3] M.Dobrowolski, M.Karusik, M.Śliwowski, NDTEST Wa-wa : „Przykład wzorcowej karty KOR w sektorze przemysłowym 6: „wytwarzania i przetwórstwo metali”, POPÓW 2003 (in Polish)
- [4] M.Dobrowolski UDT-CERT, J.Kozłowski EKOPOL-JRL : „Projekt WKO radiogramu egzaminacyjnego – Sektor przemysłowy 7” , 32 KKBN 2003, Międzyzdroje (in Polish)