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**Non-destructive testing of welds - Radiographic
testing - Part 1: X-and gamma-ray techniques with film**

焊缝无损检测 射线检测 第 1 部分: X 和伽玛射线的胶片技术

(ISO 17636-1:2013, MOD)

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Table of Contents

Foreword.....	3
1 Scope.....	6
2 Normative references.....	6
3 Terms and definitions	7
4 Symbols and abbreviations	9
5 Grading of radiographic testing technology.....	9
6 General rules	10
7 Recommended radiographic testing technology	13
8 Test report.....	29
Appendix A (Normative) Minimum image quality value	31
Appendix B (Normative) Recommended number of exposures for 100% radiographic testing of butt girth welds.....	34

Non-destructive testing of welds - Radiographic testing - Part 1: X-and gamma-ray techniques with film

1 Scope

This part of GB/T 3323 specifies the radiographic testing technology for fusion welding of metallic materials.

This part applies to radiographic testing of welded joints of plates, pipes or other welded joints.

This part does not include the acceptance level of radiographic testing of welded joints of metallic materials.

If the parties to the contract use testing conditions, which are lower than this part, the quality of the testing images is very likely to drop significantly.

Note: This part meets the requirements of GB/T 19943. The detector used is film.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) is applicable to this standard.

GB/T 9445 Non-destructive testing - Qualification and certification of NDT personnel (GB/T 9445-2015, ISO 9712:2012, IDT)

GB/T 12604.2 Non-destructive testing - Terminology - Terms used in radiographic testing (GB/T 12604.2-2005, ISO 5576:1997, IDT)

GB/T 19348.1 Non-destructive testing - Industrial radiographic film - Part 1: Classification of film systems for industrial radiography (GB/T 19348.1-2014, ISO 11699-1:2008, MOD)

GB/T 19348.2 Non-destructive testing - Industrial radiographic films - Part 2: Control of film processing by means of reference values (GB/T 19348.2-2003, ISO 11699-2:1998, IDT)

GB/T 19802 Non-destructive testing - Industrial radiographic illuminators -

Minimum requirements (GB/T 19802-2005, ISO 5580:1985, IDT)

GB/T 19943 Non-destructive test - Radiographic examination of metallic materials by X-and gamma-rays - Basic rules (GB/T 19943-2005, ISO 5579:1998, IDT)

GB/T 23901.1 Non-destructive testing - Image quality of radiographs - Part 1: Determination of the image quality value using wire-type image quality indicators (GB/T 23901.1-2019, ISO 19232-1:2013, IDT)

GB/T 23901.2 Non-destructive testing - Image quality of radiographs - Part 2: Determination of the image quality value using step/hole-type image quality indicators (GB/T 23901.2-2019, ISO 19232-2:2013, IDT)

GB/T 23901.4 Non-destructive testing - Image quality of radiographs - Part 4: Experimental evaluation of image quality values and image quality tables (GB/T 23901.4-2019, ISO 19232-4:2013, IDT)

GB/T 25758 (all parts) Non-destructive testing - Focus characteristics of industrial X-ray system

EN 12679 Non-destructive testing - Radiographic testing -Determination of the size of industrial radiographic gamma sources

3 Terms and definitions

The terms and definitions as defined in GB/T 12604.2, as well as the following terms and definitions, apply to this document.

3.1

Nominal thickness

t

The nominal thickness of the base metal, which does not consider the manufacturing deviation.

3.2

Penetrated thickness

w

The thickness of the material, in the direction of ray transmission, which is determined by the nominal thickness of the material.

to technical or structural reasons (such as the type of radiation source, the source-to-object distance, etc.), as agreed by the parties to the contract, it may select the penetration conditions, which is specified in the grade A technology. At this time, the loss of sensitivity can be compensated, by increasing the minimum blackness of the negative to 3.0 OR selecting a higher level of film system, which has a minimum blackness of 2.6; however, the other conditions specified in the grade B shall remain unchanged, especially the image quality to achieve (see Table A.1 ~ Table A.12 in Appendix A). Since the sensitivity, after compensation, is better than the grade A technology, it can be considered that the workpiece is penetrated, according to the grade B technology. For the penetration layout of 7.1.4 and 7.1.5, if the source-to-film distance is reduced, according to 7.6, there is no need to perform sensitivity compensation, according to the above method.

6 General rules

6.1 Radiation safety protection

If it is lack of proper protection measures, X or gamma rays may cause serious harm to human health. The use of X-ray equipment or radioactive sources shall comply with the requirements of laws and regulations on radiation protection. When carrying out radiographic testing work, it shall strictly implement the safety protection measures, which are stipulated by relevant laws and regulations.

6.2 Surface treatment and testing timing

The surface of the workpiece usually does not need to be treated. However, when the surface defect or the coating affects the detection of the defect, the surface of the workpiece shall be polished OR the coating shall be removed.

Unless otherwise specified, radiographic testing shall be carried out after manufacturing, such as after grinding or heat treatment.

6.3 Positioning of welds on radiographic film

When the boundary of the weld cannot be clearly displayed, on the radiographic film, it shall place the positioning marks of high-density materials, on both sides of the weld.

6.4 Marking of radiographic film

For each penetration segments of the tested workpiece, it shall place the identification mark, which is composed of letters, numbers, symbols, such as: product number, weld number, repair mark, penetration date, etc., to represent the information of the workpiece and location to which the tested image belongs.

The marked image shall be located outside the effective evaluation area; meanwhile it shall ensure that each segment is clearly and correctly marked.

6.5 Marking of workpiece

The surface of the workpiece should be permanently marked, to ensure the accurate positioning of each film (for example: zero point, direction, marking, size, etc.).

If the nature of the material or the conditions of use do not allow permanent marking on the surface of the workpiece, it can be recorded, by means of penetration diagrams or photographs.

6.6 Film overlap

When more than two films are used, to detect the penetration area, each film shall have a certain overlap area, to ensure that the entire tested area is penetrated. The high-density lap mark shall be placed on the surface of the workpiece in the lap area, meanwhile it can be displayed on each radiographic film.

6.7 Minimum image quality value

The minimum image quality requirements for radiographic testing of metal material welds are as shown in Table A.1 ~ Table A.12. The image quality requirements, for radiographic testing of other materials, shall be determined by the parties to the contract, in accordance with the provisions of GB/T 23901.4.

When Ir192 or Se75 is used for testing, if the image quality value cannot meet the requirements of Table A.1 ~ Table A.12, the following requirements can be implemented, as agreed by the parties to the contract:

Double-wall double-shadow penetration technology, grade A and grade B ($w = 2t$):

- Use Ir192, $10 \text{ mm} < w \leq 25 \text{ mm}$, which allows image quality value minus 1;
- Use Se75, $5 \text{ mm} < w \leq 12 \text{ mm}$, which allows image quality value minus 1.

Single-wall single-shadow and double-wall single-shadow penetration technology, grade A:

- Use Ir192, $10 \text{ mm} < w \leq 24 \text{ mm}$, which allows image quality value minus 2;
- Use Ir192, $24 \text{ mm} < w \leq 30 \text{ mm}$, which allows image quality value minus 1;
- Use Se75, $5 \text{ mm} < w \leq 24 \text{ mm}$, which allows image quality value minus 1.

When the image quality indicator is placed on the side of the film, the type "F" shall be placed, close to the image quality indicator. Meanwhile, it shall be indicated in the test report.

If relevant measures are taken to ensure that, the same penetration part of the tested workpiece or area is ray detected, by the same penetration parameters and penetration technology, meanwhile there is no difference in the contrast sensitivity of the obtained images, it is not necessary to determine the contrast sensitivity of each image. For the determination of specific image's contrast sensitivity, the requirements should be negotiated by the parties to the contract.

For pipe butt welds, which have an outer diameter greater than or equal to 200 mm, when using the ray source center method for circumferential penetration, it should place at least three image quality indicators, at equal intervals, in the circumferential direction.

6.9 Evaluation of image quality

The observation conditions of the film shall meet the requirements of GB/T 19802.

By observing the image of the image quality indicator on the film, determine the number of the thinnest identifiable wire diameter OR the number of the smallest aperture, as the image quality value. For the wire type image quality indicator, if there is at least 10 mm of wire length, which is continuously and clearly visible, in the uniform blackness area, the wire is considered to be identifiable. For the stepped hole type image quality indicator, if there are two holes having the same diameter on the step, then both holes shall be identifiable; and the step is considered identifiable.

In the radiographic testing report, it shall indicate the type and model of the image quality indicator used AND the achieved image quality value.

6.10 Personnel qualifications

The personnel who carry out radiographic testing, according to this part, shall be qualified and certified, in accordance with GB/T 9445 OR agreed by the parties to the contract; obtain the qualification level certificate of the relevant industrial category of radiographic testing. The employer or its agent shall provide professional training and authorization for them.

7 Recommended radiographic testing technology

7.1 Penetration method

7.1.1 General

Under normal circumstances, the weld's radiographic testing technology shall be implemented, in accordance with the provisions of Figure 1 ~ Figure 19.

The film shall be placed as close to the tested workpiece as possible.

If D_e is greater than 100 mm, OR t is greater than 8 mm, OR the pipe butt girth weld which has a width of greater than $D_e/4$, it should not use the double-wall double-shadow elliptical penetration technique of Figure 11. When the double-wall double-shadow ellipse penetration is used, if t/D_e is less than 0.12, it will be penetrated twice at a 90° interval; if the conditions are not met, it will be penetrated three times at a 120° or 60° interval. The maximum distance between the elliptical images shall be approximately one weld width.

For pipe butt girth weld, which has an outer diameter D_e less than or equal to 100 mm, if it is difficult to use the double-wall double-shadow ellipse penetration, it may use the vertical penetration technology (see Figure 12), to penetrate 3 times, at 120° or 60° intervals, according to 7.1.7.

When using the penetration layout of Figure 11, Figure 13, Figure 14, the incident angle of the ray beam shall be as small as possible; however, it shall prevent the overlap of the upper and lower weld images. Under the premise of meeting 7.6, when using the penetration layout of Figure 13, f shall be as small as possible. The image quality indicator and type "F" shall be placed close to the film.

Due to the difference in the geometry of the workpiece or the thickness of the material, through negotiation by the parties to the contract, it may use other penetration technologies. One of the methods is given in 7.1.9. For workpieces, which have uniform cross-sectional thickness, the multi-film method shall not be used, to reduce the exposure time. In addition, the same material can be used for thickness compensation.

Note: See Appendix B, for the number of exposures, which is required for 100% penetration of butt girth welds.

7.1.2 Single-wall penetration method

The ray source is on one side of the tested workpiece; the film is on the other side, as shown in Figure 1.

The darkroom processing of the film is carried out, in accordance with the conditions recommended by the film and chemical manufacturers, to obtain the performance of the selected film system. Particular attention shall be paid to temperature, development time, developing time. Film processing shall be checked regularly, according to GB/T 19348.2. The radiographic film should not be falsely displayed, on the radiographic negative, due to defects in the film's manufacturing, processing, exposure or darkroom processing.

7.10 Film evaluation conditions

The evaluation of the negative shall be carried out in a dimly lit room. The brightness of the image viewer shall be adjustable. The light screen should have a shading plate, to block the non-evaluation area. The film viewer shall meet the requirements of GB/T 19802.

8 Test report

After the radiographic testing, it shall record the test results and related test parameters in detail; fill the test report, so that the test results can be inquired, under any circumstances.

The test report shall contain at least the following information:

- a) Testing organization;
- b) The name of the workpiece;
- c) Material;
- d) Heat treatment status;
- e) The groove form of the weld;
- f) Nominal thickness;
- g) Welding method;
- h) Testing standards, including acceptance requirements;
- i) Radiographic testing technology and grade, including image quality indicators and required image quality values;
- j) Penetration layout;
- k) Marking;
- l) Layout picture;

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