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Standard for Radiological Protection in Industrial Radiography

工业探伤放射防护标准

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Standard for Radiological Protection in Industrial Radiography

1 Scope

This Standard specifies the radiological protection requirements for X-ray and γ-ray defect detection.

This Standard is applicable to defect detection using X-ray radiography facilities and γ-ray radiography facilities of 600 kV and below (including stationary defect detectors and mobile defect detectors). Industrial CT defect detection and non-destructive testing within the same radiation source range for non-defect detection purposes may take this as a reference.

This Standard is not applicable to industrial defect detection performed by accelerators and neutron defect detectors.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 9445 Non-destructive Testing - Qualification and Certification of NDT Personnel

GB 11806 Regulations for the Safe Transport of Radioactive Material

GB/T 14058 Apparatus for Gamma Radiography

GB 18871 Basic Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources

GB/T 26837 Non-destructive Testing Instruments - Stationary Type and Movable Type Industrial X-ray Radiographic Equipment

GBZ 98 Health Requirements and Surveillance Specifications for Radiation Worker

GBZ 128 Specifications for Individual Monitoring of Occupational External Exposure

GBZ/T 250 Radiation Shielding Specifications for Room of Industrial X-ray Radiography

GA 1002 Public Security Protection Requirements for Hypertoxic Chemicals and Radioactive Sources Storage Site

usually two source holes: the old source is pushed into one source hole of the source changer, and the new source is removed from the other source hole.

3.7 pipe crawler

A mobile pipe defect detection device installed in the pipeline. The frame of the defect detection device is installed in the pipeline, and the source is driven by power to translate (forward or backward) together with the frame in the pipeline to perform radiographic defect detection on the pipeline welds. A control source is utilized to control the forward direction and position of the defect detection equipment.

3.8 control source

A sealed radioactive source used for guidance and positioning control of the pipe crawler.

3.9 operating organization

An operating organization that utilizes industrial defect detection device to perform industrial defect detection.

4 Radiological Protection Requirements for Operating Organization

4.1 The operating organization that carries out industrial defect detection shall bear the main responsibility for radiological protection safety.

4.2 A radiological protection management organization shall be established, radiological protection management personnel and their responsibilities shall be clarified, and radiological protection management systems and measures shall be established and implemented.

4.3 The personnel engaged in defect detection shall be subject to personal dose monitoring in accordance with the requirements of GBZ 128 and occupational health monitoring in accordance with the requirements of GBZ 98.

4.4 Before starting formal work, the defect detection personnel shall obtain non-destructive testing personnel qualifications that comply with the requirements of GB/T 9445.

4.5 Radiation dose rate meters and personal dose alarms shall be equipped.

4.6 An emergency plan for radiation accidents shall be formulated.

5 Radiological Protection Requirements for Defect Detectors

5.1 X-ray Radiography Facilities

i) Check whether the warning labels and source signs are clear;

j) Measure whether the ambient dose equivalent rate at a certain distance from the surface of the source container complies with the requirements of 5.2.1.1 and confirm that the radioactive source is in a shielded state.

5.2.2 Maintenance of γ-ray radiography facilities

5.2.2.1 Components involving radiological protection in the γ-ray radiography facilities shall be regularly inspected and maintained, and problems shall be repaired in a timely manner. When repairing the γ-ray radiography facilities, the manufacturer's professionals shall pour the radioactive source into the source changer. The personnel of the operating organization shall not independently repair the γ-ray radiography facilities.

5.2.2.2 The control components of the γ-ray radiography facilities, including the crank handle and the source transfer conduit, shall be frequently lubricated and scrubbed. Gears shall be frequently lubricated, and the joints of the source transfer conduit shall be scrubbed to keep them away from dust and grit.

5.2.3 Storage and use of radioactive sources

5.2.3.1 The operating organization shall establish a special-purpose storage warehouse for the radioactive sources (or defect detectors with sources).

5.2.3.2 The temporary storage of source-containing containers or radioactive sources, and control sources intermittently during mobile defect detection shall be performed in special-purpose storage facilities. On-site storage facilities include lockable rooms, special-purpose storage boxes or storage pits, etc. The storage facilities shall have the same level of protection as those used at the operating organization's main base. After temporary storage is completed, patrol inspections shall be performed to ensure storage safety.

5.2.3.3 Radioactive source storage facilities shall reach the following requirements:

a) Rigorously control the irradiation of surrounding people, prevent radioactive sources from being stolen or damaged, and prevent unauthorized personnel from taking any actions that may harm themselves or the public. Ionizing radiation warning signs shall be set up at the entrance of the storage facilities;

b) They shall be able to be used under conventional environmental conditions, be structurally fireproof, and be kept away from corrosive and explosive hazards;

c) At the point closest to the external surface that is accessible to the public, the shielding shall be such that the ambient dose equivalent rate is less than 2.5 μSv/h or the control level approved by the regulatory authority;

d) The doors of the storage facilities shall be kept locked, and double-locked management shall be implemented;

e) Regularly check the item list to confirm the storage locations of defect detection sources, source containers and control sources.

5.2.3.4 The storage of radioactive sources shall comply with the relevant requirements of GA 1002.

5.2.3.5 The operating organization shall formulate a system for the collection and return of radioactive sources, establish a collection account, clarify the flow of radioactive sources, and have a dedicated person in charge of this.

5.2.3.6 When collecting and returning a source container containing radioactive sources, the ambient dose equivalent rate at a certain distance from the outer surface of the source container shall be measured to confirm that the radioactive source is in the source container. Source containers containing radioactive sources shall be stored in specified locations, and there shall be detailed registration of the collection and return.

5.2.4 Transport and movement of radioactive sources

5.2.4.1 The freight transport requirements for radioactive sources shall comply with the stipulations of GB 11806, and the requirements for Class-A and Class-B transport packages shall be satisfied. During transportation, the source window shall be closed and equipped with a special-purpose locking device.

5.2.4.2 Source-containing devices shall be transported in storage facilities and cannot be moved until they are correctly locked and keyed in a suitable source container.

5.2.4.3 When moving within plant areas that do not involve public roads, small-scale vehicles or trolleys shall be used, and the source-containing devices shall be kept under the surveillance.

5.2.5 Disposal of waste radioactive sources

The operating organization shall sign a waste radioactive source return agreement with the production and sales organization. When the radioactive source needs to be scrapped, the waste radioactive source shall be returned to the production organization or the original exporter in accordance with the stipulations of the agreement. The purpose and disposal procedures of radioactive sources shall comply with the specific regulations of the corresponding review and management departments, and relevant documents and records shall be archived.

6 Radiological Protection Requirements for Stationary Defect Detection

6.1 Radiological Protection Requirements for Defect Detection Room

6.1.1 The setting of the defect detection room shall pay full attention to the surrounding radiation safety. The operation room shall be kept away from the direction of beam irradiation

shall be explained in a conspicuous location.

6.1.7 Monitoring devices shall be installed in the defect detection room and at the entrances and exits of the defect detection room. There shall be a dedicated monitor on the control console of the console cabinet, which can monitor the activities of personnel in the defect detection room and the operation of the defect detection equipment.

6.1.8 The protective door of the defect detection room shall have ionizing radiation warning signs and Chinese warning instructions that comply with the requirements of GB 18871.

6.1.9 Emergency stop button or pull rope shall be installed in the defect detection room to ensure that irradiation can be immediately stopped in the event of an emergency. The button or pull rope shall be installed so that personnel can use it without passing through the main beam at any position in the defect detection room. The button or pull rope shall be labeled with instructions for use.

6.1.10 The defect detection room shall be equipped with a mechanical ventilation device, and the outer opening of the exhaust duct shall avoid facing areas with dense human activities. The number of effective ventilation and air changes per hour shall be no less than 3 times.

6.1.11 The defect detection room shall be equipped with a stationary site radiation detection alarm device.

6.2 Radiological Protection Requirements for Defect Detection in the Defect Detection Room

6.2.1 For the defect detection room in normal use, protective safety measures, such as: the protective door-machine interlocking device and irradiation signal indicator light of the defect detection room shall be inspected.

6.2.2 When entering the defect detection room, in addition to wearing a conventional personal dosimeter, the defect detection personnel shall also carry a personal dose alarm device and a portable X-γ dose rate meter. When the dose rate reaches the set alarm threshold, the defect detection personnel shall immediately exit the defect detection room, and meanwhile, prevent other people from entering the defect detection room, and immediately report to the person in charge of radiological protection.

6.2.3 The dose rate level in the area around the defect detection room shall be regularly measured, including the operator's working position and the surrounding adjacent areas where people live. The measured value shall be compared to the reference control level. When the measured value is higher than the reference control level, the defect detection shall be terminated and reported to the person in charge of radiological protection.

6.2.4 Before using the portable X-γ dose rate meter during a shift change or a shift, check whether it can normally operate. If it is found that the portable X-γ dose rate meter is not normally operating, then, the defect detection shall not be started.

6.2.5 The defect detection personnel shall correctly use the radiological protection devices provided, such as: collimators and additional shielding, to minimize potential radiation.

6.2.6 Before each irradiation, the operator shall confirm that no one is staying in the defect detection room and close the protective door. Defect detection can only be started when the protective door is closed, and all protective and safety device systems are activated and operating normally.

6.2.7 When carrying out work that is not anticipated when designing the defect detection room, for example, if due to special reasons like excessively large workpieces, the door must be opened for defect detection, the requirements of 7.1 ~ 7.4 shall be followed.

6.3 Decommissioning of Defect Detection Facilities

When industrial defect detection facilities are no longer in use, decommissioning procedures shall be implemented, which include the following content:

a) γ radioactive sources with useful value can be transferred to another institution with a license for use after obtaining approval from the regulatory institution, or be handled in accordance with the waste radioactive source disposal requirements in 5.2.5 of this Standard.

b) Shielding devices incorporating depleted uranium shall be treated the same as γ-ray sources.

c) X-ray generators shall be disposed of beyond service or transferred to another licensed institution after obtaining approval from the regulatory institution.

d) Pipe crawlers containing low-activity γ-ray sources shall be implemented in accordance with the relevant requirements.

e) After all radiation sources are removed from the site, the operating organization shall go through relevant procedures in accordance with the requirements of the regulatory institution.

f) Remove all ionizing radiation warning signs and safety notices.

g) Conduct comprehensive radiation monitoring of decommissioning sites and related items to confirm that no radioactive sources are left on the site and to confirm the contamination conditions.

7 Radiological Protection Requirements for Mobile Defect Detection

7.1 Pre-work Preparation

7.2.3 Ionizing radiation warning signs shall be set up at appropriate locations at the boundaries of the control zone and a clearly visible "NO ENTRY INTO THE RADIATION WORKING AREA" warning sign shall be hung. The defect detection personnel shall operate outside the boundaries of the control zone, otherwise, specialized protective measures shall be taken.

7.2.4 Physical barriers shall be set up as much as possible at the boundaries of the control zone, including utilizing existing structures (for example, walls), temporary barriers or temporarily raised cordons (ropes), etc.

7.2.5 During the mobile defect detection operation, other operations shall not be simultaneously carried out in the control zone. In order to minimize the range of the control zone, an appropriate collimator shall be used, and conditions, such as: the distance between the defect detector and the object being detected, irradiation direction, time and on-site shielding, shall be thoroughly considered. Local shielding measures shall be adopted as appropriate.

7.2.6 Each defect detection team shall be equipped with at least one portable X-γ dose rate meter and regularly perform verification / calibration on it. Personal dose alarms that can be heard, seen or generate a vibrating signal under on-site environmental conditions shall be equipped.

7.2.7 During the defect detection operation, the dose rate of representative points at the boundaries of the control zone shall be detected. Especially when the defect detection position changes in this direction or the direction of the ray beam changes, the boundaries of the control zone shall be adjusted in a timely manner.

7.2.8 The area outside the boundaries of the control zone and where the ambient dose equivalent rate is greater than 2.5 μSv/h during operation shall be classified as a supervision zone. In addition, a clearly visible "AUTHORIZED PERSONNEL ONLY" warning sign shall be hung at the boundaries, and when necessary, a dedicated guard shall be set up.

7.2.9 When mobile defect detection is carried out in a multi-floor factory or construction site, personnel on the upper or lower floors of the mobile defect detection working area shall be prevented from entering the control zone through stairs.

7.2.10 The console of the defect detector (X-ray generator control panel or γ-ray exit disk) shall be set in an appropriate position or equipped with a delay startup device, so as to reduce the operating personnel's exposure dose as much as possible.

7.3 Safety Warnings

7.3.1 The entrusting organization (owner organization) shall cooperate with the radiological protection of the defect detection, publish defect detection operation information in advance through appropriate channels, and notify all relevant personnel to prevent accidental exposure.

7.3.2 There shall be indicator lights and sound prompts displaying the "ready" and "irradiation" status. There shall be a clear distinction between the "ready" signal and the "irradiation" signal, which shall also be clearly distinguished from other alarm signals used in the workplace. During

night operations, warning lights shall be installed at the boundaries of the control zone.

7.3.3 The warning signal indicating device for X-ray and γ-ray defect detection shall be interlocked with the defect detector.

7.3.4 The "ready" and "radiation" signals shall be clearly audible or visible at all boundaries of the control zone.

7.3.5 Prompt information, such as: ionizing radiation warning signs and warnings shall be posted in conspicuous locations at the boundaries of the supervision zone and at the entrances and exits of buildings.

7.4 Border Patrol and Detection

7.4.1 Before starting mobile defect detection, the defect detection personnel shall ensure that there are no other people in the control zone and prevent anybody from entering the control zone.

7.4.2 The range of the control zone shall be clearly visible, and there shall be good lighting during operation, so as to ensure that no one enters the control zone. If the control zone is too large or some areas cannot be seen, sufficient personnel shall be arranged to conduct patrol inspections.

7.4.3 During a trial run (or first exposure), the dose rate at the boundaries of the control zone shall be measured to verify that the boundaries are correctly set. If necessary, the range and boundaries of the control zone shall be adjusted.

7.4.4 Before starting mobile defect detection, the portable X-γ dose rate meter shall be checked to confirm that it can normally function. During the mobile defect detection, the portable X-γ dose rate meter shall always be turned on to prevent abnormal radiation exposure or abnormal termination.

7.4.5 During the mobile defect detection, in addition to regular personal monitoring, the personnel shall also wear personal dose alarms. Personal dose alarms are not a substitute for portable X-γ dose rate meters, and both shall be used.

7.5 Operational Requirements for Mobile Defect Detection

7.5.1 Mobile defect detection with X-ray

7.5.1.1 When a circumferential defect detector is used for mobile defect detection, the X-ray tube head assembly shall be placed inside the object to be detected for transillumination inspection. A collimator shall be used when performing directional irradiation (only the directional irradiation port is opened).

7.5.1.2 Factors, such as: the distance among the controller, the X-ray tube, and the object to be detected, the irradiation direction, time and shielding conditions, shall be considered to select the optimum equipment layout, and appropriate protective measures shall be taken.

rate generated around accessible pipelines shall not exceed 100 μSv/h.

7.5.2.5 The special requirements for underwater γ-ray defect detection are as follows:

a) Divers shall receive appropriate professional trainings.

b) Before the defect detector enters water, it shall be ensured that the control mechanism, guide tube and irradiation container are tightly connected; check the connection points to confirm that the connection is firm, and the radioactive source assembly is in a safe position.

c) Floats and emergency positioning devices (for example, flashlights) shall be installed on the irradiation container.

d) All measuring instruments and personal dose alarms shall be designed for underwater use.

8 Radiological Protection Detection

8.1 General Requirements for Detection

8.1.1 Detection plan

The operating organization shall develop a radiological protection detection plan. The detection plan shall stipulate the location and frequency of detection, and the storage of detection results, etc., and provide the reference control level for each measurement location and the actions and measures that shall be taken when the reference control level is exceeded.

8.1.2 Detection instruments

Appropriate radiological protection detection instruments shall be selected, regular verification / calibration shall be carried out as required, and corresponding certificates shall be obtained. Before use, the radiation detection instrument shall be inspected, including whether there is physical damage, zero adjustment, battery and instrument response to radiation, etc.

8.2 Detection with Defect Defectors

8.2.1 Protection performance detection

8.2.1.1 Detection method

The detection method for the protection performance of X-ray radiography facilities shall comply with the requirements of GB/T 26837; the detection method for the protection performance of γ-ray radiography facilities shall comply with the requirements of GB/T 14058.

8.2.1.2 Detection cycle

The operating organization shall detect the protection performance of the radiography facilities

every year. After the radiography facilities are moved, the performance of the safety device shall be detected.

8.2.1.3 Result evaluation

The result evaluation of the protection performance detection of X-ray radiography facilities shall comply with the requirements of 5.1.1 in this Standard. The result evaluation of the protection performance detection of γ-ray radiography facilities shall comply with the requirements of 5.2.1.1 in this Standard.

8.2.2 Leakage inspection of sealed radioactive sources

8.2.2.1 Inspection method

Use filter paper or soft material dipped in 5% EDTA-Na_2 solution or other detergents to wipe the inner wall of the sealed guide tube and measure the radioactivity of the wipe. If there is a significant increase (for example, 20 Bq), the radioactive source shall be sent back to the manufacturer for further inspection.

8.2.2.2 Inspection cycle

The radioactive source transmission pipeline of the radiography facilities is inspected for radioactive contamination every year, so as to check the sealing performance of the radioactive sources.

8.3 Radiological Protection Detection of Defect Detection Room

8.3.1 Detection conditions

The detection conditions shall comply with the following requirements:

a) The X-ray radiography facilities shall be placed as close as possible to the test point under the rated working conditions. If circumferential radiography facilities are used, they shall be in a circumferential irradiation state; the detection of the main shield shall be carried out when there are no defect detection workpieces, and the detection of the auxiliary shield shall be carried out when there are defect detection workpieces.

b) The γ-ray defect detection acceptance inspection shall be carried out at the rated source loading activity, when there are no defect detection workpieces, and the radiography facilities are placed as close as possible to the test point; the routine inspection shall be carried out in accordance with the actual working condition.

8.3.2 Patrol inspection of radiation level

During the radiological protection detection of the defect detection room, especially during the acceptance inspection, the surrounding radiation level shall be subject to the patrol inspection first, and a portable X-γ dose rate meter shall be used for the patrol inspection of the radiation level 30 cm outside the wall of the defect defection room, so as to find possible high radiation

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