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Protection Rules for Industrial X-ray Radiographic Equipment up to 500 kV

(Draft for Approval)

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Contents

Foreword

Apart from Sections 1 and 2, all other sections of this standard are mandatory.

This standard is non-equivalently referenced to DIN 54113-1: 1992 Non-destructive testing; radiation protection rules for the technical application of X-ray radiographic equipment up to 500 kV; general technical safety requirements and testing and DIN 54113-2: 1992 Non-destructive testing; radiation protection rules for the technical application of X-ray radiographic equipment up to 500 kV; general technical safety requirements and testing for manufacture, installation and operation.

This standard is based on JB 7788-1995 Protection Rules for Industrial X-ray Radiographic Equipment up to 500 kV, revised according to GB 1.1-2000 Standardisation Guideline – Part One: Standard Structure and Compiling Rules and GB/T 1.2-2002 Standardisation Guideline – Part Two: Defining Method of Main Technical Elements in Standard Specifications. The main differences between them are:

- The radiation leakage exposure rate has been changed to the radiation leakage air kerma rate, i.e. C/kg.s changed to m Gyh and μ Gy/h; the specific requirement has been raised according to GB 18871-2002 Basic Safety Standard on Ionising Radiation Protection and Radiation Sources;
- The technical requirement in the appendix has been moved to the main body;
- The protection requirement for education and training on X-ray radiation has been added;
- The protection requirement on X-ray radiation during operation has been added;
- The content, foreword and introduction to the reference documents have been added.

This standard will replace and revoke the industrial standard JB 7788-1995 from the date of issuing.

This standard was proposed by the China Machinery Industry Association.

This standard is under the jurisdiction of Liaoning Instrument Research Institute.

The main drafter of this standard is Liaoning Instrument Research Institute.

The organisations involved in drafting this standard are Liaoning Instrument Research Institute, Dandong Radiation Apparatus Company Ltd, Dandong City Wanqian Non-destructive Test Instrument Factory, Dandong Municipal Sanitation Supervision Office, Shanghai Chaoqun Non-destructive Test Equipment Company Ltd, Dandong Non-destructive Test Equipment Company Ltd.

The main drafters of this standard are Yu Zhijun, Li Yibin, Zhang Hong, Jian Jieli, Chen Ninlong and Bao Ruling.

First issue of this standard.

All previous versions of the standard superseded by this standard are:
- ZB Y315-1985 (first issue)

– JB 7788-1995 (first revision)

Protection Rules for Industrial X-ray Radiographic Equipment up to 500 kV

1. Scope

This standard specifies the protection performance requirements for industrial X-ray radiographic defect detection equipment (abbreviated hereinafter as X-ray radiographic equipment, which includes normal structure X-ray radiographic equipment, precision structure X-ray radiographic equipment, special grade X-ray radiographic protection equipment, complete X-ray radiographic protection equipment, etc), the structural protection requirements for X-ray radiographic equipment and X-ray protection during operation, the operation rules and the inspection requirements.

This standard is applicable to the design, manufacture, installation and operation of X-ray radiographic equipment up to 500 kV.

2. Normative References

The provisions of the following documents become provisions of this standard after being referenced. For dated reference documents, all later amendments (excluding corrigenda) and versions do not apply to this standard; however, the parties to the agreement are encouraged to study whether the latest versions of these documents are applicable. For undated reference documents, the latest versions apply to this standard.

GB/T17150-1997 Radiation Sanitation Monitor Specification – Part One: Industrial Radiographic Defect Detection
GB18871-2002 Basic Safety Standard on Ionising Radiation Protection and Radiation Sources

3. Requirements

3.1 X-ray radiographic equipment radiation leakage air kerma rate limit (shortened below as radiation leakage kerma rate)

3.1.1 Normal structure X-ray radiographic equipment

For fixed X-ray radiographic equipment, mobile X-ray radiographic equipment and portable X-ray radiographic equipment with a normal structure operating at the maximum voltage specified by the manufacturer, with the hood over the main beam window of the X-ray tube, the air kerma rate is measured by a protection level dosimeter. When the tube voltage is under 200 kV, the radiation leakage air kerma rate at 1 metre from the focus point should not be higher than 2.5 mGy/h and under a voltage higher than 200 kV, it should not be higher than 5 mGy/h.

3.1.2 Precision structure X-ray radiographic equipment

For precision structure X-ray radiographic equipment operating at the maximum voltage specified by the manufacturer, with the hood over the main beam window of the X-ray tube, the radiation leakage kerma rate measured by a protection level dosimeter at 0.5 m from the focus point should not be higher than 25 μ Gy/h.

For X-ray tubes with a beryllium window there should be a removable hood with a thickness of no less than 2 mmAl. When measuring the radiation leakage kerma rate, the X-ray window should be shielded by a hood with a thickness equivalent to 10 half-value layers, said thickness being as indicated in Table 1.

Table 1 Lead Thickness of X-ray Radiographic Equipment Hood

X-ray Tube	100	150	160	200	225	250	300	320	400	450	500

Voltage (kV)											
Lead Thickness of Hood (mm)	2	2.2	3.5	4.2	7.8	8.7	17	20	25	27	31

3.1.3 Special grade X-ray radiographic protection equipment

Under the specified operating conditions of the special grade X-ray radiographic protection equipment, the radiation leakage kerma rate measured by a protection level dosimeter at 0.1 m from the surface of the radiation protection cover should not be higher than 25 μ Gy/h. The high voltage will be disconnected when the cover is removed or opened.

Under the maximum operating condition specified by the manufacturer the radiation leakage kerma rate in its radiation field should not be higher than 0.25 mGy/h; the radiation leakage kerma rate should not be higher than 25 μ Gy/h when operating with the protection cover open.

3.1.4 Complete X-ray radiographic protection equipment

The radiation leakage kerma rate of complete X-ray radiographic protection equipment measured by a protection level dosimeter at 0.1 m from the surface of the radiation protection cover should not be higher than 25 μ Gy/h. One protection device or two independent mechanical devices should guarantee the X-ray tube can only operate when the protection cover is in place; the cover can only be opened when the window hood is applied during the operation, and under this condition the radiation leakage kerma rate in the protection cover should not be higher than 7.5 μ Gy/h. The protection cover can only be regarded as up to the standard when meeting these conditions.

3.2 X-ray radiographic equipment structural protection

3.2.1 Controller

The controller should guarantee that the equipment cannot be started without permission. There should be a clear yellow light or sound device to indicate when the equipment is operating. The controller should be used as a protection safety device during mobile operation of the X-ray radiographic equipment. Operation related to the protection functions should be clearly marked. During the operation of mobile X-ray radiographic equipment there should be a yellow light with a 20 m long wire and an emergency protection switch as an additional protection safety device. There should be a locking mechanism in the safety device which can disconnect the high voltage of the X-ray tube (such as the X-ray radiographic equipment switch, gate contact and grating), and there should be an indicator to show if the outside is connected.

3.2.2 X-ray output window

The X-ray output window is in the X-ray protection safety cover with a locking mechanism or in a protection assembly on the X-ray tube base. If the X-ray output window is open this should be clearly indicated by a safety device (such as a warning light) near the X-ray protection safety cover or X-ray generator. For multi-window X-ray tubes each window should be equipped with an independent safety device.

3.2.3 Applied apparatus

The protection safety device of the X-ray window should guarantee that the controller can only emit the radiating command when the applied apparatus is connected; the X-ray output window should be closed automatically when the applied apparatus is disconnected. The applied apparatus installation should not be changed randomly.

3.2.4 Dismantling the X-ray tube or generator

The safety device should guarantee the generator is cut off automatically when taking the X-ray tube out of the X-ray protection cover or taking the X-ray generator from its holder.

3.2.5 Multi-window X-ray tube

When the multi-window X-ray tube is used, the X-ray output windows not in use on the X-ray tube protection cover should be fitted or covered with a dual protection cover. This cover can only be removed with tools when the X-ray window is not in use.

3.2.6 Opening of X-ray protection device

When opening the X-ray protection device, the safety device should disconnect the generator or activate another safety protection device, so as to avoid the effective X-ray beam radiation escaping; when the X-ray protection device is opened, there should not be any radiation leakage from the X-ray radiographic equipment.

3.2.7 Change of pattern

During the pattern change the high voltage of the X-ray radiographic equipment should be disconnected automatically or the radiation of the X-ray radiographic equipment should be shielded automatically.

3.2.8 Shielding material

The thickness of the X-ray shielding materials laid in the duct head of the X-ray radiographic equipment should conform to the requirements of the radiation leakage kerma rate in 3.1 of this standard.

4 Protection monitor during operation

4.1 Personnel radiation dosage limit

Regular personal dosage monitoring must be conducted on the personnel exposed to radiation, and a record of personal dosage and health must be set up. The dosage limits should conform to the requirements in Appendix B of GB 18871:

a) The average effective dosage in 5 continuous years should not be higher than 20 mSv;
b) The effective dosage in any year should not be higher than 50 mSv;
c) One year's equivalent dosage in the ocular lens should not be higher than 150 mSv;
d) One year's equivalent dosage in limbs (arms and legs) should not be higher than 500 mSv.

4.2 Control area

4.2.1 Fixed working site control area

The area where the personnel could receive an annual effective dosage of 15 mSv on average should be defined as a control area and the control area should be marked. The dosage rate in a control area should be calculated by the working time of the X-ray radiographic equipment. The control area should be clearly marked No Entry to X-ray Area.

4.2.2 Mobile working site control area

During the mobile X-ray radiographic equipment operating period, calculated as 7.5 hours switched on per week, the effective dosage rate in the control area should not be higher than 40 μ Gy/h; the agreement of the supervising department must be obtained if this is to be higher than 40 μ Gy/h. The border of the control area must be marked and under control. The operators must operate the equipment outside the border; otherwise protection measures must be taken. Measures such as the use of lead shielding should be taken, so as to limit the control area of the mobile X-ray radiographic equipment operation as far as possible and in an appropriate range.

The following steps should be taken when setting up a control area:

a) Estimate the range of the control area;
b) Define the border of the control area;
c) Mark the control area.

Using the measured dosage rate when the X-ray radiographic equipment is switched on to determine the control area's border is not permitted. Before first operation, the border of the control area must be marked according to an estimate

and past experience. During first operation the dosage rate needs to be measured by a dosimeter and the border needs to be adjusted. Use cords or strips for partitioning or assign security guards to stop people other than operators from entering the control area. There must be a warning sign at each entrance; the on-site supervisor must be equipped with radiation monitoring instruments. Dedicated personnel must be assigned as guides in front of the X-ray radiation field.

4.3 Monitoring area

4.3.1 Fixed working site monitoring area

The area where personnel could receive an annual whole body effective dosage of 5 mSv on average should be defined as a monitoring area and the monitoring area should be marked. A monitoring area belongs to the working area. The mark must take the form of a clearly visible sign in orange letters saying No Entry to X-ray Area by Non-operators.

4.3.2 Mobile working site monitoring area

The area outside the control area where the radiation leakage air kerma rate is higher than 25 μ Gy/h is a monitoring area.

5 Operating rule

5.1 Person or deputy in charge of protection

The registrant of the X-ray apparatus operator is the person in charge of radiation protection. This person in charge should assign an appropriate number of formally professionally trained people as the radiation protection deputies, define their duty range in the enterprise and report to the examination and administration department for record-keeping.

5.2 Guidance

The X-ray radiographic equipment operators should have the necessary professional radiation protection knowledge. The person in charge of the radiation protection should pay attention to the training and guidance of these operators before the first time they operate the equipment and their regular training and guidance afterwards. The content and time of training should be recorded.

5.3 Dosage measurement

Use a dosimeter (such as a general dosimeter) conforming to the national standard and assigned by the examination and administration department to conduct the dosage monitoring on the operators. In the meantime, the examination and administration department should ensure that the person and his/her deputies in charge of the radiation protection are able to operate the measuring instrument independently, so that the dosage monitoring work can be conducted at any time.

5.4 Installation

Before the installation of the X-ray radiographic equipment an evaluation and simulation test verification must be carried out on the structural facilities for the radiation protection in accordance with the predicted working conditions.

The passage to the control area must normally meet the following conditions:

- It must be possible to see when the X-ray radiographic equipment is switched on by using a device;
- It must be possible to disconnect the high voltage in the X-ray radiographic equipment in an emergency from the

controller or a switching device nearby;

- A safety device (such as gate contact, grating) must be set up at the passage so that the X-ray can be switched off in the range. When the X-ray radiographic equipment needs to be switched on again, it can only be switched on via the switch-on device;
- The passage to the control area must be clearly marked in red letters: No Entry to X-ray Area.

5.5 Operation

The operation of X-ray radiographic equipment should comply with the operating rules of this standard, the requirements in the attached equipment documents and the written protection requirements for working with X-rays, such as the permitted X-ray beam direction, the minimum distance between the protection wall and the X-ray radiographic equipment, the thickness of the protection wall, the maximum range and connecting time, as well as forbidding lingering or restricting conditions.

5.6 Documentation for X-ray radiation protection

5.6.1 Equipment documents

The equipment documents include the X-ray radiographic equipment production licence issued by the examination and administration department and the main protection performance of the X-ray radiographic equipment. The protection performance of X-ray radiographic equipment with various structures should conform to GB 18871 standard.

The documentation should include the following documents and marking:

a) Approval certificate;
b) Inspection certificate from specialised test department;
c) Markings of X-ray radiographic equipment.

5.6.2 Qualification of X-ray radiographic equipment operator

a) Professional knowledge certificate;
b) Training certificate;
c) Measured dosage result;
d) Health check-up information.

5.6.3 Information supplied by X-ray operating organisation

a) Inspection report and certificate by specialist;
b) Authorisation certificate or a copy to the operating organisation;
c) Radiation protection area plan and working method based on it;
d) Illustration of the X-ray radiographic equipment operating rules, the protection measures based on the rules, the permitted operating methods and working parameters, as well as the integration with other defect detection equipment or accessories, where applicable.
e) Radiation protection marking.

5.7 Conditions for use of X-ray radiographic equipment awaiting approval

X-ray radiographic equipment for which approval has been applied to the local examination and administration

department can be used if the following conditions are met:

a) The structure of the X-ray radiographic equipment has been approved;
b) The X-ray radiographic equipment has been inspected by a specialist approved by the examination and administration department;
c) The deputy in charge of the radiation protection has a vocational training certificate on radiation protection, and has professional knowledge obtained from participating in radiation protection training courses and vocational examination tests endorsed by the examination and administration department;
d) Other professional staff should master the necessary professional knowledge in terms of radiation protection and meet the requirements of 5.2 and 5.62.
e) Before operating the X-ray apparatus, it should be reported to the local examination and administration department within the specified period; the report should include a copy of the permitted structural type certificate, together with parts inspection certificates, specialist inspection certificates, special knowledge survey reports, the approval certificate and the professional training certificate of the deputy in charge of the X-ray radiation protection.

5.8 Exemption conditions for special grade X-ray radiographic protection equipment

It must meet all the following conditions:

a) The structure of the special grade X-ray radiographic protection equipment has been approved;
b) The deputy in charge of the radiation protection has a professional certificate on radiation protection;
c) Before operating the special grade protection device, it should be reported to the local examination and administration department within the specified period; the report should include the permitted structural type certificate, together with copies of parts inspection certificates and the professional certificate of the deputy in charge of the X-ray radiation protection.

5.9 Exemption conditions for complete X-ray radiographic protection equipment

It must meet all the following conditions:

a) The structure of the X-ray radiographic protection equipment has been approved;
b) 14 days before operating the complete X-ray radiographic protection equipment, it should be reported to the local examination and administration department; the report should include a copy of the permitted structural type certificate, together with parts inspection certificates.

5.10 Operation requiring approval

When any unapproved key component (such as an unapproved type of X-ray tube) in the X-ray radiographic equipment has been changed, the operation of this X-ray radiographic equipment needs to be approved by the local examination and administration department.

6 Inspection

6.1 Requirements for inspection instruments

The regulations of GB/T 17150 should be referenced: minimum range 0-10 μ Gy/h, energy response 30-500 kV, maximum error ±30%, reading response time less than 15s. The instruments can only be used after they have been

verified by an authorised test laboratory.

6.2 Scope of inspection

6.2.1 Environment and condition inspection

The distance between the X-ray tube and the wall should be greater than 2 m and there should be no object which would cause scattering within a range of 2 m from the focal point of the X-ray tube. The voltage and the current of the X-ray tube should be at their nominal values. The distance of the measuring points should conform to 3.1.

6.2.2 Inspection period

The inspection period for the X-ray radiographic equipment and the mobile X-ray radiographic equipment is yearly; the inspection period for the fixed and mobile X-ray radiographic equipment is two-yearly.