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Non-destructive testing — Gamma ray scanning method on process columns

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National foreword

This British Standard is the UK implementation of ISO 23159:2020.

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 5, *Radiographic testing*.

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Introduction

Gamma ray scanning is a non-intrusive and non-destructive method, which is widely used in petrochemical and chemical process plants for troubleshooting and diagnosing purposes. Gamma ray scanning provides an indication of online conditions inside processing columns and vessels. Gamma ray scanning has proven itself as a method for the identification of plant and process problems, resulting in considerable economic savings. The gamma ray scanning method is an inspection which is carried out while the process is in operation, without interruption.

The benefits, obtained from the application of the gamma ray scanning method for problem solving, are many folds, such as safety improvement, environment pollution prevention and economic savings.

Gamma ray scanning is based on the gamma ray transmission techniques. When a gamma ray passes through a column, the intensity of the transmitted beam is related to the path length and density of the material through which the beam passes. An appropriate gamma source and a detector are aligned at the same elevation opposite to each other on the exterior of the column. Measurements of radiation intensity are taken at appropriate positions as the source and detector are moved together along the column. The source-detector data thus obtained are shown in plots of radiation intensity or material density as a function of the position. Detailed analysis of these data enables making assessments about the condition of internal structures and process materials within the column.

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Non-destructive testing — Gamma ray scanning method on process columns

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This document is used for non-destructive testing by the gamma ray scanning method for troubleshooting and testing process columns in industries. This document is applicable to the testing of all kinds of separation processes columns and pipes. This includes columns with different tray configurations and with packed beds.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5576, *Non-destructive testing — Industrial X-ray and gamma-ray radiology — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5576 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
column
vertical cylindrical vessel used for facilitating the separation of a liquid mixture through distillation or extraction

3.2
demister
device, often fitted with vapour-liquid separator vessels, to enhance the removal of liquid droplets or mist entrained in a vapour stream

[SOURCE: ISO/TR 27912:2016, 3.25]

3.3
downcomer
device conveying liquid from one tray to the next one below it in a *column* (3.1)

3.4
entrainment
mist, fog droplets or particles transported by a fluid

[SOURCE: ISO 3857-4:2012, 2.37]

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3.5
flooding
phenomenon that upsets the normal operation of a distillation *column* (3.1) due to an excessive speed of vapour travelling up the column, preventing liquid from flowing

[SOURCE: ISO 1998-4:1998, 4.10.052]

3.6
foaming
expansion of liquid that provides high interfacial liquid-vapor contact in a distillation *column* (3.1)

3.7
grid scanning
system of four or more individual scans in a grid pattern across equal quadrants of a *packed bed column* (3.8) to investigate the packing and liquid/vapor distribution quality through packed or structured trays beds

3.8
packed bed column
column (3.1) with one or more packed beds or structured trays beds that ensures the separation of two or more components of a mixture

3.9
weeping
phenomenon that the pressure exerted by the vapor is insufficient to hold up the liquid on the tray and the liquid leaks through perforations from one tray to the next one below

4 Personnel qualification

The personnel shall prove to have received additional training and qualification in gamma ray scanning.

NOTE Annex A provides recommendations for testing personnel.

5 Protection against ionizing radiation

WARNING — Exposure of any part of the human body to ionizing radiation can be highly injurious to health. Wherever radioactive sources are in use, it is the responsibility of the user of this document to identify the appropriate legal and safety requirements and regulations.

Further information can be found in the IAEA General Safety Requirements[9].

6 Equipment requirements

Equipment required for a column scan includes the following:

— a suitable sealed radiation source;

NOTE 1 The guidance for the selection of a sealed radiation source is provided in Annex B.

— a suitable source holder in which the source can be raised or lowered on the column; the source holder should be capable of giving a collimated beam and the position at which the beam emerges from the holder should be clearly indicated, see Annex C;

— a suitable radiation detection system (including data acquisition system) by which the radiation intensity at a given measurement time can be measured and recorded at different elevations on the column;

NOTE 2 E.g. the detector can be a sodium iodide crystal. A typical dimension is 5 cm × 5 cm (2'' × 2'').

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— a suitable device (e.g. computer and software) for displaying the data as a scan profile;

— a suitable calibrated radiation monitor by which the radiation level can be monitored for radiation safety; the equivalent dose rate at the boundary of a controlled area is usually defined by national legislation;

— barriers and warning notices to cordon off the “controlled area”;

— appropriate handling tools for the safe transfer of the radioactive source from the transport container to the source holder to be used for scanning.

The equipment shall be tested before deployment to the site and securely packaged for transportation to the work site to ensure good working condition.

The sealed radiation source shall be transported to the worksite in an approved Type A container, labelled and documented, taking national and international regulations into account.

NOTE 3 This can include i.e.

— the vehicle equipment;

— a special driver qualification;

— a special personnel protective equipment;

— a transport permission.

A check list shall be prepared, and all items be checked before shipment. See an example in Annex D.

7 Execution of work at site

7.1 Mechanical design of column and work permission

Prior to carrying out any work, the Level 3 should agree with the client the objectives of the work and scanning procedure. The Level 3

— will acquire details of the column diameter and wall thickness and details of the trays or packed beds;

— will acquire a suitable general arrangement drawing showing the location of features within the column;

— will ensure that there is suitable and safe access to the parts of the column where the scanning team needs to operate;

— will ensure that there are sufficient resources to carry out the work and that a suitable sealed radiation source can be used at the site.

The documentation of the mechanical designs shall:

— select a proper reference (zero) point (manhole, external pipe, etc.);

— determine all positions of internal and external structures and refer it to the point zero;

— generate a list of the characteristics of the column, see an example in Table 1;

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Table 1 — Characteristics of the column

Type of the process	Type of the column	Identification of the column	Material of the wall	Internal diameters	Nominal wall thicknesses	Height of the column
				D_i	t	h
				mm	mm	mm
...	...	...	...	...	...	...

— show the orientation of downcomers and liquid flooding;

— ensure that a suitable permit to work is issued by the local supervisor (upon arrival at the work site by the Level 3 or the Level 2);

— inspect the work site;

— ensure that there is safe access;

— visually inspect the transport container;

— visually inspect the source holder;

— confirm by monitoring that the source is still present;

— immediately report any abnormalities to the Level 3, who shall decide on the required action.

7.2 Execution of scanning

The project team will carry out the scan in the agreed manner. Any deviation to the agreed scanning procedure shall be approved by the Level 3 after consultation with the client.

Record the count rate (i.e. counts per time interval) each 5 cm (or other intervals according to the distance between trays), either with a computer or a notebook. The count rates or dose measurements can be registered in a table, see an example in Table 2.

NOTE 1 The determination of time interval for the count rate measurement is described in Annex B.

NOTE 2 The selection of sources (detector orientations for scanning) is described in Annex E.

Table 2 — Record of count rate along the column height

Elevation	Counts per time interval[a]	Remarks[b]
mm		
...	...	...

[a] The counting time shall be documented.

[b] Observations regarding obstacles or external structures shall be noted in the remarks. This will improve the interpretation of the data.

8 Data processing and reporting

8.1 Data processing and documentation

The measurement of the count rate obtained by the radiation detector is recorded in a table. A graphical representation (scan profile) shall be prepared. The gamma ray scanning profile provides information

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