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Remote-handling devices for radioactive materials —

Part 1: General requirements

Dispositifs de manipulation à distance pour matériaux radioactifs — Partie 1: Exigences générales

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17874-1 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

ISO 17874 consists of the following parts, under the general title *Remote handling devices for radioactive materials*:

— *Part 1: General requirements*

— *Part 2: Mechanical master-slave maipulators*

— *Part 3: Electrical master-slave manipulators*

— *Part 4: Power manipulators*

— *Part 5: Remote-handling tongs*

Introduction

ISO 17874 deals mainly with multipurpose remote-handling devices for nuclear applications.

These devices replace hands and arms in areas inaccessible to personnel (mostly behind shielding walls).

It should be noted that there are special remote-handling devices designed for narrow fields of application or for special purposes only, but these are beyond the scope of ISO 17874.

Multipurpose remote-handling devices have five to ten, or even more, possibilities of movement in order to cope with the planned range of tasks.

Four categories of such remote-handling devices are used worldwide for the handling of radioactive materials. These categories are as follows:

— mechanical master-slave manipulators;

— electrical master-slave manipulators;

— power manipulators;

— remote-handling tongs.

Various special designs, prototypes, experimental devices and obsolete types cannot be assigned to any category or do not correspond to all the requirements of ISO 17874. These devices are not covered by ISO 17874.

The main applications of the different categories are explained in clause 5.

Remote-handling devices were originally developed for hot cells designed for research and development in nuclear-power reactor-fuel elements. They are now also in widespread use in other nuclear installations, such as plants for fabrication or reprocessing of fuel elements, waste treatment stations and decommissioning of nuclear facilities.

Remote-handling devices are sometimes used for non-nuclear applications. ISO 17874 does not address the special requirements of any of these fields, although designers may be able to take advantage of standardized components from the nuclear sector to achieve cost-effective designs for other purposes, where appropriate.

ISO 17874 is intended to provide assistance to designers of nuclear process plants, as well as manufacturers, users and licensing authorities.

The overall content is divided into five parts. This part of ISO 17874 is concerned with general requirements; the other parts concern, respectively, the four categories of remote-handling devices defined above.

Remote-handling devices for radioactive materials —

Part 1:
General requirements

1 Scope

This part of ISO 17874 describes requirements concerning devices for remote handling of radioactive materials.

The classification of remote-handling devices (categories and different designs within a category) and the distribution in the different parts of ISO 17874 are shown in Figure 1.

2 Normative references

The following referenced documents are indispensable for the application 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 7212:1986, *Enclosures for protection against ionizing radiation — Lead shielding units for 50 mm and 100 mm thick walls*

ISO 9404-1:1991, *Enclosures for protection against ionizing radiation — Lead shielding units for 150 mm, 200 mm and 250 mm thick walls — Part 1: Chevron units of 150 mm and 200 mm thickness*

ISO 11933-1:1997, *Components for containment enclosures — Part 1: Glove/bag ports, bungs for glove/bag ports, enclosure rings and interchangeable units*

ISO 11933-2:1997, *Components for containment enclosures — Part 2: Gloves, welded bags, gaiters for remote-handling tongs and for manipulators*

3 Terms and definitions

For the purposes of this part of ISO 17874, the following terms and definitions apply.

3.1
mechanical master-slave manipulator
manipulator reproducing the movements of hand and arm by means of mechanical transmission elements, installed in a shielding wall

3.2
electrical master-slave manipulator
manipulator reproducing the movements of hand and arm by means of a master arm and of bilateral electrical position control (force reflection)

NOTE The slave arm is generally mounted on a transporter (mobile).

3.3
power manipulator
manipulator driven by switch-operated motors (open loop)

3.4
remote handling tongs
mechanical device consisting of a gripper, a handle and a rod between them. It is either installed in a shielding wall by using a mounting device or hung on a carrying system for use in a water pool, or carried by the operator

4 Classification of multipurpose remote-handling devices

The classification of remote-handling devices (categories and different designs within a category) and the distribution in the different parts of ISO 17874 are shown in Figure 1.

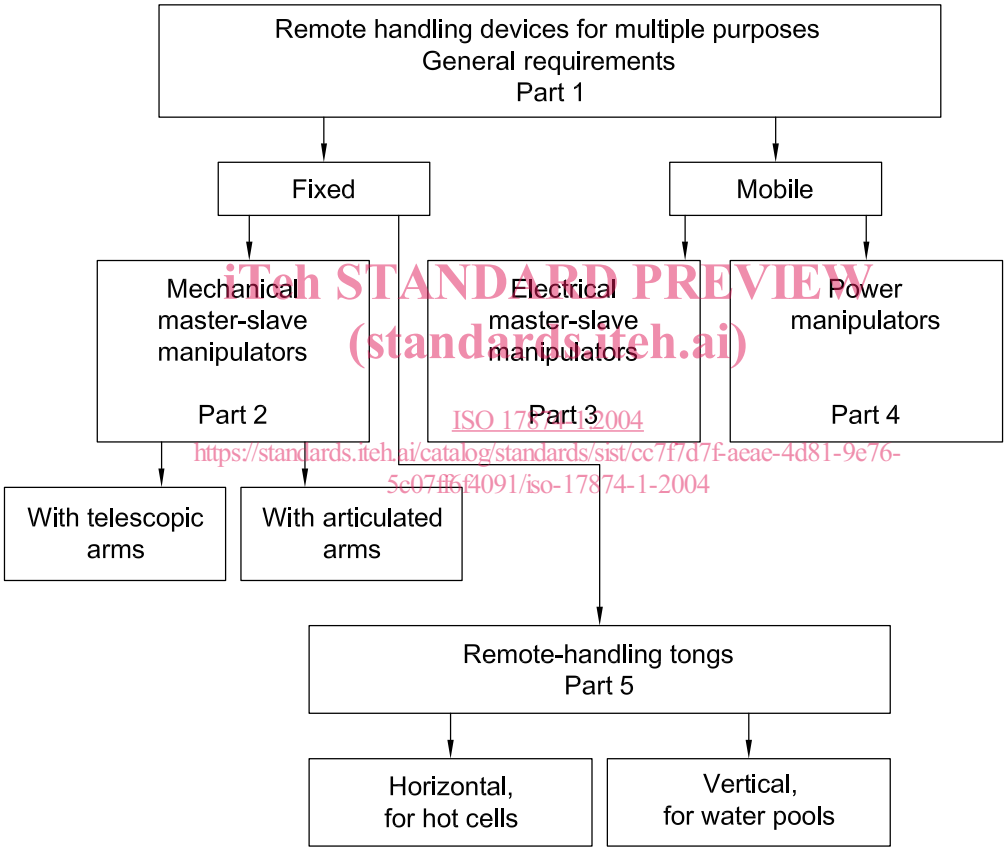


Figure 1 — Categories of remote-handling devices and location within parts of ISO 17874

Concerning the working volume, two principle designs are to be considered:

a) Fixed remote-handling devices

These devices are fitted in the shielding wall or sometimes in the ceiling of hot cells and accordingly can function only in a rather limited volume. Such devices are mechanical master-slave manipulators and remote-handling tongs.

b) Mobile remote-handling devices

These devices are fitted on a transporter (e.g. a moveable bridge or a vehicle on the ground). The working volume depends mainly on the possible motion of the transporter. Such devices are electrical master-slave manipulators and power manipulators.

5 Application of multipurpose remote-handling devices

5.1 Introduction

The different categories of remote-handling devices are used for various applications as described in 5.2 to 5.5.

5.2 Mechanical master-slave manipulators

5.2.1 Mechanical master-slave manipulators with telescopic arms

These manipulators allow the transmission of forces up to (depending on the type) the maximum magnitude that an operator would employ in unaided manual activity. They are suitable for complicated tasks, and are usually installed in pairs on a working station. They are designed for hot cells of all sizes with shielding walls of concrete or also of lead in some cases. They constitute the main working devices in such kinds of cells.

A version with short arms is available, if higher forces than possible with the manipulators defined in 5.2.2 shall be transmitted. Compact manipulators also exist with a double telescope in the slave arm, available for hot cells with restricted height.

5.2.2 Mechanical master-slave manipulators with articulated arms

These manipulators allow the transmission of forces up to a medium level, such as an operator would easily employ repeatedly in unaided manual activity. They are suitable for complicated tasks, and are usually installed in pairs on a working station. They are designed for hot cells of all sizes with shielding walls typically of lead, or also of cast iron in some cases. They are also used in containment enclosures. They have small dimensions and therefore provide a relatively small working volume. They are used instead of remote-handling tongs as described in clause 5.5.1, if a larger working volume and/or more dexterity are needed.

5.3 Electrical master-slave manipulators

These manipulators allow not only the execution of forces equivalent to those an unaided operator can achieve, but also (depending on the type) forces up to a much higher level. They are suitable for complicated tasks, and often they are installed in pairs. They allow the performance of complicated work throughout the whole volume of large hot cells and not only near the operation walls, by means of the mobility of the slave arm. As a result of their load capacities, they can be used also in place of light and medium load-capacity power manipulators. They may be used not only inside facilities but also on vehicles (including in the open air).

5.4 Power manipulators

These manipulators allow the execution of high forces and therefore the handling of heavy objects, typifying their application. According to the load capacity of their hoist, they can also be used like a crane of light load capacity. They are not suitable for complicated tasks. They are used in medium-sized or large hot cells. Normally they have large dimensions and are used to assist mechanical master-slave manipulators. They are used for tasks to be performed in areas that cannot be reached by mechanical master-slave manipulators and for transportation of objects over significant distances. They may also be used on vehicles (including in the open air).

5.5 Remote-handling tongs

5.5.1 Remote-handling tongs, used horizontally

These tongs allow the transmission of forces of a low level, which any operator working unaided would consider small. They can be used only if a moderate level of dexterity and a small working volume are required. In the horizontal mode of use, remote-handling tongs are mostly installed in pairs. They are typically

used in hot cells with shielding walls made of lead. The installation on the shielding wall is realized using standardized ball mountings (called sphere units, in accordance with ISO 7212 and ISO 9404-1).

These remote-handling tongs can also be used without any mounting and shielding. In this case, protection is achieved by the operator maintaining an appropriate distance from the radioactive sources.

5.5.2 Remote-handling tongs, used vertically

These tongs allow the transmission of forces up to a high level (depending on the type), close to the maximum magnitude that an operator would employ in unaided manual activity. They can be used if dexterity is only required up to a moderate level. In this mode of use, remote-handling tongs are typically installed above water pools. They can be handled manually by the operator or fixed in a carrying system, which would typically have three positioning motions.

NOTE To facilitate understanding in this part of ISO 17874, only the four common categories of remote-handling devices listed in 5.2 to 5.5 and their usual applications are considered. This does not exclude the development of equipment with more specialist features.

6 Kinematic systems for multipurpose remote-handling devices

A multipurpose remote-handling device shall have several possibilities of movement (termed motions) so as to be able to achieve a great variety of remote-handling tasks. The motions are executed mechanically either by the hands and arms of the operator or by electric motors.

A fully articulate remote-handling device, which should in principle not be limited concerning its motions, shall have at least seven independent motions. It shall be able to execute three independent translation movements (and forces) on an object in the directions of the three coordinate axes throughout the working volume. It shall also be able to execute three independent rotation movements (and torques) on an object around the three coordinate axes without any special prior adjustment, again throughout the working volume. The seventh motion corresponds to the gripping movement.

NOTE Specific aspects of kinematic systems for handling are described in Annex A.

7 General requirements concerning the different categories of multipurpose remote-handling devices

7.1 Mechanical master-slave manipulators (for more details see ISO 17874-2)

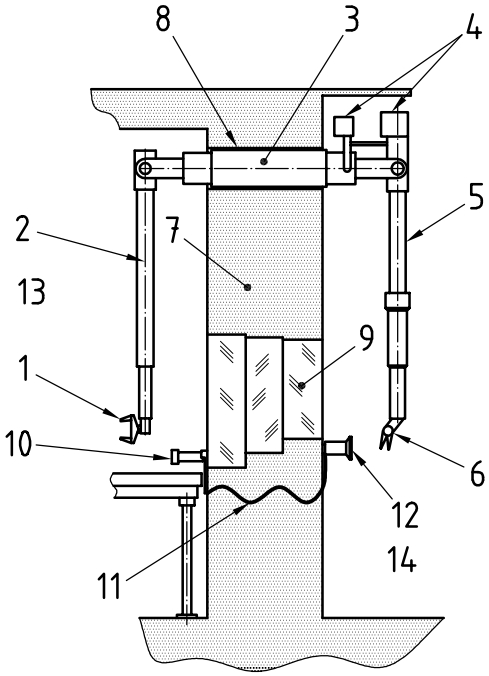
7.1.1 General

A mechanical master-slave manipulator shall consist of three main components, a master arm and a slave arm connected by a connection tube incorporating mechanical transmission elements (see Figures 2 and 3). The master arm and the slave arm shall have the same number, geometry and arrangement of motions. The connection shall be made in such a manner that the motions, forces and torques respectively executed by the hand of the operator on the handle of the master arm are transmitted faithfully to the slave arm.

The manipulator shall have seven motions; three positioning motions, three orientation motions and one gripping motion, corresponding to the requirements of clause 6. The manipulator shall ensure force reflection between the slave arm and the master arm. The transmission elements shall communicate motions, forces and torques reversibly. The connection tube may be unsealed for β-γ hot cells or sealed for α-γ hot cells. The jaws of the tong and/or the complete tong shall be remotely exchangeable.

The slave arm can be equipped with a gaiter (American: booting). Gaiters are already standardized in ISO 11933-2. Concerning mechanical master-slave manipulators, two different designs have to be distinguished: master-slave manipulators with telescopic arms and master-slave manipulators with articulated arms. Both constructions are typically installed in shielding walls (see Figures 2 and 3).

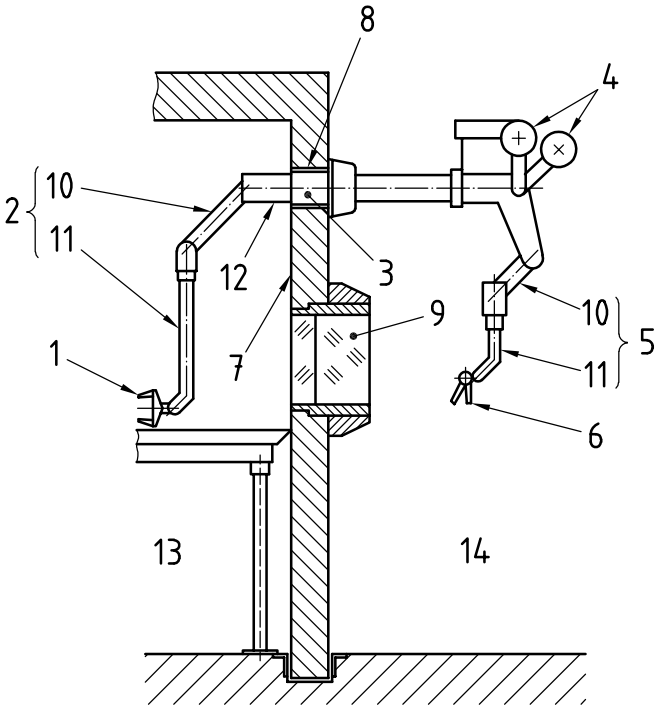
For task observation during work carried out inside a hot cell, shielding windows are used and viewing geometry constraints should be considered in the overall design.



Key

1 tong with parallel jaws
2 slave arm
3 connection tube
4 counter weights
5 master arm
6 handle
7 shielding wall
8 through-wall tube
9 shielding window
10 microphone
11 sound-signal transmission cable
12 loudspeaker
13 hot cell
14 operating room

Figure 2 — Mechanical master-slave manipulator with telescopic arms



Key

1 tong with parallel jaws
2 slave arm
3 connection tube
4 counter weights
5 master arm
6 handle
7 shielding wall
8 through-wall tube
9 shielding window
10 upper arm
11 forearm
12 overhang
13 hot cell
14 operating room

Figure 3 — Mechanical master-slave manipulator with articulated arms

7.1.2 Mechanical master-slave manipulators with telescopic arms

The kinematics of mechanical master-slave manipulators with telescopic arms shall correspond to Figure 4. Depending on the type of manipulator, the load capacities range from 4,5 kg to 45 kg.

The positioning motions for the x and y directions of the slave arm should be adjustable relative to the master arm by electrically actuated indexing to enlarge the working volume and minimize operator strain. Extended reach versions feature a double telescope in the slave arm with an additional electrically actuated positioning motion in the z direction.

In some types, the slave arm can be disconnected and removed remotely.

For hot cells with restricted height (and/or with a small working volume), compact types are required, with a manually operated double telescope in the slave arm.

In addition to visual feedback, transmission of sound from the hot cell into the operating room can be helpful.

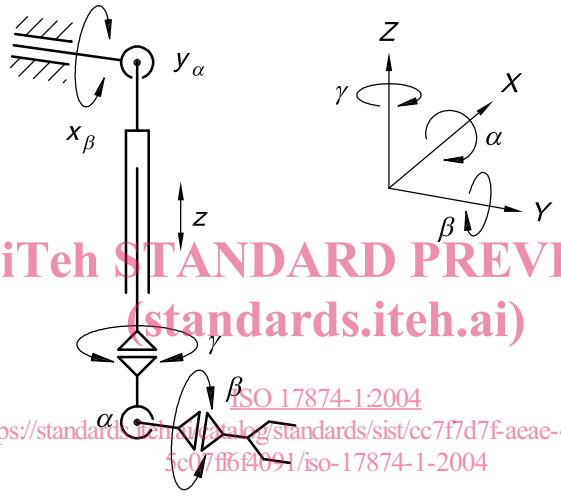


Figure 4 — Mechanical master-slave manipulators with telescopic arms (kinematic diagram)

7.1.3 Mechanical master-slave manipulators with articulated arms

The kinematics of mechanical master-slave manipulators with articulated arms shall correspond to Figure 5. Depending on the type of manipulator, the load capacities range from 2,3 kg to 12 kg.

The master arm may have the same length as the slave arm or may be shorter than the slave arm.

A lever at the handle may be provided to lock the gripping motion. Brakes may be provided to lock the positioning and orientation motions.

Electrically actuated indexing of the inclination of the upper arm of the slave arm may also be provided by a switch-operated electric motor, to minimize operator strain. The overhang of the slave arm in the hot cell can be varied in some types to increase the reach by moving the whole manipulator along the axis of the through-wall tube.