INTERNATIONAL STANDARD

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Remote handling devices for radioactive materials —

Part 4: Power manipulators

Dispositifs de manipulation à distance pour matériaux radioactifs

Partie 4: Télémanipulateurs télécommandés

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 17874-4 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 manipulators*
- *Part 4: Power manipulators*
- *Part 5: Remote handling tongs*

A Part 3, *Electrical master-slave manipulators*, is under study.

Introduction

This part of ISO 17874 deals with power manipulators used for nuclear applications. These manipulators consist mainly of multipurpose remote handling devices.

These devices replace hands and arms and even light hoists, depending on the model used, in areas inaccessible to personnel (mostly behind shielding walls).

Power manipulators were originally developed for hot cells designed for research and development in fuel elements for nuclear power reactors. They are now also in widespread use in other nuclear installations, such as plants for reprocessing of fuel elements, waste treatment stations, and decommissioning of nuclear facilities.

Alternative manipulators used in these fields and resulting in a wide variety of different designs are considered to be skill in an emergent phase or applied uniquely in special circumstances and are not addressed further in this current edition of this standard.

Power manipulators are sometimes modified or especially designed for non-nuclear applications. This part of ISO 17874 does not address the special requirements of any of these applications. Although designers may not be taken advantage of standardized features and components from the nuclear sector to achieve efficient and cost-effective designs for other purposes where appropriate.

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

Remote handling devices for radioactive materials —

Part 4:
Power manipulators

1 Scope

This part of ISO 17874 defines the main features of power manipulators for use in ionizing radiation fields. It outlines basic principles which relate to the design and testing of power manipulators for use behind shielding walls, mainly in hot cells.

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 2768-1:1989, *General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

ISO 11933-5:2002, *Components for containment enclosures — Part 5: Penetrations for electrical and fluid circuits*

ISO 17874-1:2004, *Remote handling devices for radioactive materials — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
axis
directions of a Cartesian coordinate system defined from the operator standing point, considered as the origin of this system

NOTE The following axes are considered: Axis X: from right to left along the shielding wall. Axis Y: forward into the shielded cell. Axis Z: up to the ceiling of the shielded cell.

3.2
arm
⟨manipulator⟩ component reproducing effectively the functions of an human arm, respecting in most cases the same distribution and corresponding articulations

NOTE Corresponding articulations are shoulder pivot, upper arm, elbow pivot, forearm, wrist pivot, etc.

3.3
mechanical arm
arm of a power manipulator being able to execute positioning and orientation motions and equipped with an end-effector

3.4
shoulder hook
device similar to a crane hook attached near the shoulder pivot

3.5
grip hook
end-effector with a linear motion for lifting and handling an object

3.6
disconnection
mechanical operation allowing the separation of two assembled component

EXAMPLE Disconnection of the mechanical arm from the transporter.

3.7
jaws
components fixed on the end of the tongs, which facilitates the handling of an object

NOTE The jaws can be disconnectable.

3.8
operating volume
space in which the operation of tongs are possible, considering all the positions in which the different components of the slave arm of a manipulator can be moved

3.9
gaiter
specially profiled flexible sleeve designed to protect the mechanical arm and optionally also the telescope

NOTE This component is also called a booting (USA).

3.10
drum manipulator
simplified power manipulator designed to transport and to stack radioactive waste drums

3.11
orientation motion
rotation motions around certain axes of the manipulator

NOTE According to the axis considered, the three following motions are distinguished: tilt (α), twist (β) and swivel or azimuth motion (γ).

3.12
positioning motion
motion effecting a displacement of the tongs (or end-effector)

NOTE According to the axis considered, three different motions are distinguished: x, y and z.

3.13
tongs
gripping device fixed at the end of the mechanical arm and consisting of an actuator assembly and jaws

3.14
handle
component gripped by the operator, facilitating the control of the movements of the manipulator and fixed at the operating consol

3.15
transporter
kinematical system for moving and positioning the mechanical arm within the operating volume

3.16
power manipulator
manipulator driven by electrical motors (open loop in position)

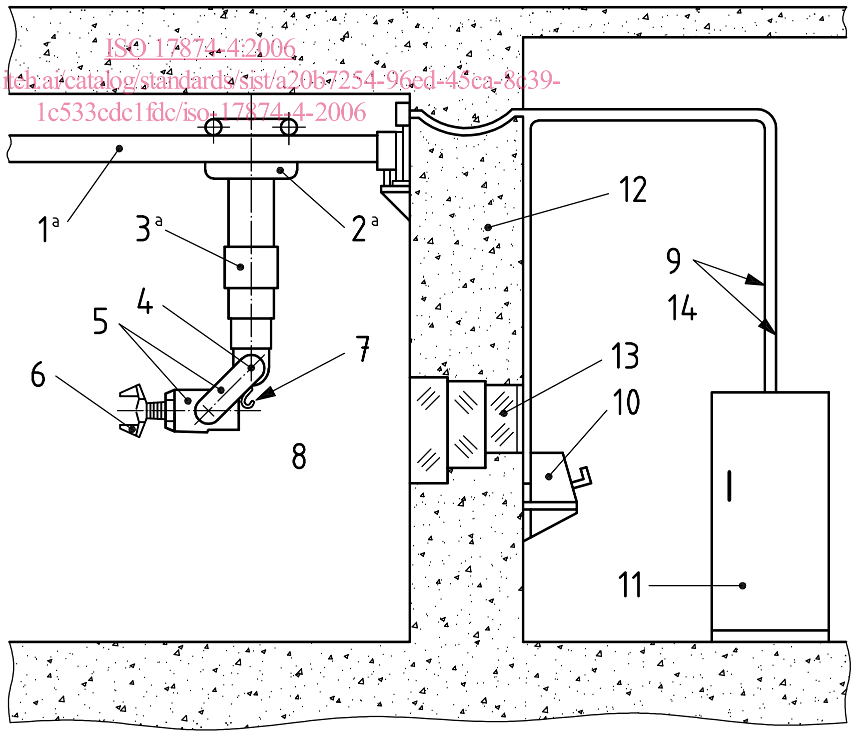
4 Applications of power manipulators

Power manipulators are used inside buildings, especially in hot cells. They consist of a mechanical arm mounted on a transporter running on rails, or sometimes on a remotely controlled vehicle. Transporters on rails usually consist of a movable bridge, a carriage and a vertical telescope (see Figure 1). The arm can also be installed on a rail vehicle on the cell floor.

They allow, in most cases, the exertion of high forces and therefore the handling of heavy objects, typifying their application. Power manipulators can be used as the only remote handling devices, but in medium-sized and large hot cells they are generally used in combination with mechanical master-slave manipulators (see ISO 17874-2). Both categories assist each other.

The mobility gives the power manipulators a large working volume, which is not offered by 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.

The relatively low working speed is one of the disadvantages of power manipulators. In addition, they are not suitable for complicated tasks.



Key

1 movable bridge
2 carriage
3 telescope with hoist
4 shoulder pivot
5 articulated arm
6 tongs
7 shoulder hook
8 hot cell
9 transmission cable
10 operating console
11 control cabinet
12 shielding wall
13 shielding window
14 operating room

[a] The movable bridge, the carriage and the telescope with hoist constitute the transporter.

Figure 1 — Power manipulator — Design for hot cells

5 General features

A power manipulator, within the meaning of this part of ISO 17874-4, is an electric motor-driven handling device operated remotely using speed control achieved by switches or potentiometers and analogue control (traditionally) or digital control. As a general rule, it exhibits the following characteristics: it has an articulated mechanical arm which is located on a positioning system, called a transporter (see Figure 1).

The arm is in most cases fitted with a tong with parallel jaws, by means of which objects can be handled and forces and torques exerted. The tongs are to be arranged to rotate without limit. The tongs can be exchanged (in some cases remotely) for other gripper types (typically a grip hook) or mechanical or electrically driven tools by means of in-cell fixtures. With the aid of a lifting hook on the articulated shoulder (called a shoulder hook), it is possible to lift substantially heavier objects than can be lifted with the tongs [see Figure 2 a)].

The transporter in most cases consists of a movable bridge, a cross-travel carriage and a vertical multiple telescope with a hoist for application in hot cells (see Figure 1). The functions of a light crane can be made available as a result of the load capacity of the hoist of the vertical telescope.

The speed of each motion can be fixed, controlled in several steps or continuously adjustable depending on the manipulator model. The operational forces are currently not directly reflected, but the gripping force can be transmitted to the operator by appropriate means. The gripping force can be measured and limited by steps, or by pre-selection or by means of an indicator and a variable sound.

The maximum velocities of different power manipulator models vary in a wide range. For power manipulators designed for use in hot cells, the following characteristics are available:

— rotation of the tongs: 10 r/min;

— inclination of hand, forearm and upper arm: 1 r/min;

— arm rotation: 5 r/min;

— lifting, carriage and bridge travel: 5 m/min.

6 Requirements

6.1 General aspects

Power manipulators have to meet a number of technical and safety specifications and in addition requirements concerning the operating environment (e.g. the presence of contamination, ionizing radiation, corrosive atmosphere, excessive humidity or temperature). Four classes of load capacity can be distinguished: light, medium, heavy and super-heavy, as given in Table 1.

Table 1 — Classes of power manipulators defined by load capacity

Class of load capacity	Load capacity, m kg			
	Tong	Grip hook		Shoulder hook [c]
	Horizontal arm position [a]	Arm position		
		Horizontal [a]	Vertical [b]	
Light	$20 \leqslant m < 50$	—	—	$250 \leqslant m < 500$
Medium	$50 \leqslant m < 125$	$50 \leqslant m < 125$	$50 \leqslant m < 1\,000$	$500 \leqslant m < 1\,000$
Heavy	$125 \leqslant m < 300$	$125 \leqslant m < 300$	$125 \leqslant m < 3\,000$	$1\,000 \leqslant m < 3\,000$
Super heavy	$300 \leqslant m < 500$	$300 \leqslant m < 500$	$300 \leqslant m < 5\,000$	$3\,000 \leqslant m < 5\,000$

[a] The load capacities for arms in the horizontal position are derived from the strength of the drive mechanisms.

[b] The additional load capacities in the vertical position are optional; they should be defined according to the operational requirements and are achieved by appropriate design of the pivots, hoists and transporter mechanism.

[c] The load capacities of the shoulder hooks are based on the capacities of the hoist and transporter mechanism.

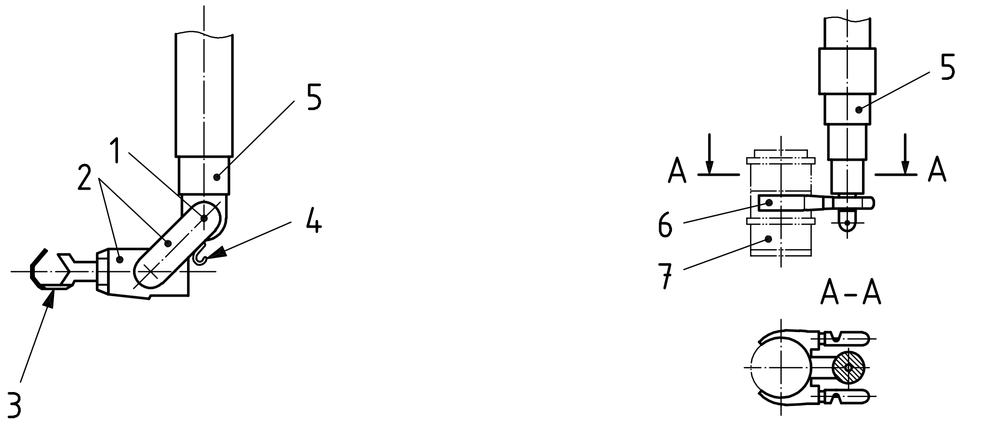
In addition to the preferred transporters for hot cells which consist of a movable bridge, a carriage and a vertical telescope (see Figure 1), there are transporters with different designs in use, e.g. movable mountings on a sidewall with a boom, movable portals, swivelling stands and other special designs.

There are also simplified manipulators for special purposes which are derived from power manipulators. Three common simplified manipulators are the following:

a) drum manipulators designed to transport and to stack radioactive waste drums, having a large gripper that can be tilted [see Figure 2b)] instead of an articulated arm;

b) manipulators intended for exchange of process components, having a double-grip hook instead of an articulated arm at the lower end of the vertical telescope;

c) remotely operated cranes, derived from power manipulator transporters, having no vertical telescope.



a) Power manipulator with a grip hook **b) Drum manipulator**

Key

1 shoulder pivot
2 articulated arm
3 grip hook
4 shoulder hook
5 multiple telescope with hoist
6 gripper for drums
7 waste drum

Figure 2 — Power manipulators — Examples

6.2 Materials

Since power manipulators are generally large, heavy units of equipment that are difficult to access safely, it is important to minimize the frequency of intervention for their maintenance and repair. Accordingly, the materials of component parts with exposed surfaces shall be protected against corrosion, ensuring compatibility with their function; corrosion can be promoted by ionizing radiation. All surfaces shall be designed to facilitate a high standard of decontamination. The decontamination processes envisaged shall not significantly degrade the functionality of the components, even when used repeatedly (e.g. the compatibility of the detergent type with the material of construction).

If different materials are bonded to one another, any contact corrosion shall be prevented by suitable measures. In certain cases, organic materials have to be used for specific applications (e.g. cable installations, bearing seals, lubricants). In this case, the material selected shall take into account the predicted radiation field, so as to avoid significant degradation between normal maintenance intervals.

6.3 Surface treatment

Aluminium alloys shall be anodized. Steels that are not rust-resistant shall be painted in a manner to facilitate decontamination (typically one coat of primer and two top coats), and if the surfaces are subjected to mechanical stress, they shall be suitably plated (e.g. in hard chrome). Stainless steels shall be subjected to an appropriate surface treatment, e.g. they shall be pickled and passivated. Depending on the environmental conditions, other surface treatments may be applied (e.g. painting or galvanization of carbon steel surfaces).

