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**Industrial automation systems and  
integration — Numerical control of  
machines — Coordinate system and motion  
nomenclature**

*Systèmes d'automatisation industrielle et intégration — Commande  
numérique des machines — Systèmes de coordonnées et nomenclature  
du mouvement*

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 841 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC 1, *Physical device control*.

This second edition cancels and replaces the first edition (ISO 841:1984), which has been technically revised. The following changes have been made:

- the content has been restructured in a more logical order;
- axes and motions have been clearly distinguished;
- new machine types have been added;
- motion designation for more complex machines has been added.

Annex A forms a normative part of this International Standard.

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## Introduction

This International Standard defines a standard machine coordinate system and the machine motions so that a programmer can describe the machining operations without having to know whether the tool approaches the workpiece or the workpiece approaches the tool.

The standard machine coordinate system is used to provide the coordinates of a moving tool (or point in the working space or on a drawing) with respect to a stationary workpiece.

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# Industrial automation systems and integration — Numerical control of machines — Coordinate system and motion nomenclature

## 1 Scope

This International Standard describes a machine coordinate system related to the primary motions of individual numerically controlled machines and the associated machine motions.

The machine coordinate system is used to provide the coordinates of a moving tool (or a point in the working space or on the drawing) with respect to a stationary workpiece. Thus a programmer can describe the machine operations without having to know whether the tool approaches the workpiece or the workpiece approaches the tool.

NOTE 1 Individual numerically controlled machines means that all axes are mounted on one base or frame and all motions are related to one standard coordinate system.

NOTE 2 For the sake of simplicity the majority of the text of this International Standard is written in terms accorded to machine tools but nevertheless accorded to numerically controlled machines in general. Coordinate systems and axis motion nomenclature for industrial robots is defined in ISO 9787, *Manipulating industrial robots — Coordinate systems and motion nomenclatures*.

## 2 Normative references

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The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 2806:1994, *Industrial automation systems — Numerical control of machines — Vocabulary*

ISO 6983-1:1982, *Numerical control of machines — Program format and definition of address words — Part 1: Data format for positioning, line motion and contouring control systems*

## 3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 2806 apply.

## 4 Machine coordinate system

### 4.1 Designation

The machine coordinate system is a right-hand rectangular system with the three principal axes labelled *X*, *Y* and *Z*, with rotary axes about each of these axes labelled *A*, *B* and *C*, respectively (see Figure A.1).

## 4.2 Origin

The location of the origin of the machine coordinate system shall be defined by the manufacturer.

## 4.3 Z axis

### 4.3.1 General

The Z axis is parallel to the principal spindle of the machine. For the case where the machine has no spindle, see 4.3.4 and 4.3.5.

NOTE 1 On machines used for milling, grinding, boring, drilling and tapping, the spindle rotates the tool.

NOTE 2 On machines such as lathes, cylindrical grinders and others which generate a surface of revolution, the spindle rotates the work piece.

### 4.3.2 More than one spindle

Where there are several spindles, one shall be selected as the principal spindle, preferably perpendicular to the workholding surface.

### 4.3.3 Swivelling or gimbaling spindle

Where the principal spindle can be swivelled or gimballed, the Z axis shall be parallel to spindle axis when the spindle is in the zero position. The preferred zero position is with the spindle perpendicular to the work-holding surface.

Where the principal spindle axis can be swivelled and if the extent of its motion allows it to lie in only one position parallel to one of the axes of the standard three-axis system, this standard axis is the Z axis.

Where the extent of the swivelling motion is such that the principal spindle can lie parallel to two of the three axes of the standard three-axis system, the Z axis is the standard axis which is perpendicular to the work holding surface of the work table of the machine, ignoring such auxiliary devices as mounting brackets or angle plates.

### 4.3.4 No spindle

For cutting and forming machines, the Z axis shall be perpendicular to the work-holding surface.

For coordinate measuring machines, the Z axis should be collinear with the acceleration of gravity vector (i.e. perpendicular to the surface of the earth).

### 4.3.5 Direction

For cutting and forming machines, the + Z axis direction is defined from the workpiece to the tool holder.

NOTE For lathes, the tail stock is considered as the tool holder.

For coordinate measuring machines, the + Z direction is defined as in the opposite sense as the acceleration of gravity vector (i.e. pointing away from the surface of the earth).

## 4.4 X axis

### 4.4.1 General

Where possible, the X axis shall be horizontal.



#### 4.4.2 Machines with rotating tools

Horizontal  $Z$  axis: Positive  $X$  shall be to the right when viewed in the negative  $Z$  direction.

Vertical  $Z$  axis, single column: Positive  $X$  shall be to the right when viewed from the front of the machine into the column.

Vertical  $Z$  axis, gantry type: Positive  $X$  shall be to the right when viewed from the principal spindle to the left-hand gantry support.

See also note 1 in 4.3.1.

#### 4.4.3 Machines with rotating workpieces

The  $X$  axis shall be radial and parallel to the cross slide. The positive direction shall be away from the axis of rotation.

See also note 2 in 4.3.1.

#### 4.4.4 Machines with no spindle

For cutting machines, positive  $X$  shall be parallel to and in the principal direction of cutting.

For coordinate measuring machines, positive  $X$  shall be defined by the manufacturer.

#### 4.5 $Y$ axis

Positive  $Y$  shall be in the direction to make a right-hand set of coordinates (see Figure A.1).

#### 4.6 Rotary axes $A$ , $B$ and $C$

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##### 4.6.1 Designation

$A$ ,  $B$  and  $C$  define rotary axes about linear axes  $X$ ,  $Y$  and  $Z$  respectively.

##### 4.6.2 Direction

Positive  $A$ ,  $B$  and  $C$  are in the direction to advance right-hand screws in the positive  $X$ ,  $Y$  and  $Z$  directions respectively (see Figure A.1).

### 5 Principal machine motions

#### 5.1 Designation

The principal linear motions of the machine which are parallel to the axes of the machine coordinate system shall be designated  $X$ ,  $Y$  and  $Z$  respectively. The principle machine rotary motions which are around one or more of the principal coordinate system axes shall be designated  $A$ ,  $B$  and  $C$  respectively.

#### 5.2 Direction

##### 5.2.1 General

Motion in the positive direction of the linear or rotary axes increases the positive position values and decreases the negative position values.

Letter designations shall be used to denote movement of either the tool or the workpiece.

### 5.2.2 Moving the tool

When moving the tool, the direction of movement and the axes directions are equal. Positive movements are designated with  $+X$ ,  $+Y$ ,  $+Z$ ,  $+A$ ,  $+B$ ,...

### 5.2.3 Moving the workpiece

When moving the workpiece, the direction of movement and the axis direction are opposite. To indicate the opposite direction, positive movements are designated with  $+X'$ ,  $+Y'$ ,  $+Z'$ ,  $+A'$ ,  $+B'$  ... (i.e. the axis direction  $-X = +X'$  of the workpiece movement).

## 6 Additional motions

### 6.1 Linear motions

When, in addition to the primary linear motions  $X$ ,  $Y$  and  $Z$ , there exists secondary linear motions parallel to the primary motions, these shall be designated  $U$ ,  $V$  and  $W$  respectively. Similarly, for tertiary motions, they shall be designated  $P$ ,  $Q$  and  $R$  respectively. When linear motions exist which are not (or may not be) parallel to  $X$ ,  $Y$  and  $Z$ , they may be designated  $U$ ,  $V$ ,  $W$ ,  $P$ ,  $Q$ , or  $R$  as is most convenient.

The primary linear motions should be those nearest the principal spindle, the secondary the next nearest, and the tertiary are the farthest.

For milling machines, the cutting-bit with respect to a facing slide should be designated  $U$  or  $P$  if these letters are available.

For machines with multiple units or many parallel movements, the designation of these motions may be indexed by using a letter and a number (e.g.  $X1$ ,  $X2$ , ...). The index shall be a positive integer greater than zero. The primary motion(s) may or may not have an index. Thus it is possible on one machine to have motions with and without indices.

### 6.2 Rotary motion

When, in addition to the primary rotary motions, there exists secondary rotary motions, either parallel to  $A$ ,  $B$ , or  $C$  or compounded or gimbaled to  $A$ ,  $B$ , or  $C$ , they shall be designated  $D$  or  $E$  (if these letters are available). As with linear motions, rotary motions may be indexed (see 6.1).

### 6.3 Letter restrictions

Certain letters (e.g.  $G$ ,  $M$ ,  $F$ ) shall not be used for motion (see ISO 6983-1).

### 6.4 Direction

The rules given in 5.2 for determining the direction of principal machine motions shall apply to additional motions.

## 7 Schematic drawings of machines

### 7.1 Examples of machine drawings

The schematic drawings of machines in annex A are the official interpretation for those machines. Where a conflict exists between the text of this International Standard and a given schematic, the schematic drawing shall take precedence.

## 7.2 Designation

The schematic drawing shows the machine coordinate system as appropriate to that machine together with the machine motions. Letters indicate axes and machine motions, arrows indicate positive directions.

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