INTERNATIONAL STANDARD

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Test conditions for machining centres —

Part 9: Evaluation of the operating times of tool change and pallet change

Conditions d'essai pour centres d'usinage —

Partie 9: Évaluation des temps opératoires de changement d'outils et de changement de palettes

Reference number
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Contents

Page

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 part of ISO 10791 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10791-9 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

ISO 10791 consists of the following parts, under the general title *Test conditions for machining centres*:

— *Part 1: Geometric tests for machines with horizontal spindle and with accessory heads (horizontal Z-axis)*

— *Part 2: Geometric tests for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis)*

— *Part 3: Geometric tests for machines with integral indexable or continuous universal heads (vertical Z-axis)*

— *Part 4: Accuracy and repeatability of positioning of linear and rotary axes*

— *Part 5: Accuracy and repeatability of positioning of work-holding pallets*

— *Part 6: Accuracy of feeds, speeds and interpolations*

— *Part 7: Accuracy of a finished test piece*

— *Part 8: Evaluation of the contouring performance in the three coordinate planes*

— *Part 9: Evaluation of the operating times of tool change and pallet change*

— *Part 10: Evaluation of the thermal distortions*

— *Part 11: Evaluation of the noise emission*

Annex A of this part of ISO 10791 is for information only.

Introduction

A machining centre is a numerically controlled machine tool capable of performing multiple machining operations, including milling, boring, drilling and tapping, as well as automatic tool changing from a magazine or similar storage unit in accordance with a machining programme. Most machining centres have facilities for automatically changing the direction in which the workpieces are presented to the tool.

The purpose of ISO 10791 is to supply information as wide and comprehensive as possible on tests and checks which can be carried out for comparison, acceptance, maintenance or any other purpose.

ISO 10791 specifies, by reference to the relevant parts of ISO 230, *Test code for machine tools*, several families of tests for machining centres with horizontal or vertical spindle or with universal heads of different types, standing alone or integrated in flexible manufacturing systems. ISO 10791 also establishes the tolerances or maximum acceptable values for the test results corresponding to general purpose and normal accuracy machining centres.

ISO 10791 is also applicable, totally or partially, to numerically controlled milling and boring machines, when their configuration, components and movements are compatible with the tests described herein.

Test conditions for machining centres —

Part 9:
Evaluation of the operating times of tool change and pallet change

1 Scope

This part of ISO 10791 specifies certain standard test conditions for assessing the conventional length of the operating times spent by the machine to carry out different metal cutting functions. It considers two types of operating times, namely those taken by the functions of:

— automatic tool change (see clause 5);

— automatic pallet change (see clause 6).

The purpose of the methods described in this part of ISO 10791 is to permit the comparison of the performance of different machining centres of similar size and features.

The data obtained may also be used to establish conventional change times in technical literature in a uniform and comparable way. It is also possible to check them on a machine, both when it is new and during its working life.

2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this part of ISO 10791. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10791 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 10791-1:1998, *Test conditions for machining centres — Part 1: Geometric tests for machines with horizontal spindle and with accessory heads (horizontal Z-axis)*.

ISO 10791-2:2001, *Test conditions for machining centres — Part 2: Geometric tests for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis).*

ISO 10791-3:1998, *Test conditions for machining centres — Part 3: Geometric tests for machines with integral indexable or continuous universal heads (vertical Z-axis).*

3 Terms and definitions

For the purposes of this part of ISO 10791, the following terms and definitions apply.

3.1
cut-to-cut tool change time
CTC
interval of time between the beginning of the removal of a tool to be changed from a reference position, P_R, in the machining volume and the end of the approach of the next tool to the same position

NOTE CTC is more suitable to judge the automatic tool change operation than the pure tool change time, because CTC takes into account all the steps required for changing tools in an automatic process.

3.2
pallet change time
PCT
interval of time between the beginning of the removal of a pallet to be changed from a reference position, P_R, in the machining volume and the end of the approach of the next pallet to the same position

4 Preliminary remarks

4.1 Measuring units

In this part of ISO 10791 all linear dimensions are expressed in millimetres and time is expressed in seconds.

4.2 Measuring instruments

The measuring instruments indicated are only examples. Other instruments, measuring the same quantities and having at least the same accuracy, may be used.

4.3 Test to be performed

When testing a machine, it is not always necessary or possible to carry out all the tests described in ISO 10791. When the tests are required for acceptance purposes, it is up to the user to choose, in agreement with the supplier/manufacturer, those tests relating to the components and/or the properties of the machine which are of interest. These tests are to be clearly stated when ordering a machine. The mere reference to ISO 10791 for the acceptance tests, without specifying the tests to be carried out and without agreement on the relevant expenses, cannot be considered as binding for the contracting parties.

4.4 Safeguarding

For safety reasons, the machine, where reasonably practicable, should be fully assembled and guarded, with guards and protective devices in place and functional.

5 Evaluation of the cut-to-cut tool change time (CTC)

5.1 Process

CTC includes, where applicable:

a) the movement between the reference position, P_R, and the tool change position, P_C;

b) the search for the next tool (in most cases, see Table A.2);

c) the tool change;

d) the opening and closing of movable covers between the tool store and the work zone;

e) the return to the reference position from the tool change position.

NOTE Spindle deceleration and acceleration times are assumed to be contained within phases a) and e) mentioned above.

5.2 Reference position and tool change position

5.2.1 Identification of the machining volume

The machining volume shall be identified by the maximum working travel distances of the three main coordinate axes. The extensions of the travel ranges of these coordinate axes which are used for auxiliary functions only (such as tool change or pallet change) shall be considered outside the machining volume.

Movable components in excess of the three main coordinate axes, such as sliding spindles, quills or rams, shall be maintained retracted, in a position not requiring their movement for the tool change.

5.2.2 Reference position, P_R

The reference position, P_R, is a position in the machining volume generally defined by the values along the three main coordinate axes as specified in this part of ISO 10791.

5.2.2.1 Machining centres with horizontal Z-axis

For machine configurations such as those shown in Figure 1 of ISO 10791-1:1998, the reference position is identified by the following values:

— X_R at mid-travel of the X-axis;

— Y_R at 1/4 of the Y-travel from its lower limit;

— Z_R at a position where the spindle nose is at the edge of the table nearest to the column.

If the table is rectangular, its longer side shall be parallel to the X-axis.

5.2.2.2 Machining centres with vertical Z-axis

For machine configurations such as those shown in Figure 1 of ISO 10791-2:— and ISO 10791-3:1998, the reference position is identified by the following values:

— X_R at mid-travel of the X-axis;

— Y_R at mid-travel of the Y-axis;

— Z_R at mid-travel of the Z-axis.

5.2.3 Tool change position, P_C

The tool change position, P_C, is determined by the machine configuration. Its coordinates are X_C, Y_C and Z_C.

5.3 Tool store configurations

5.3.1 General

The three configurations of tool stores given in 5.3.2 to 5.3.4 can be considered, where N indicates the store capacity in number of spaces.

5.3.2 Drum or chain type bidirectional tool stores

In this type of tool store the last tool T_N is the closest to T_1 and $T_{N/2}$ is the furthest from T_1.

5.3.3 Drum or chain type unidirectional tool stores

In this type of tool store, the last tool T_N is the closest to T_1 in one direction and the furthest in the opposite direction.

5.3.4 Box or matrix type tool stores

In this type of tool store, the last tool T_N is the furthest from T_1 and T_2 is the closest to T_1.

5.4 Tool store management

5.4.1 General

As far as the store management is concerned, the two types of tool stores given in 5.4.2 and 5.4.3 are considered in this part of ISO 10791.

5.4.2 Fixed access tool stores

In these types of stores, tools are directly exchanged between the machine spindle and the store, and the management of the tool handling is rigid, in that each tool shall be put back in its slot before the next one can be taken. They may be movable tool stores (for instance drum or chain stores) or fixed tool stores (for instance box type stores) where each tool is assigned to its own slot.

5.4.3 Random access tool stores

In these types of stores, a two-position tool changer is used to exchange tools between the machine spindle and the store. This design allows a random positioning by which a tool can be stored in any one of the empty slots after the next one has been loaded into the machine spindle. They may be movable tool stores (for instance drum or chain stores) or fixed tool stores (for instance stores served by a robot).

5.5 Test procedure

5.5.1 Data to be measured

With both fixed access tool stores and random access tool stores, the tool change time is variable, depending mainly on the search time. Therefore, this part of ISO 10791 specifies methods enabling the maximum and the minimum values of the tool change time to be measured.

5.5.2 Testing equipment

The test requires a minimum of two tool holders and a stopwatch. A dial gauge can be used to record that the spindle has reached the reference position.

5.5.3 Test execution

5.5.3.1 General

The complete test is made up of ten tool change cycles carried out under numerical control without interruption of the test programme between the start and the finish.

The test programme starts with the first tool holder in the spindle and the other(s) ready in the appropriate slot(s) of the store according to the time to be measured (as specified in 5.5.3.2.1, 5.5.3.2.2 or 5.5.3.3.1) or in the waiting position of the tool changer (see 5.5.3.3.2). The machine axes shall be in the reference position, P_R, specified in 5.2.2.

The test programme ends when all the programmed tool change cycles have taken place, with the last tool holder in the spindle and the machine axes back in the reference position, P_R.

Each test cycle shall start with a rapid traverse from the reference position, P_R, to the tool change position using any one of the machine axes if necessary.

A tool change operation then follows, followed by a rapid traverse to the reference position, P_R.

For the purposes of this clause, the spindle does not need to rotate, and the dwell time in the reference position, P_R, shall be zero. It shall be oriented, if necessary, in the position for changing the tool.

After the test programme has been completed, the total measured time will be divided by ten in order to obtain the required time.

5.5.3.2 Fixed access tool stores

5.5.3.2.1 Maximum cut-to-cut tool change time

To determine this value, each tool change operation is carried out drawing from the store the tool which is furthest from the one just stored.

5.5.3.2.2 Minimum cut-to-cut tool change time

To determine this value, each tool change operation is carried out drawing from the store the tool which is closest to the one just stored.

5.5.3.3 Random access tool stores

5.5.3.3.1 Maximum cut-to-cut tool change time

To determine this value, each tool change operation is carried out drawing from the store the tool which is furthest from the one just stored.

Since the search time is partially masked by other functions during the cycle, the first cycle may have a different length from the others. Therefore, in this case, eleven cycles are run during the course of the test programme, and the time to be measured starts when the spindle returns to the reference position, P_R, for the first time. The first cycle is then disregarded, and ten identical cycles are measured.

5.5.3.3.2 Minimum cut-to-cut tool change time

To determine this value, the test programme simulates the circumstances in which the entire search time is masked by the machining time and, therefore, does not appear in the tool change time.

For this purpose, the next tool does not need to be drawn from the store; it shall be ready in the waiting position of the tool changer.

5.6 Universal heads

In some cases, universal heads, which can be oriented in different directions, parallel to several coordinate axes, shall move back to one specified position for changing the tool. This is mostly the case of fixed access tool stores, where no tool changer exists.

In other cases, the tool changer can serve the universal head in several orientations (for instance horizontal and vertical).

In both cases, the maximum cut-to-cut tool change times (see 5.5.3.2.1 and 5.5.3.3.1) and the minimum cut-to-cut tool change times (see 5.5.3.2.2 and 5.5.3.3.2) shall be determined with the spindle in a horizontal and in a vertical orientation.

5.7 Presentation of the results

5.7.1 General

The information given in 5.7.2 to 5.7.5 shall be included in the test report.

5.7.2 Test data

The place, date when the measurements were performed and the person responsible for the test.

5.7.3 Machine under test

The description of the machine, including

— the manufacturer;

— the type;

— the serial number;

— the year of manufacture;

— the distance travelled by the three main coordinate axes (X_C-X_R, Y_C-Y_R, Z_C-Z_R), in millimetres (mm) (see 5.2.1);

— rapid feed rate of each axis, in metres per minute (m/min);

— the head orientation (horizontal, vertical, universal).

5.7.4 Tools and store

The description of tooling and tool store, including:

— the type and size of the tool shank;

— the length and weight of the tool holders used during the test;

— the tool store configuration and capacity (see 5.3);

— the tool store management (see 5.4).

5.7.5 Test results

a) The maximum cut-to-cut tool change time, CTC_{max}, determined according to 5.5.3.2.1 or 5.5.3.3.1.

b) The minimum cut-to-cut tool change time, CTC_{min}, determined according to 5.5.3.2.2 or 5.5.3.3.2.

c) If the machine tool has a universal head:

— the maximum cut-to-cut tool change time for horizontal orientation;

— the minimum cut-to-cut tool change time for horizontal orientation;

— the maximum cut-to-cut tool change time for vertical orientation;

— the minimum cut-to-cut tool change time for vertical orientation.

6 Evaluation of the pallet change time (PCT)

6.1 Process

The PCT may include the following steps:

a) the traverse of the receiver with the old pallet from the reference position, P_R, to the pallet change position;

b) the unclamping of the pallet from the receiver;

c) the opening of the safety guard;

d) the removal of the old pallet;

e) when required, the positioning of the receiver to a second position to take over the next pallet;

f) the approach of the next pallet;

g) the clamping of the next pallet on the receiver;

h) the closing of the safety guard;

i) the return of the receiver with the next pallet from the pallet change position to the reference position, P_R.

6.2 Reference position, P_R

6.2.1 General

The reference position, P_R, is a position in the machining volume generally defined by the values along the three main coordinate axes as given in 5.2.2, excluding those extensions of their travels used for auxiliary functions only (such as tool change or pallet change).

6.2.2 Machining centres with horizontal Z-axis

For machine configurations such as those shown in Figure 1 of ISO 10791-1:1998, the receiver may move along different linear axes, as shown hereafter:

along no axis: types 05, 08 and 11

along the X-axis only: types 07 and 10

along the Y-axis only: type 12

along the Z-axis only: type 02

along the X- and Y-axes: types 06 and 09

along the Z- and X-axes: types 01 and 04

along the three axes: type 03

6.2.3 Machining centres with vertical Z-axis

For machine configurations such as those shown in Figure 1 of ISO 10791-2:2001 and ISO 10791-3:1998, the receiver may move along different linear axes, as shown hereafter:

along no axis: types 05, 08 and 11

along the X-axis only: types 07 and 10

along the Y-axis only: type 02

along the Z-axis only: type 12

along the X- and Y-axes: types 01 and 04

along the Z- and X-axes: types 06 and 09

along the three axes: type 03

Consequently, operations a), e) and i) in 6.1 may be carried out by more or less complex movements, or by no movement at all.

6.3 Pallet store configuration

6.3.1 General

The following configurations of pallet stores can be considered, where N indicates the store capacity in number of places.

6.3.2 Carousel or chain type bidirectional pallet stores

In this type of pallet store, the last pallet P_N is the closest to P_1 and $P_{N/2}$ is the furthest from P_1.

6.3.3 Carousel or chain type unidirectional pallet stores

In this type of pallet store, the last pallet P_N is the closest to P_1 in one direction and the furthest in the opposite direction.

6.3.4 Two-place pallet stores

In this type of pallet store, usually placed on the machine itself, either a carousel carries the two pallets, one in the machining position and the other in the load/unload position, or two places are located in the load/unload position and the machine itself stores and takes the pallets.

6.3.5 Straight-line and multi-storey pallet stores

These types of stores usually serve a number of machining centres, using shuttle or rail dependent two-axis transfer equipment supplying pallets to the individual pallet changers. They can be placed on both sides of the transfer equipment.

In this type of pallet store, the last pallet P_N is the furthest from P_1, and P_2 is the closest to P_1.

6.4 Pallet store management

6.4.1 General

As far as store management is concerned, this part of ISO 10791 takes the two types of pallet stores 6.4.2 and 6.4.3 into account.

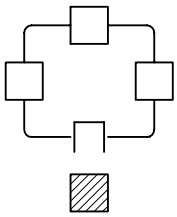
6.4.2 Fixed access pallet stores

In these types of stores, pallets are directly exchanged between the machine receiver and the store, and the management of the pallet handling is rigid, that is each pallet shall be back in its own place before the next one can be taken. They may be movable pallet stores (for instance carousel or chain stores) or fixed pallet stores (for instance two-place stores) where each pallet is assigned to its own place.

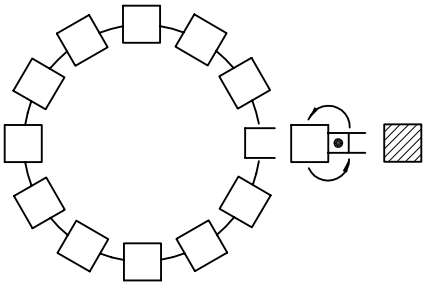
6.4.3 Random access pallet stores

In these types of stores, a two-position pallet changer is used to exchange pallets between the machine receiver and the store. This design allows a random positioning by which a pallet can be stored in any empty place after the next one has been loaded into the machine receiver.

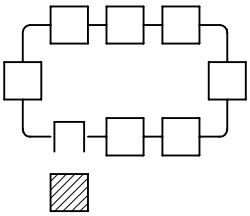
They may be movable pallet stores (for instance carousel or chain stores) or fixed pallet stores (for instance straight-line or multi-storey stores served by a shuttle).



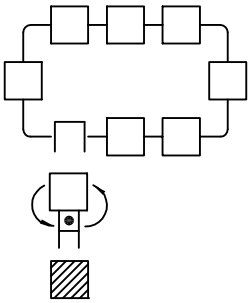
Carousel type store
(6.3.2 and 6.3.3)



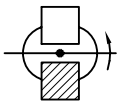
Carousel type store
(6.3.2 and 6.3.3)



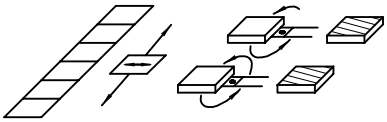
Chain type store
(6.3.2 and 6.3.3)



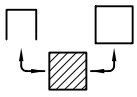
Chain type store
(6.3.2 and 6.3.3)



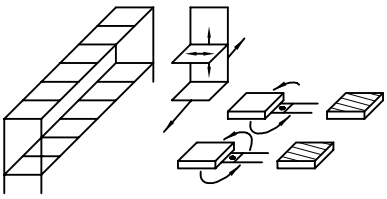
Carousel two-place store
(6.3.4)



Straight-line pallet store
(6.3.5)



Fixed two-place store
(6.3.4)



Multi-storey pallet store
(6.3.5)

corresponds to the pallet on the receiver in the working zone

corresponds to the empty place in the pallet store

Figure 1 — Configurations of fixed access pallet stores

corresponds to the pallet on the receiver in the working zone

corresponds to the empty place in the pallet store

Figure 2 — Configurations of random access pallet stores

6.5 Test procedure

6.5.1 Data to be measured

The pallet change time for fixed access multiple-place pallet stores varies in relation to the search time. Therefore methods are specified in this part of ISO 10791 in order to measure the maximum and the minimum value of the pallet change time.

The pallet change time for fixed access two-place pallet stores is in principle the same in the two directions. Therefore only one value shall be measured.

The search time of the next pallet for random access pallet stores is considered to be always shorter than the machining time on the current pallet. Therefore it can be disregarded and only one value shall be measured.

6.5.2 Testing equipment

The test requires a minimum of two pallets and the use of a dial gauge and a stop watch. The dial gauge can be used to show the pallet movement from and to the reference position, P_R.

6.5.3 Test execution

6.5.3.1 General

The complete test consists of ten pallet change cycles carried out in numerical control without interruption of the test programme between the very start and the finish.

The test programme starts with the first pallet on the receiver and the other(s) ready in the appropriate place(s) of the store according to the time to be measured (as specified in 6.5.3.2.1, 6.5.3.2.2 or 6.5.3.3) or in the waiting position of the pallet changer (see 6.5.3.4). The machine axes shall be in the reference position, P_R, specified in 6.2.

The test programme ends when all the programmed pallet change cycles have taken place, with the last pallet on the receiver and the machine axes back in the reference position, P_R.

Each test cycle shall start with a rapid traverse from the reference position, P_R, to the pallet change position.

A pallet change operation is then carried out, followed by a rapid traverse to the reference position, P_R.

For the purposes of this clause, the spindle does not need to rotate, and the dwell time in the reference position, P_R shall be zero.

After the test programme has been completed, the total measured time is divided by ten to obtain the time required.

6.5.3.2 Fixed access multiple-place pallet stores

6.5.3.2.1 Maximum pallet change time

To determine this value, each pallet change operation is carried out by taking from the store the pallet which is furthest from the one just stored.

6.5.3.2.2 Minimum pallet change time

To determine this value, each pallet change operation is carried out by taking from the store the pallet which is closest to the one just stored.

6.5.3.3 Fixed access two-place pallet stores

To determine the single value, the test programme may start irrespective of which pallet is on the receiver. Care should be taken that the random differences between the two symmetrical pallet changes are reasonably low.

6.5.3.4 Random access pallet stores

To determine this value, the test programme simulates the circumstances in which the entire search time is totally masked by the machining time and, therefore, does not appear in the pallet change time.

For this purpose, the next pallet does not need to be taken from the store; it shall be ready in the waiting position of the pallet changer.

6.6 Presentation of the results

6.6.1 General

The information given in 6.6.2 to 6.6.5 shall be included in the test report.

6.6.2 Test data

The place, date when the measurements were performed and person responsible for the test.

6.6.3 Machine under test

Description of the machine, including:

— the manufacturer;

— the type;

— the serial number;

— the year of manufacture;

— the distance travelled by the three main coordinate axes, in millimetres (mm) (see 5.2.1);

— the rapid feed rate of each axis, in metres per minute (m/min).

6.6.4 Pallets and store

— nominal size of the pallets;

— pallet store configuration and capacity (see 6.3);

— pallet store management (see 6.4).

6.6.5 Test results

6.6.5.1 Fixed access multiple-place pallet stores

— maximum pallet change time, $PCT_{max,}$ determined according to 6.5.3.2.1;

— minimum pallet change time, PCT_{min}, determined according to 6.5.3.2.2.

6.6.5.2 Fixed access two-place pallet stores or random access stores

— the pallet change time, PCT, determined according to 6.5.3.3 or 6.5.3.4 respectively.

Annex A
(informative)

Principles on which the test cycles are based

A.1 Fixed access tool stores

As mentioned in 5.4.2, each tool shall be replaced in its own position before the next one can be taken.

In this type of store, the tools are usually directly exchanged between the machine spindle and the store and vice versa. Therefore the search time in its entirety will form a part of the overall tool change time.

The tool change time may then have two extreme values, a maximum value and a minimum value depending on the search time of the furthest or of the closest tool respectively.

A.2 Random access tool stores

As mentioned in 5.4.3, a tool can be stored in any empty slot after the next one has been loaded into the machine spindle.

For this, a tool changer with at least two places is required. Although on very fast machining centres up to three places are used in tool changers, only two-place tool changers are considered for the test cycles described in this part of ISO 10791.

In this case, all or part of the search time can be masked within the machining time of the current tool. Furthermore, the tool change time may vary between two extreme values: the maximum value is found by joining a hypothetical null machining time with the search of the furthest tool, and the minimum value is found when the machining time exceeds the search time, irrespective of which tool is the object of the search.

A.3 Fixed access pallet stores

A.3.1 General

As mentioned in 6.4.2, each pallet shall be back in its own place before the next one can be taken.

A.3.2 Multiple-place pallet stores

In this type of store, pallets are usually directly exchanged between the machine receiver and the store and vice versa. Therefore the search time is an integral part of the overall pallet change time.

The pallet change time may then have two extreme values, a minimum value and a maximum value depending on the search time of the furthest or of the closest pallet respectively.

A.3.3 Two-place pallet stores

The pallet change operation takes place in a similar way to the case of multiple place pallet stores, with the only difference that, in principle, the pallet change time does not have two extreme values, aside from the random variations between the two symmetrical changes.

The pallet change time has then only one value, generally taken as the average value of the two symmetrical changes.

A.4 Random access pallet stores

As mentioned in 6.4.3, a pallet can be stored in any empty place after the next one has been loaded onto the machine receiver.

For this purpose a two-place pallet changer is required.

In this case all the search time is masked within the machining time of the pallet load currently being machined. Furthermore, the pallet change time may have two extreme values but, for the purposes of this part of ISO 10791, the machining time of a hypothetical workpiece on the current pallet is always considered as being longer than the search time of the following pallet, whichever it is.

As a result, there is only the pallet change time.

A.5 Summary

Table A.1 shows the values to be determined in each of the five cases described above.

Table A.1 — Tool change time and pallet change time on different store types

Type of store	Times to be determined	
Fixed access tool store	CTC_{max}	CTC_{min}
Random access tool store	CTC_{max}	CTC_{min}
Fixed access multiple-place pallet store	PCT_{max}	PCT_{min}
Fixed access two-place pallet store	PCT (one only)	
Random access pallet store	PCT (one only)	

Table A.2 shows the main differences in the test conditions for the different tests taken into account in this part of ISO 10791.

Table A.2 — Influences on tool change time and pallet change time

Store management	Tool Change				Pallet Change			
	Fixed access		Random access		Fixed access multiple-place		Fixed access two-place	Random access
Change time	CTC_{max}	CTC_{min}	CTC_{max}	CTC_{min}	PCT_{max}	PCT_{min}	PCT	PCT
Search time included	yes	yes	partially	no	yes	yes	yes	no
Store position	furthest	closest	furthest	any	furthest	closest	fixed	any

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