INTERNATIONAL STANDARD 2818

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Plastics — Preparation of test specimens by machining

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2818 was drawn up by Technical Committee ISO/TC 61, *Plastics*, and circulated to the Member Bodies in July 1972.

It has been approved by the Member Bodies of the following countries :

Austria	Ireland	Spain
Belgium	Israel	Sweden
Brazil	Italy	Switzerland
Czechoslovakia	Japan	Thailand
Egypt, Arab Rep. of	Netherlands	Turkey
France	New Zealand	United Kingdom
Germany	Poland	U.S.A.
Hungary	Portugal	U.S.S.R.
India	Romania	
Iran	South Africa, Rep. of	

This International Standard has also been approved by the International Union of Pure and Applied Chemistry (IUPAC).

No Member Body expressed disapproval of the document.

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Plastics — Preparation of test specimens by machining

1 SCOPE AND FIELD OF APPLICATION

This International Standard describes methods for the preparation of plastics test specimens by machining.

The requirements of clauses 2 and 6 are mandatory while the machining practices described in clauses 3, 4 and 5, and in annexes A, B and C are recommended as proven means for meeting those requirements. However, the validity of any method of preparing test specimens by machining must be established by showing that the specimens produced yield test results which are satisfactory in both average and spread.

2 SPECIMENS

2.1 There are normally three different types of test specimens used :

- rectangular bars;
- curvilinear test specimens (dumb-bells);
- circular discs.

The shape, dimensions, and tolerances of these test specimens shall be in accordance with the relevant ISO publications.

2.2 Because of anisotropy and/or heterogeneity of plastic plates it is necessary to record the precise position of the specimens relative to the plates. This is particularly true when the specimens are thinner than the original plates.

2.3 All surfaces which matter must be free from visible flaws, scratches or imperfections, when viewed with a low-powered (approximately X5) magnifying glass.

2.4 If the specimen as machined does not meet the requirements of 2.3, then marks left by machining operations must be carefully removed with a fine file or abrasive, and the filed surfaces then smoothed with abrasive paper.

2.5 The finishing strokes shall be made along, rather than across, the edges of the test specimen.

2.6 The required degree of finish depends on the material and the test method to be employed.

2.7 In machining a specimen, undercuts or sharp discontinuities shall be avoided. Care shall also be taken to avoid other common machining defects.

3 MACHINING PROCESSES

The following processes have been found suitable :

- milling;
- grinding.

NOTE — It is also possible in the case of rectangular test specimens to produce these by sawing, but only if a very sharp saw, for example diamond tipped, is used.

4 APPARATUS

The following machines have been found to give good results :

a) milling machines;

b) high-speed rotary machines;

c) abrasive discs and circular cutters.

4.1 Milling machine

Tool rotation speed 50 to 2 500 rev/min.

4.2 High-speed rotary machine (preferably a copy milling machine)

Tool rotation speed 20 000 to 30 000 rev/min although lower speeds down to 8 000 rev/min have been found better for some materials.

This method, based on the use of a cylindrical tool of 5 to 20 mm diameter, is particularly suitable for the machining of curved surfaces (for example, tensile strength test specimens).

The use of templates permits exact machining of test specimens with minimum difficulty (see annex A for one suggested assembly).

The construction of the machine usually includes the following features :

a) a driving motor either so situated, or so constructed, as to allow the use of a cooling fluid. In some cases adequate specimens can be produced by good machining

practice without the use of coolants. Fluid coolants should only be used where they are necessary for the production of good specimens;

b) a motor sufficiently powerful to maintain the machining operation at the speed selected;

c) a device to vary the speed of the cutter between 8 000 and 30 000 rev/min, in order to adapt the working conditions to each material machined;

d) a device to vary the depth of cut with a precision of 20 μm (*minimum depth 20 μm), if necessary* for the specimens being machined;

e) a device allowing the test specimen, together with the template, to be guided and moved against the tool in a smooth and continuous movement;

f) a suction device allowing removal of the dust or shavings formed.

4.3 Abrasive disc type block slicing machine (see annex B for one suggested assembly)

This machine can be used only to obtain straight cuts.

4.4 Tubular abrasive machine tool (circular cutter)

See figure 2 in annex C.

5 PROCEDURE

Several recommended methods of operation are described in annexes A, B and C. The table can be used as a guide, in the absence of specified instructions.

6 REPORT

The report shall include the following particulars :

a) description of plate (material, orientation, method of preparation, etc.);

b) method of preparation of the material to be machined;

c) method of machining;

d) machining conditions,

— characteristics of the tool, speed of the tool, angle of backing off, speed of feed, depth of cut, cooling;

e) dimensions of the machined test specimens;

f) precise description of position of test specimens relative to plates;

g) other details as necessary.

TABLE – **Machining conditions found suitable for thicknesses less than 10 mm**

Material	Method of machining[2)3)]	Geometry of the tool			Number of teeth	Rotating speed of tool	Speed of cut	Speed of feed	Depth of cut	Cooling
		Angle of backing off	Angle of cut	Diameter						
		degrees	degrees	mm		rev/min	m/min	m/min	mm	
Thermo-plastics[1)]	1 (4.1)	5 to 20	5 to 15	150	10	50 to 200		slowly by hand	3	air or water
	2a) (4.2 and annex A)	5 to 20	10 to 15	10 to 15	4 to 8	8 000 to 30 000		slowly by hand	0,2	air or water
	–	–	–	–	–	–	–	–	–	–
	3 (4.3 and annex B)			200 to 300			1 000 to 2 000	0,5 to 3		air or water
Thermo-sets	2b) (4.2 and annex A)			15 to 20		20 000		slowly by hand	0,5	water
	3 (4.3 and annex B)			150 to 250			2 200			water
	4 (4.4 and annex C)			40 to 100			120 to 150	slowly by hand		water

1) Cooperative testing has been carried out on the following materials :
PS, SAN, SB, ABS, PE, PA, PVC, PC, PMMA. However, the conditions given are considered applicable to other plastic materials as well.

2) 1 = Milling machine with high-speed steel alternating-tooth disc milling cutter
2a) = High-speed rotary machine (preferably a copy milling machine) having a cylindrical milling cutter with helical teeth
2b) = High-speed rotary machine (preferably a copy milling machine) having a cylindrical diamond-faced cutter
3 = Block slicing machine with abrasive disc
4 = Tubular cutting machine with cylindrical diamond-brazed circular cutter

3) Methods 1 and 2a) also are considered applicable to thermosets, but as such materials were not included in the recent cooperative study of cutting conditions, no recommendations for them are given at this time.

ANNEX A

MACHINING OF CURVILINEAR TEST SPECIMENS

A.1 APPARATUS

The apparatus (figure 1) used is a manually guided copy milling machine comprising the features given in 4.2, and the following elements :

- a horizontal stand serving as guide path for the moving platen and supporting the cylindrical guide bar;
- a moving platen supporting the blank test specimens to be machined and the template;
- a cooling unit with tank;
- a rotating arbor with driving motor;
- various cylindrical tools.

A.1.1 Stand

This item consists of a thick, rigid horizontal platen on which the moving platen slides. It also bears the motor supports and, in the tool extension, supports the cylindrical guide bar.

A.1.2 Moving platen

This slides over the surface of the stand, with the aid of supports composed of a material of low coefficient of friction (graphite-filled polyamide, MoS_2 or polytetrafluoroethylene). It is fitted with fixing bolts for the test specimen clamps and fixing pins for the interchangeable templates. The test specimen and template are superimposed.

A.1.3 Cooling unit

This unit consists of one or more nozzles making it possible to project water (in a jet or spray) or compressed air onto the point of contact between the disc and the workpiece.

NOTE – Precautions may be necessary as compressed air ordinarily available in working areas sometimes contains traces of oil detrimental to some plastics.

A cooling medium must be selected which does not adversely affect the machined product.

A housing is used to protect the electrical apparatus from splashes.

A.1.4 Rotating arbor and motor

The cutter arbor must be perpendicular to the surface of the stand, and turn with an eccentricity of less than 20 μm. Operation may be pneumatic or by electric motor, with the arbor speed adjustable within the range 8 000 to 30 000 rev/min. A method of fixing with the aid of clips makes rapid tool changing possible and ensures correct tool centring.

A.1.5 Tools

The tool, milling cutter or diamond grinding wheel, is chosen in accordance with the characteristics of the material to be machined.

The diamond grinding wheel is preferred for thermosetting materials :

- diameter : 12 to 20 mm;
- granulation of the diamond particles : 80 to 120;
- binder : bronze;
- concentration of diamond particles : A-75 to A-200[1].

A hard-metal milling cutter of suitable diameter is used for machining thermoplastic materials :

- diameter : 6 to 16 mm;
- angle of the helix of the teeth : 85° or 45°.

A.2 PROCEDURE

Fix a template corresponding to the shape of the test specimens to be machined to the moving platen. Then put the guide stop into position.

Prepare in advance a series of rectangular blanks of such size that test specimens with specified dimensions can be machined from them. The process described in annex B, for example, may be used.

Attach these blanks, piled to a height of 10 to 25 mm according to the height of the tool, by means of a clamp onto the moving platen. Carry out the machining by means of successive cuts, moving the platen transversely by hand.

Use the cutting speeds and cooling conditions recommended in the specifications. If these directions are not available, consult the table for the conditions recommended for the material in question.

NOTE – After machining, and particularly when the coolant used is water, it is necessary to condition the resultant test specimens in accordance with ISO/R 291.

1) According to the Diamond Board index.

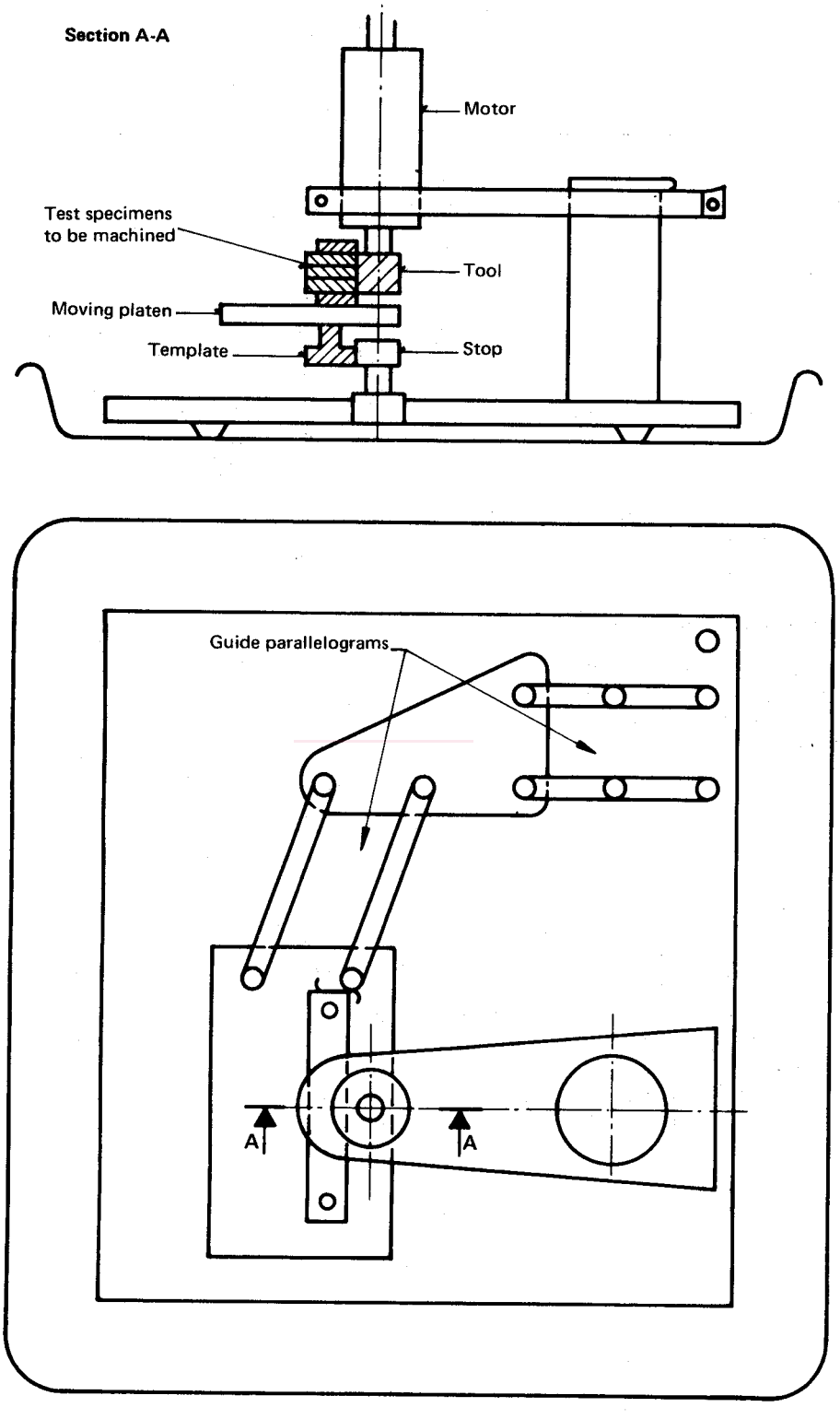


FIGURE 1 – **Manually guided copy milling machine**

ANNEX B

CUTTING OF RECTANGULAR TEST SPECIMENS BY MEANS OF A DIAMOND DISC

B.1 APPARATUS

The apparatus consists of the following items (see also 4.3) :

– a frame supporting the guide rails of the moving table;

– a motor and grinding spindle assembly;

– a cutting table;

– a diamond disc;

– a cooling unit and tank.

B.1.1 Frame

The frame supporting the guide rails must be sufficiently rigid to ensure uniformity of cutting upon repetition, with a precision of 0,1 mm (see B.1.3).

B.1.2 Motor and grinding-spindle assembly

This unit must be capable of operating at different speeds. It must be free from vibration and supported by bearings without clearance. Its height above the cutting table must be adjustable. The axis of rotation must be strictly perpendicular to the guide rails of the table.

B.1.3 Cutting table

This is supported on the guide rails. It must have a supporting edge for the test specimens, perpendicular to its direction of movement. This edge serves as guide for a support plate, preferably adjustable parallel to the nearest 0,1 mm with the plane of the cutting disc over a length equal to the diameter of the disc. The table contains a slot or slit in which the disc can penetrate to a depth, if possible, equal to at least a quarter of its diameter. It is desirable that the table be moved by a mechanism exercising a constant force in pressing the test specimen against the edge of the disc (for example, by means of a counterweight and a flexible cable passing over a pulley); in this case, the apparatus is fitted with a device maintaining pressure on the sample and keeping it immobile in relation to the table.

B.1.4 Diamond disc

This disc is a thin circular steel core with, around its periphery, a circular band 5 to 20 mm wide of a metal binder (bronze or nickel alloy) covering and retaining the diamond particles. It has the following characteristics :

– diameter : 150 to 300 mm[1)];

– thickness of the working part : 0,8 to 2 mm[1)];

– nature of the metal binder : bronze or nickel alloy;

– granulation of the diamond particles : granulation 36/52 to 100/120 (unless otherwise specified, the value 100/120 is preferred);

– concentration of diamond particles : from A-20 to A-40[2)] (unless otherwise specified, concentration A-40 is recommended).

B.2 PROCEDURE

If available use the conditions recommended in the relevant specifications; otherwise consult the table for the conditions considered most appropriate.

NOTE – After cutting, and particularly when the coolant used is water, it is necessary to condition the resultant test specimens in accordance with ISO/R 291.

Clamp the specimen on the table and feed it to the cutter at the rate required by the relevant specification. In the absence of such direction, the rate of feed (speed of movement of the cutting table) and the force applied to the specimen should be chosen from the conditions given in the table in the light of experience.

1) Usual range of dimensions – for guidance only.

2) According to the Diamond Board index.

ANNEX C

CUTTING OF CIRCULAR TEST SPECIMEN WITH CIRCULAR CUTTER

C.1 APPARATUS

The apparatus consists of a drill and drill stand and includes the following items (see also 4.4) :

- a spraying device;
- a circular cutter of suitable diameter;
- a clamping device for the sample;
- a trough for the removal of coolant and dust.

The general arrangement is shown in figure 2.

C.1.1 Chuck and spraying device

This consists essentially of a spatial chuck mounted on the turning spindle of the drill, intended to hold the circular cutter vertically at its lower end.

The chuck is fitted with a sleeve and rotating fluid-tight couplings so that cooling fluid can be brought to the cutting tool. The fluid chosen must not affect the product to be machined.

C.1.2 Circular cutter

The cutter consists of a cylindrical tubular sleeve, extended in its axis by a cylindrical or conical shank (Morse taper) to hold it on the turning spindle of the drill. The shank is pierced by one or more openings to allow cooling fluid to reach the inside.

The cutter is extended at its lower end by an abrasive sleeve consisting of a metal binder containing diamond particles. The sleeve contains slots parallel to the axis of the cutter, to permit evacuation of the water and the dust arising from the machining. These slots must be restored with the aid of a file as the abrasive sleeve becomes worn.

The characteristics of the cutter are as follows :

- internal diameter : corresponding to that of the disc to be produced;
- thickness of the abrasive sleeve : from 0,8 to 2 mm (usual – for guidance only);
- nature of the metal binder : bronze or nickel alloy;
- granulation of the diamond particles : 36 to 120 (unless otherwise specified, the value 100/120 is preferred);
- concentration of diamond particles : A-20 to A-401) (unless otherwise specified, concentration A-40 is recommended).

In order to avoid the formation of fins at the time that the cutter is withdrawn, it is advised that a slight slope be given to the cutting edge of the tool so that the drive is produced on the inside diameter.

C.1.3 Clamping device for sample

The sample is held flat by a suitable clamping device on a block several millimetres thick. This block has a circular opening into which the cutter can pass without touching the sides.

An adjustable stop is placed on the downstroke mechanism of the drill to halt any further downward movement of the cutter once the sample has been penetrated.

C.1.4 Trough for removal of coolant

The platen of the machine is fitted with a device to collect the liquid after it has passed over the axis of the cutter, so that, according to the circumstances, it may be finally removed or recycled by means of a pump.

C.2 PROCEDURE

A circular cutter of selected diameter is so mounted in the chuck that coolant can be supplied to its cutting edge.

A 3 to 6 mm thick block (see note) with plane parallel faces and with a round hole (of slightly greater diameter than the cutter) bored through its centre is so positioned on the platen that the centre of the hole is in line with the central axis of the cutter. The sample to be cut is then clamped securely on top of the block.

NOTE – The block should be made of a rigid material such as thermoset plastic.

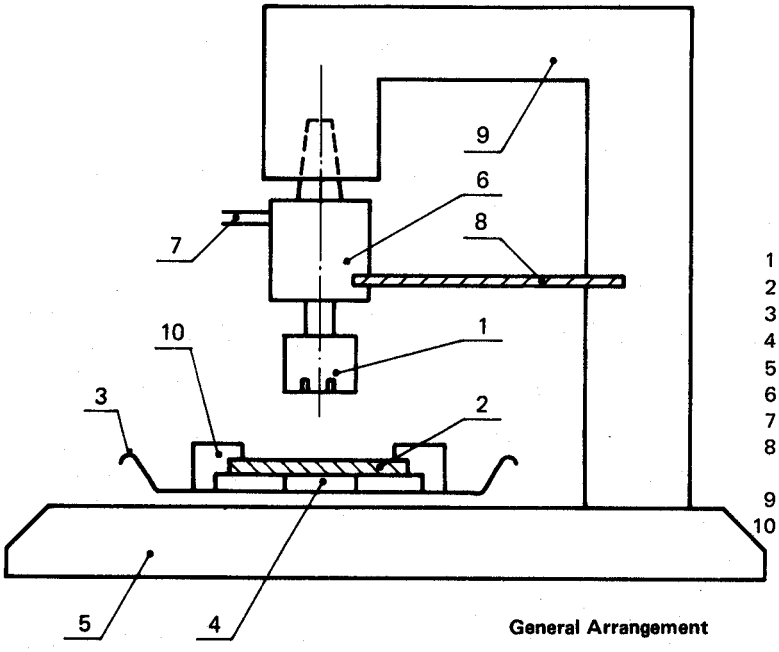
The rotational speed of the cutter is adjusted to that specified for the material to be cut. However, if the speed of rotation is not specified, it may be adjusted either to that recommended in the table or, as a first approximation, to about 150 m/min at the periphery of the tool (i.e. about 1 200 rev/min for a cutter of 50 mm diameter).

It is preferable that the tool be applied to the surface to be cut with constant force (for example, by means of a weighted cord and pulley arrangement). Cutting is accomplished by abrasion so no great force is necessary; between 20 and 10N, depending upon the diameter of the cutter and the kind of material being cut, usually is sufficient.

The descent of the tool is halted at the end of the cutting operation by a stop.

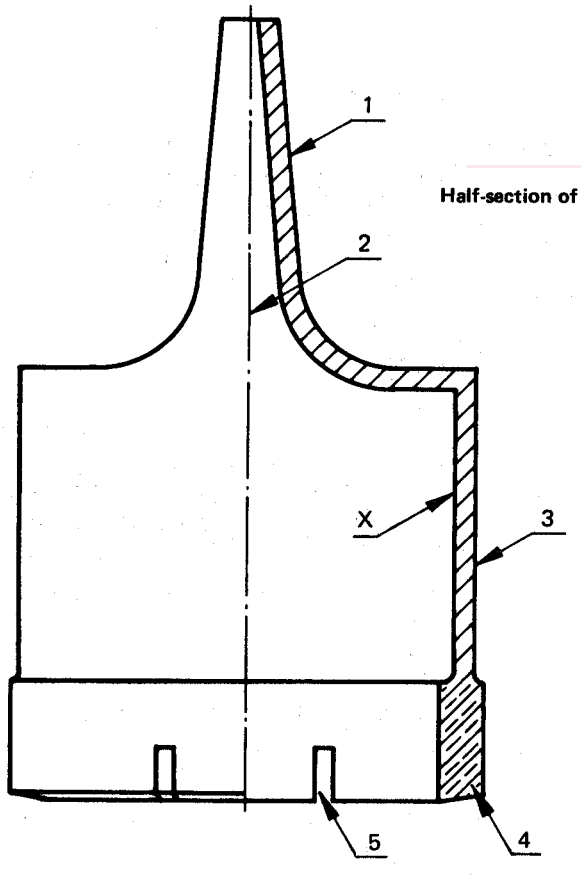
NOTE – After machining, and particularly when the coolant used is water, it is necessary to condition the resultant test specimens obtained, in accordance with ISO/R 291.

1) According to the Diamond Board index; any other equivalent values may be used.



General Arrangement

1 Circular cutter
2 Sample to be cut
3 Coolant removal trough
4 Block
5 Drill stand
6 Cooling jacket
7 Coolant feed
8 Arm to hold the jacket stationary during rotation
9 Body of the drill (diagrammatic)
10 Sample clamping device (diagrammatic)



Half-section of a diamond-edged cutter

1 Cylindrical or conical fixing shank
2 Axial coolant feed channel
3 Body of the cutter
4 Abrasive sleeve (slightly thicker than the body of the cutter)
5 Drainage holes for coolant and dust

FIGURE 2 – **Tubular abrasive machine tool**