
International Standard



5603

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Rubber, vulcanized — Determination of adhesion to wire cord

Caoutchouc vulcanisé — Détermination de l'adhérence à un câble métallique

First edition — 1986-10-01

ITeH STANDARD PREVIEW
(standards.iteh.ai)

[ISO 5603:1986](#)

<https://standards.iteh.ai/catalog/standards/sist/6b646d65-3581-46a2-9bb2-0dc82b3331f8/iso-5603-1986>

UDC 678.4 : 620.179.4 : 677.7

Ref. No. ISO 5603-1986 (E)

Descriptors : rubber, vulcanized rubber, tests, adhesion tests.

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.

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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 5603 was prepared by Technical Committee ISO/TC 45
Rubber and rubber products.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Rubber, vulcanized — Determination of adhesion to wire cord

1 Scope and field of application

This International Standard specifies two methods for determining the adhesion strength of vulcanized rubber to wire cord which is embedded in the rubber.

These methods are applicable primarily to test pieces prepared in the laboratory under standard conditions, such as may be used for the development and control of materials and processes used in the manufacture of products reinforced with wire cord.

NOTE — These methods may also be applicable to single wire, for example, bead wire.

Method 1 reduces the dependence of the measured adhesion on the modulus and strength properties of the rubber.

2 References

ISO 471, *Rubber — Standard temperatures, humidities and times for the conditioning and testing of test pieces.*

ISO 2393, *Rubber test mixes — Preparation, mixing and vulcanization — Equipment and procedures.*

ISO 5893, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse).*

3 Principle

The adhesion strength is determined by measuring the force required to pull out a single cord from the surrounding rubber of a prepared test piece. The force is directed along the axis of the cord, using a test jig containing a suitably chosen circular or square-shaped hole to ensure uniformity of stress.

Test pieces of cord and rubber are prepared together by vulcanizing them under pressure. In method 1, the exterior surface of the rubber is suitably reinforced. In method 2, such reinforcement is not employed.

4 Materials

4.1 Wire cord, conforming to the specification of the bonding system to be investigated. If no specification is given, brass plated steel cord of construction $1 \times 3 \times 0,15 \text{ mm} + 6 \times 0,27 \text{ mm}$ or of construction $7 \times 4 \times 0,22 \text{ mm}$ shall be used.

NOTE — The sizes of the cords are defined here in terms of their diameter and the number of component wires, starting from the centre core of the cord. This is contrary to that given in ISO 3578, which is not relevant here.

For quality control of cord, it should be tested in the condition received, i.e. neither cleaned nor dried.

NOTE ON STORAGE OF WIRE CORD

It is essential that the wire cord is stored in a dry atmosphere to prevent any surface deterioration. Storage can conveniently be carried out in an airtight container which also contains a desiccating material [for example silica gel (SiO_2)]. The container should only be opened when removing wire cord and should then be closed immediately. It is also essential that the cord is not contaminated with dust of the desiccating material.

4.2 Unvulcanized rubber compound, conforming to the specification of the bonding system to be investigated. Whenever possible, the rubber shall be freshly milled. If for any reason the rubber cannot be remilled, the surface shall be freshened by wiping with a solvent and allowed to dry. The preferred solvent is heptane, but a suitable alternative could be a petroleum solvent with a distillation range of about 65 to 125 °C; these solvents should possess a maximum residue on evaporation of 3 mg per 100 cm³ solvent. The compound shall be stored at $23 \pm 2 \text{ °C}$ or $27 \pm 2 \text{ °C}$ prior to use. It may be in the form of calendered sheet of suitable thickness and should be protected by a dark-coloured polyethylene film.

4.3 Reinforcement material, to stiffen the rubber block. This applies only to method 1. The reinforcement may either be a sheet metal strip treated with adhesive promoter (when the thickness is at least 0,5 mm) or a strip of rigid rubberized steel cord fabric: a suitable fabric is one containing steel cords of high bending stiffness, for example one of construction $1 \times 3 \times 0,30 \text{ mm} + 6 \times 0,38 \text{ mm}$ (when $t = 2,5 \pm 0,1 \text{ mm}$ maximum).

5 Apparatus

5.1 Mould, capable of producing a test piece in which a multiplicity of cords is embedded equally spaced along its length. Different moulds are employed for the two methods.

5.1.1 Method 1

The mould is of a semi-follow-on type to obtain maximum consolidation of rubber around the cord during the pressing stage, but thereafter becomes a fixed cavity mould.

One suitable mould designed to accommodate steel cord fabric reinforcement is shown in figure 1. This mould produces test pieces of length 310 mm containing 21 cords, but similar moulds employing other numbers of cords greater than nine are acceptable. The mould dimension x will depend on the embedded length of test piece required (which is governed by the diameter of wire cord used, see 6.2). The mould shall be provided with pairs of inserts or spacers to obtain the different lengths of cord embedment. Dimension y is sufficiently great to allow the incorporation of excess rubber during moulding (see 6.3.1).

Another suitable mould designed to accommodate steel strip reinforcement is shown in figure 2. A tensioning device for the cords may be used with this mould. Figure 3 details some mould dimensions and describes the exchangeable steel spacers which are required for different cord sizes for the moulds shown in figures 1 and 2.

Any mould producing test pieces of the correct dimensions and applying the moulding force directly on to the rubber, for example by use of a suitable spring, is also acceptable.

If desired, the moulds may impart suitable features on to the moulded test piece subsequently to facilitate cord centring during testing.

5.1.2 Method 2

The mould is described in figures 4 and 5. The mould is designed to produce four test blocks (each of length 200 mm) with the preferred dimensions (see 6.2), each containing 15 steel cords. When testing cords equal to or less than 1,7 mm the mould in figures 4 and 5 should be used to produce blocks, and when testing cords with a diameter greater than 1,7 mm the mould should be suitably modified. If more than one third of the cords break at the 12,5 mm embedment, it may be advisable to reduce the embedment by use of a suitable mould insert. Moulds designed to produce any other number of test blocks of the required dimensions are acceptable, and moulds designed to produce blocks with different embedded cord lengths are permitted.

5.2 Vulcanizing press, large enough to take the mould. It shall conform to the requirements of ISO 2393 and shall be capable of applying a force of at least 100 kN.

5.3 Tensile testing machine, conforming to the requirements of ISO 5893. It shall be capable of registering to within $\pm 2\%$ the maximum force obtained during the test, and of maintaining a rate of separation of the jaws at a constant value within the range 50 to 150 mm/min.

NOTE — Inertia type machines (pendulum dynamometers) are apt to give results which differ because of frictional and inertial effects. Low inertia machines (for example, using electronic or optical transducers) give results which are free from these effects and are therefore preferred.

5.4 Fixture, for holding the test piece in the testing machine. It shall possess a suitable slot to allow the test cord to reach the test hole: the hole dimensions shall depend on the test piece type (see 6.2). The fixture shall laterally support the test piece in a slide-fit and shall permit accurate centring of the applied load (i.e. cord position) during testing. If desired, the fixture may possess particular features to facilitate the centring of the test cord in the test hole. Suitable types of fixture are depicted in figure 6.

5.5 Jaws, for gripping the cord to be extracted in the testing machine. These may be of the wedge, pneumatic, pneumatic/hydraulic or bollard type, arranged so that the force applied to the cord during testing is normal to the face of the test piece.

iTeh STANDARDS PREVIEW
(standards.iteh.ai)

6 Test piece

NOTE — These two methods are not the same and do not necessarily give the same results.

6.1 Form

The test piece shall have one of the general forms shown in figure 7.

6.2 Dimensions

Two types of test piece are specified for method 1, depending on the wire cord diameter, and their dimensions shall comply with table 1. The dimensions of the test piece for method 2 shall comply with table 2. For both methods, for cords with

Table 1 — Dimensions of test piece for method 1

Dimensions in millimetres

Type	Cord diameter, d	Embedded length, L		Min. width of rubber between reinforcing layers, w_m	Min. cord ²⁾ spacing, S	Testing hole ²⁾ diameter or diagonal, h
		Using steel plate reinforcement	Using steel cord fabric reinforcement			
A	0,5 to 1,0	10,0	10,0	6,0 ¹⁾	62,5 % of L	85 % of L
B	1,0 to 1,7	10,0	16,0	6,0 ¹⁾	62,5 % of L	85 % of L

1) Greater widths are preferred when using steel cord fabric reinforcement.

2) The minimum cord spacing S and testing hole diameter or diagonal h should be read to the nearest 0,5 mm.

diameter below 0,5 mm or above 1,7 mm, or for smaller cords which experience cord breakages with rubber compounds of very high adhesion, the same form of test piece shall be used, with the dimensions h and L suitably scaled.

Table 2 — Dimensions of test piece for method 2

Dimensions in millimetres

Cord diameter, d	Embedded length, L	Test piece width, W	Min. cord spacing, S	Testing hole diameter, h
0,5 to 1,7	12,5	12,5	12,5	12,5

6.3 Preparation

6.3.1 General

Prepare all materials before commencing the build-up of the test piece, so that the mould may be filled quickly at the proper time. The operator should wear clean gloves during the preparation of test pieces. The cords, rubber and moulded test piece should be properly identified throughout.

NOTE — An approximately 5 % excess of rubber compound is employed so that the test piece is formed under pressure with accompanying rubber flow and consolidation.

6.3.2 Method 1

6.3.2.1 For each multiple-corded test piece prepare

- two pieces of reinforcement material, cut to the correct size to fit the mould;
- two sets of rubber compound, cut to the correct sizes to fit the mould above and below the cords: the exact sizes of the top and bottom set will depend on the mould used. Each set may consist of one thick strip, or of several thinner strips to make up the correct thickness. Remove any protective polyethylene film used during storage and, if necessary, freshen the surfaces with solvent (see 4.2). If solvent is used, allow sufficient time for the surface to dry completely;
- sufficient wire cords to occupy all stations in the mould. These should be at least 300 mm long. They must only be touched close to their ends and not in the region to be moulded to rubber. If required, the cord ends may be covered by a veneer of solder or cement to prevent fraying: the solder is applied before cutting the wire cord off the spool. Alternatively, one endless cord can be used in conjunction with a suitable tensioning frame.

6.3.2.2 If required, preheat the mould, including all component parts, to about 100 °C.

6.3.3 Method 2

The test piece preparation procedure follows that of method 1 except that the mould spacers and the reinforcement strips are omitted, and that test piece construction prior to vulcanization is carried out on a special building rack similar to the mould (figure 4).

The unvulcanized formed test pieces should be carefully removed from the building rack by pressing uniformly from the rear, placed in a desiccated container and stored at standard laboratory temperature (see ISO 471) until vulcanization. Test pieces should be vulcanized within a maximum of 12 h.

6.3.4 Both methods

Place the made up mould in the press already set at the vulcanization temperature. Allow the mould to warm up so that the rubber temperature is about 100 °C and the rubber is ready to flow. Apply a force of at least 100 kN and maintain for the duration of the vulcanization.

NOTE — In order to set the conditions to achieve a rubber temperature of 100 °C, it may be necessary to carry out a preliminary calibration using a thermocouple inserted into the rubber.

Either apply cooling water through the platens of the press for a suitable time, release the moulding force and remove the mould from the press, or allow the mould to cool after its removal from the press. Extract the test piece, if appropriate using the relevant extraction tools, avoiding any deformation of the test piece.

Examine the test piece to ensure that rubber has flowed completely along each cord-hole in the pairs of steel spacers for the method 1 test pieces.

Separate the blocks if appropriate. Trim off the shorter lengths of wire cord close to the surface of the rubber block and any spew or flash on the outer edges of the block. With test pieces for method 1 the flash near the cords need not be trimmed as it does not affect the testing procedure or result: for method 2 trim any flash with a razor blade or suitable clippers taking care not to damage the cord or body of the test piece.

The test piece should be rested at standard laboratory temperature (see ISO 471) for a minimum of 16 h before testing if no time is specified.

7 Procedure

Tests shall be performed at standard laboratory temperature (see ISO 471) unless otherwise specified.

Mount the test piece in the tensile testing machine using the relevant fixture shown in figure 6. Carefully adjust the test piece so that the first wire cord is central in the hole, thus ensuring that the testing tension will be uniformly distributed round the circumference of the cord (see figures 6 and 8). This centring may be facilitated by aligning features already mentioned in 5.1.1 and 5.4. Clamp the cord to be tested in the extraction jaws.

Apply tension by separating the extraction jaws from the fixture at a constant rate, between 50 and 150 mm/min, until the test piece breaks. Record the maximum force.

Repeat the procedure for each of the remaining cords in the test piece: at least 10 cords shall be tested.

8 Expression of results

For each test cord, calculate the adhesion strength by dividing the maximum force by the embedded length of the test piece, and express the result in newtons per millimetre or kilonewtons per metre to the nearest integer.

Determine the mean value and standard deviation for each test condition.

Examine each broken test piece and if required express the adhesion failure by one or other of the following symbols:

R — indicating that the failure is in the rubber;

M — indicating that the failure is in the interface between the cord and rubber and the bare cord surface is visible.

The symbols R and M should be completed with percentages, the results being expressed as "percent coverage" in steps of 25 %.

25 R/75 M then means that 75 % of the cord surface is visible.

9 Test report

The test report shall include the following information:

a) a description and identification of the sample tested, including

1) a description and identification of the wire cord,

2) a description and identification of the rubber compound;

b) a reference to this International Standard;

c) a reference to the method used (1 or 2);

d) details of the conditions of test, including

1) time, temperature and date of vulcanization,

2) temperature and humidity used for conditioning and testing;

e) the results and the method of expression used, including

1) the number of cords tested,

2) individual test results,

3) the mean value and standard deviation,

4) whether solvent was used to wipe surface of rubber;

f) any operation not included in this International Standard, or regarded as optional;

g) the date of the test.

ISO 5603:1986

<https://standards.iteh.ai/catalog/standards/sist/6b646d65-3581-46a2-9bb2-0dc82b3331f8/iso-5603-1986>

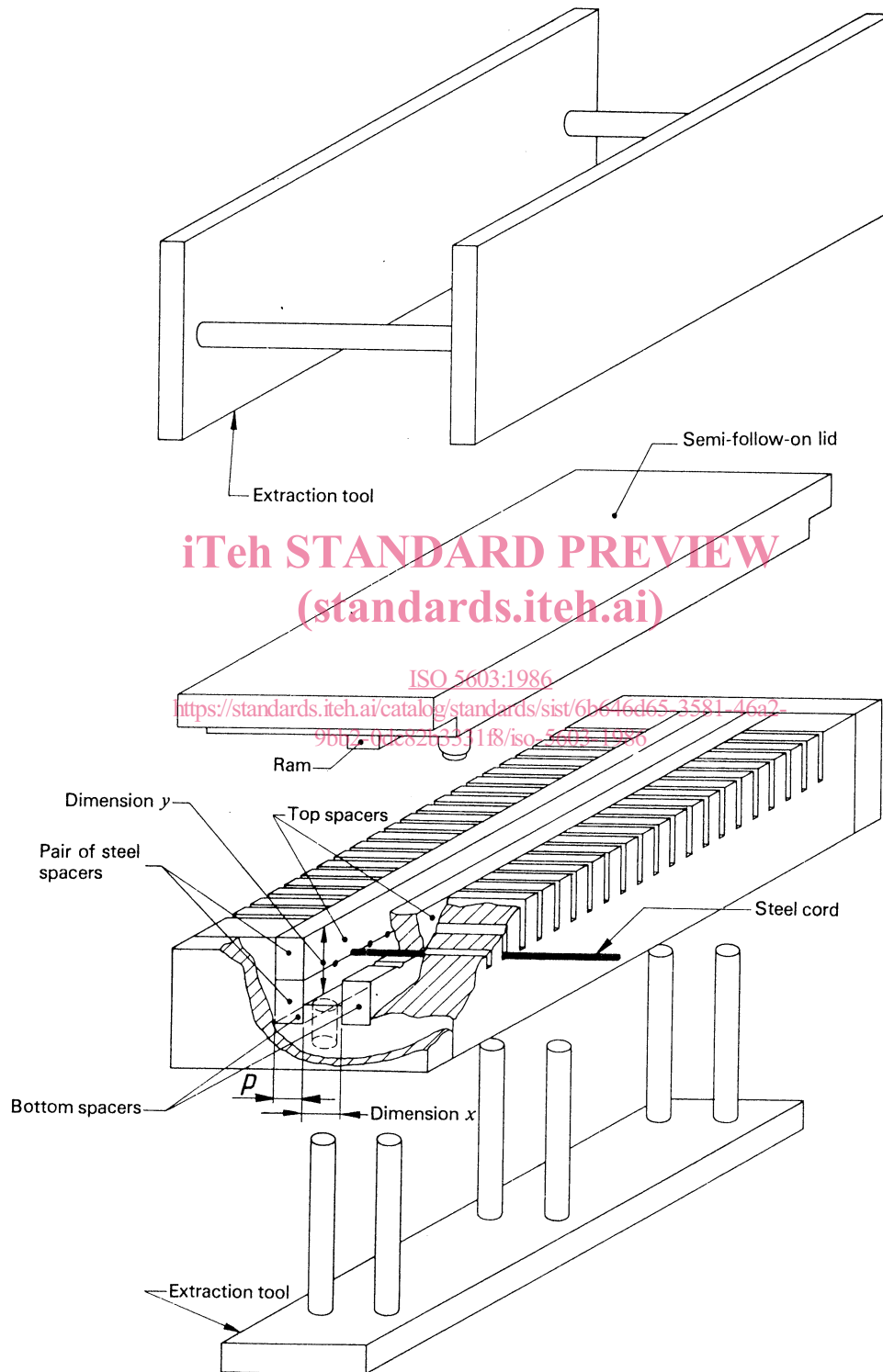


Figure 1 — Layout of one semi-follow-on mould and extraction tools for method 1

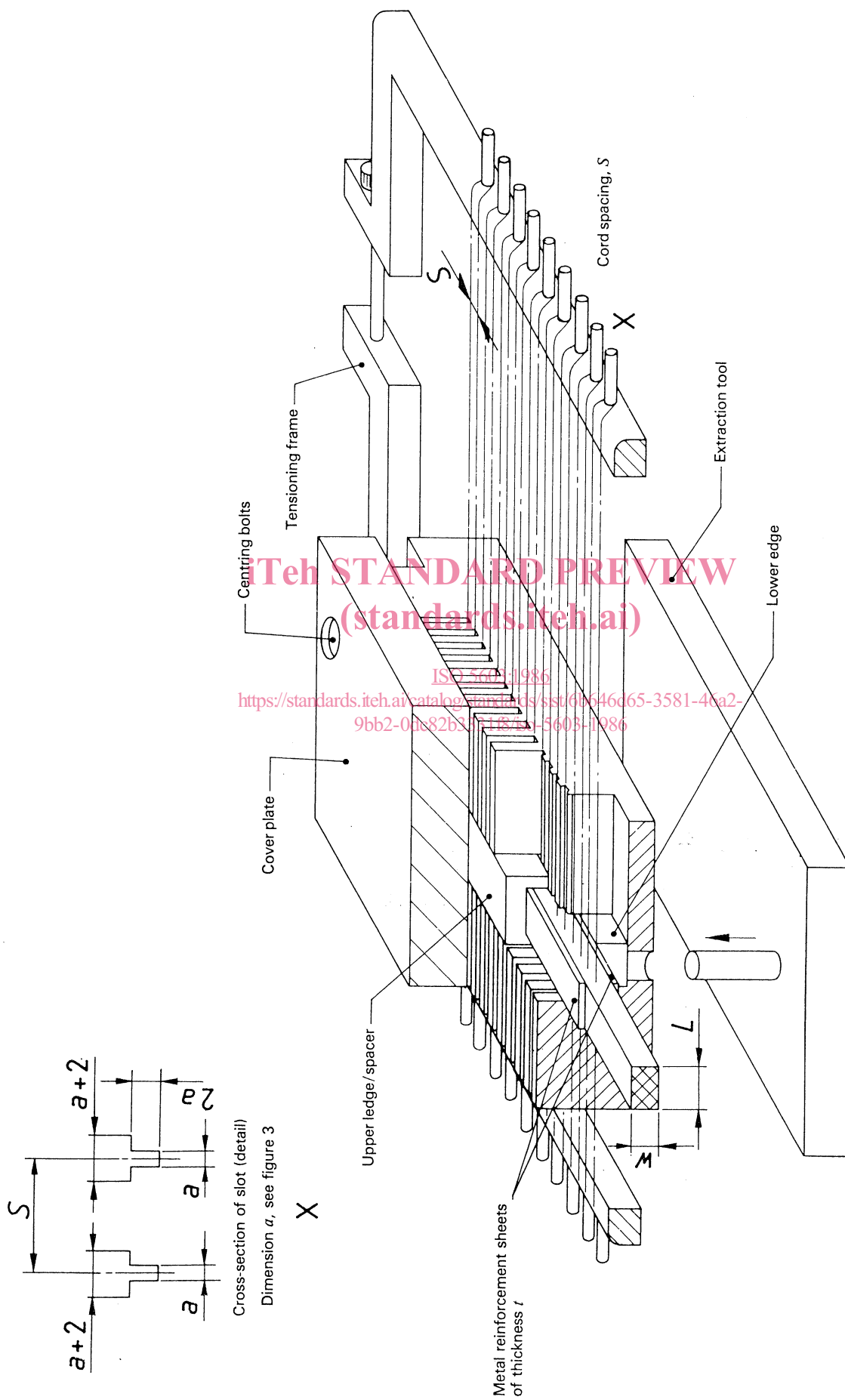
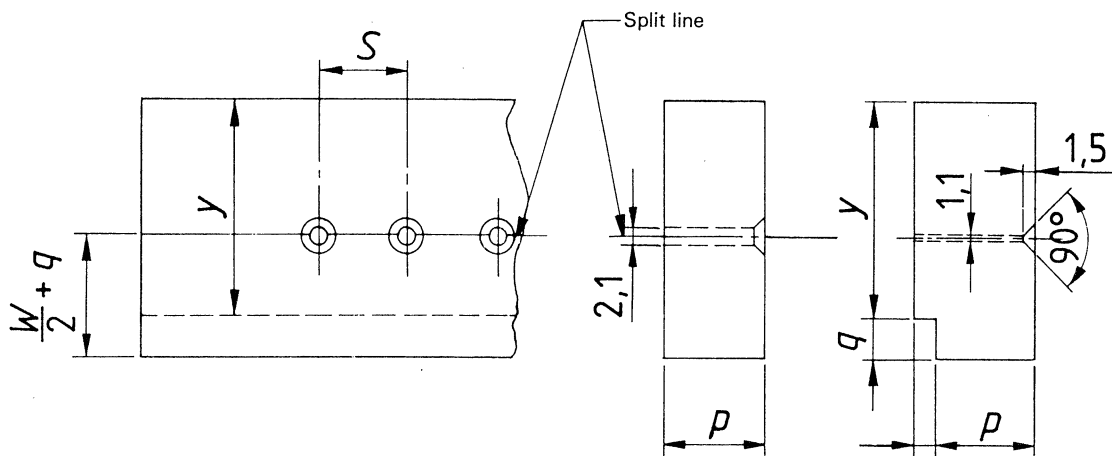


Figure 2 — Layout of a second semi-follow-on mould and extraction tool for method 1

Dimensions in millimetres

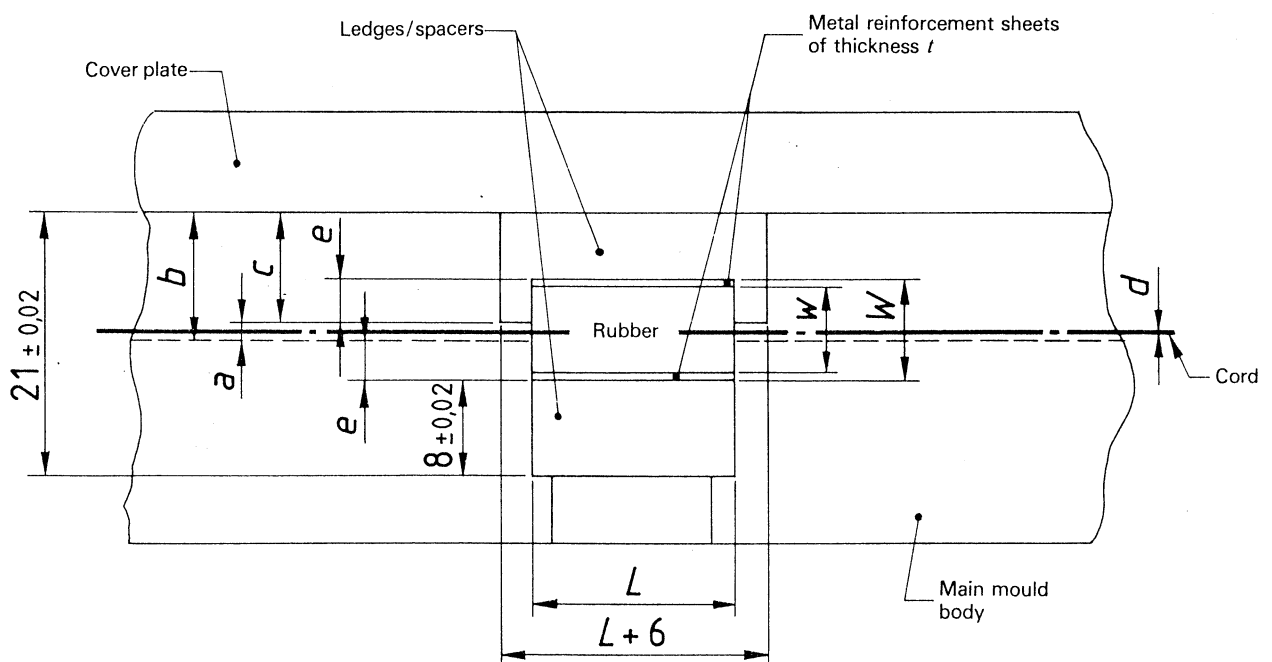


Spacers for the mould in figure 1

Cord diameter <i>d</i>	Details of ledge chosen			
	<i>a</i>	<i>b</i>	<i>c</i>	<i>e</i>
from 0,5 to 0,7	$0,7 \pm 0,02$	$9,85 \pm 0,2$	$9,15 \pm 0,02$	$3,15 \pm 0,02$
from 0,7 to 1,0	$1,0 \pm 0,02$	$10,0 \pm 0,2$	$9,0 \pm 0,02$	$3,0 \pm 0,02$
from 1,0 to 1,4	$1,4 \pm 0,02$	$10,2 \pm 0,2$	$8,8 \pm 0,02$	$2,8 \pm 0,02$
from 1,4 to 1,7	$1,8 \pm 0,02$	$10,4 \pm 0,2$	$8,6 \pm 0,02$	$2,6 \pm 0,02$

STANDARD PREVIEW
(standards.iteh.ai)

$a = b - c$ is the slot width;
 b is the slot depth;
 $2e + a = W + 2t = W$
 $e = 21 - (b + 8) = 13 - b$



Exchange ledges/spacers for the mould in figure 2

Figure 3 — Details of spacers used in the two types of semi-follow-on mould for method 1