INTERNATIONAL STANDARD ISO 86

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

Steel — Tensile testing of sheet and strip less than 3 mm and not less than 0,5 mm thick

Acier — Essai de traction des tôles et feuillards d'épaisseur inférieure à 3 mm et au moins égale à 0,5 mm

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ISO 86-1974 (E)

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 86 was drawn up by Technical Committee ISO/TC 17, *Steel*, and circulated to the Member Bodies in March 1972.

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

Australia	Germany	Spain
Austria	Hungary	Sweden
Belgium	India	Switzerland
Canada	Ireland	Thailand
Chile	Italy	Turkey
Czechoslovakia	Netherlands	United Kingdom
Denmark	New Zealand	U.S.A.
Egypt, Arab Rep. of	Poland	U.S.S.R.
Finland	Romania	
France	South Africa, Rep. of	

The Member Bodies of the following countries expressed disapproval of the document on technical grounds :

Japan
Norway

This International Standard cancels and replaces ISO Recommendation R 86-1959.

Steel — Tensile testing of sheet and strip less than 3 mm and not less than 0,5 mm thick

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies requirements for the tensile testing of flat rolled steel products less than 3 mm and not less than 0,5 mm thick.

For the tensile testing of other steel products, ISO 82, ISO 89 and ISO 375 are applicable.

2 REFERENCES

ISO 82, *Steel — Tensile testing.*

ISO 89, *Steel — Tensile testing of wire.*

ISO 375, *Steel — Tensile testing of tubes.*

ISO/R 147, *Load calibration of testing machines for tensile testing of steel.*

ISO/R 205, *Determination of proof stress and proving test for steel at elevated temperatures.*

ISO/R 377, *Selection and preparation of samples and test pieces for wrought steel.*

ISO/R 783, *Mechanical testing of steel at elevated temperatures — Determination of lower yield stress and proof stress and proving test.*

ISO 2573, *Determination of K-values of a tensile testing system.*[1]

3 PRINCIPLE

The test consists in straining a test piece by tensile stress, generally to fracture, with a view to determining one or more of the mechanical properties enumerated hereafter.

The test is carried out at ambient temperature unless otherwise specified. For tests at elevated temperatures, ISO/R 205 and ISO/R 783 are applicable.

1) At present at the stage of draft.

4 DEFINITIONS

4.1 gauge length : The prescribed part of the prismatic portion of the test piece on which elongation is measured at any moment during the test. In particular, a distinction is to be made between the following :

4.1.1 original gauge length (L_o) : Gauge length before the test piece is strained;

4.1.2 final gauge length (L_u) : Gauge length after the test piece has been fractured and the fractured parts have been carefully fitted together so that they lie in a straight line.

4.2 extensometer gauge length (L_e) : The length of the parallel portion of the test piece used for the measurement of extension by means of an extensometer. (The length may differ from L_o and may be any value greater than b (see clause 5) but less than the parallel length L_c.)

4.3 percentage permanent elongation : Increase in the gauge length of a test piece subjected to a prescribed stress and after removal of the stress, expressed as a percentage of the original gauge length. If a symbol for this elongation is used it is to be supplemented by an index indicating the prescribed stress.

4.4 percentage elongation after fracture (A) : Permanent elongation of the gauge length after fracture, $L_u - L_o$, expressed as a percentage of the original gauge length, L_o.

NOTE — The original gauge length (in millimetres) on which the elongation after fracture is calculated is to be recorded as a suffix to the symbol, for example A_{50}.

4.5 maximum load (F_m) : The highest load which the test piece withstands during the test.

4.6 stress (actually "nominal stress") : At any moment during the test, load divided by the original cross-sectional area of the test piece.

4.7 tensile strength (R_m) : Maximum load divided by the original cross-sectional area of the test piece, i.e. stress corresponding to the maximum load.

4.8 yield stresses : In a steel which exhibits a yield phenomenon, a point is reached during the test at which plastic deformation, soon after it has been initiated, continues to occur at nearly constant stress.

4.8.1 upper yield stress (R_{eH}) : The value of stress measured at the commencement of plastic deformation at yield (see figure 3);

or

the value of stress measured at the first peak obtained during yielding even when that peak is equal to or less than any subsequent peaks observed during plastic deformation at yield (see figure 4).

4.8.2 lower yield stress (R_{eL}) : The lowest value of stress measured during plastic deformation at yield, ignoring any initial transient effects which might occur. (See figures 3 and 4.)

NOTE — If a steel which usually exhibits a yield phenomenon is in a cold-worked or heat-treated condition, the yield phenomenon may not exist. In such cases a proof stress must be specified. (See 4.9 and 4.10.)

4.9 proof stress (non-proportional elongation) (R_p) : The stress at which a non-proportional elongation, equal to a specified percentage of the original gauge length, occurs. (See figure 7).

When a proof stress (R_p) is specified, the non-proportional elongation is to be stated (for example 0,2 %) and the symbol used for the stress is to be supplemented by an index giving this prescribed percentage of the original gauge length, for example $R_{p0,2}$.

4.10 proof stress (total elongation) or **proof stress under load** (R_t) : The stress at which a non-proportional elongation plus elastic elongation, equal to a specified percentage of the original gauge length, occurs. (See figure 8.)

When a proof stress (R_t) is specified, or agreed between the interested parties, the total elongation is to be stated and the symbol used for the stress is to be supplemented by an appropriate index, for example $R_{t0,5}$.

NOTE — The value obtained by the total elongation method will only be equivalent to R_p if suitable allowance is made for the measurement of elastic extension.

4.11 permanent set stress (R_r) ; **(stress at permanent set limit) :** The stress at which, after removal of load, a prescribed permanent elongation, expressed as a percentage of the original gauge length, occurs. The symbol used for this stress is to be supplemented by an index giving the prescribed percentage of the original gauge length, for example $R_{r0,2}$. (See figure 9.)

5 SYMBOLS AND DESIGNATIONS

Symbols and designations are given in the table below.

Number	Preferred symbol	Designation
1	a	Thickness of test piece (Figure 1)
2	b	Width of test piece (Figure 1)
3	L_o[1]	Original gauge length (Figure 1)
4	L_c	Parallel length (Figure 1)
–	L_e	Extensometer gauge length
5	L_t	Total length (Figure 1)
6	–	Gripped ends (Figure 1)
7	L_u	Final gauge length after fracture (Figure 2)
8	$L_u - L_o$	Permanent elongation after fracture
9	A	Percentage elongation after fracture $\left(\frac{L_u - L_o}{L_o}\right) 100$
10	S_o	Original cross-sectional area of the gauge length (Figure 1)
11	R_{eH}	Upper yield stress or upper yield point[2] (Figures 3, 4 and 5)
12	R_{eL}	Lower yield stress or lower yield point[2] (Figures 3, 4 and 5)
13	R_p (e.g. $R_{p0,2}$)	Proof stress (non-proportional elongation) or yield strength (offset)[2] (Figure 7) (0,2 % non-proportional elongation)
14	R_t (e.g. $R_{t0,5}$)	Proof stress (total elongation) or yield strength (total elongation)[2] (Figure 8) (0,5 % total elongation)
15	R_r (e.g. $R_{r0,2}$)	Permanent set stress (Figure 9) (0,2 % permanent set stress)
16	F_m	Maximum load
17	R_m[1]	Tensile strength $\frac{F_m}{S_o}$

1) In correspondence and where no misunderstanding is possible, the symbols L_o and R_m may be replaced by L and R respectively.

2) The latter term is used in the U.S.A. and in Canada.

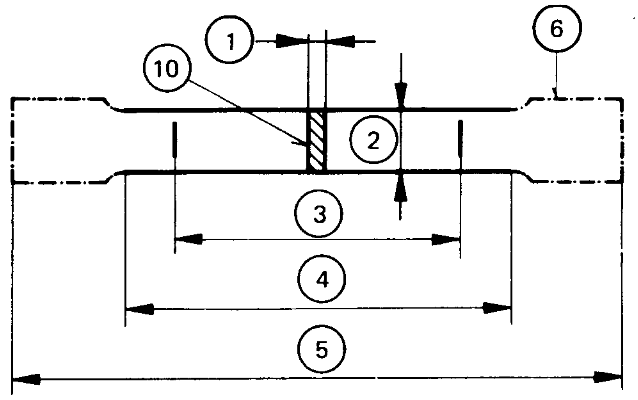

FIGURE 1

NOTE – The form of end of test piece as shown is only intended as a guide.

FIGURE 2

Load/extension diagrams illustrating yield :

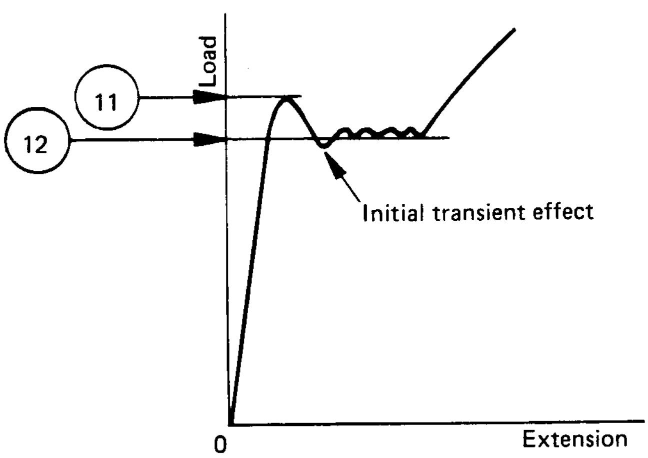

FIGURE 3

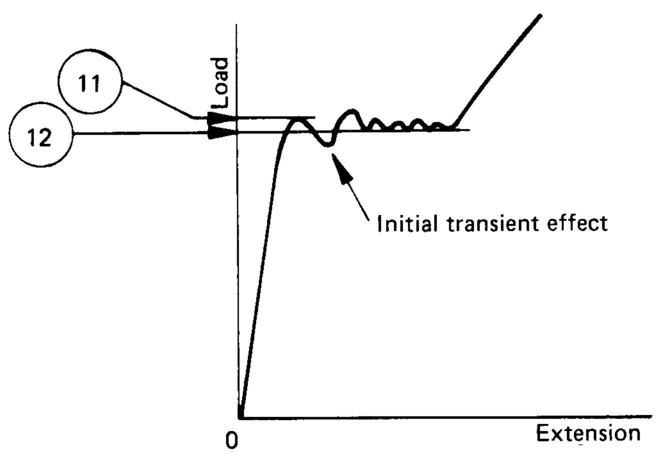

FIGURE 4

Load/extension diagrams :

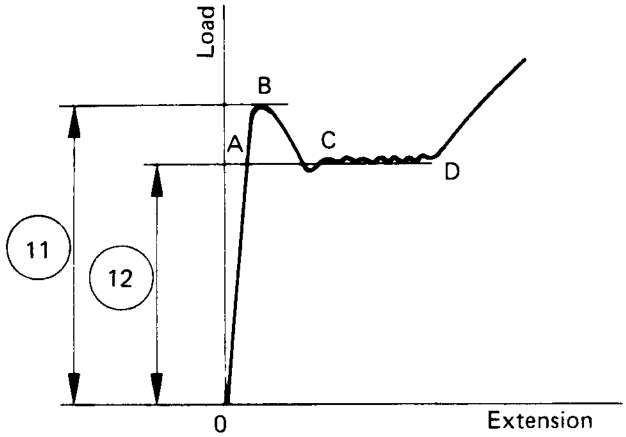

FIGURE 5

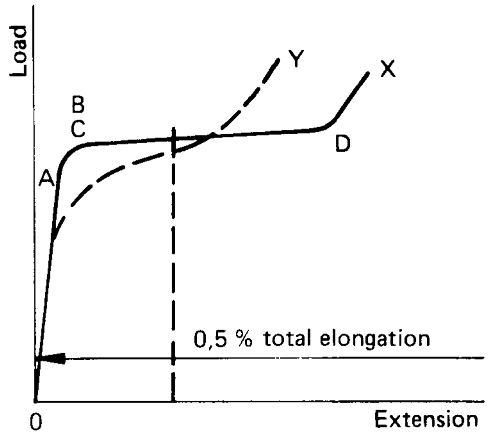

FIGURE 6

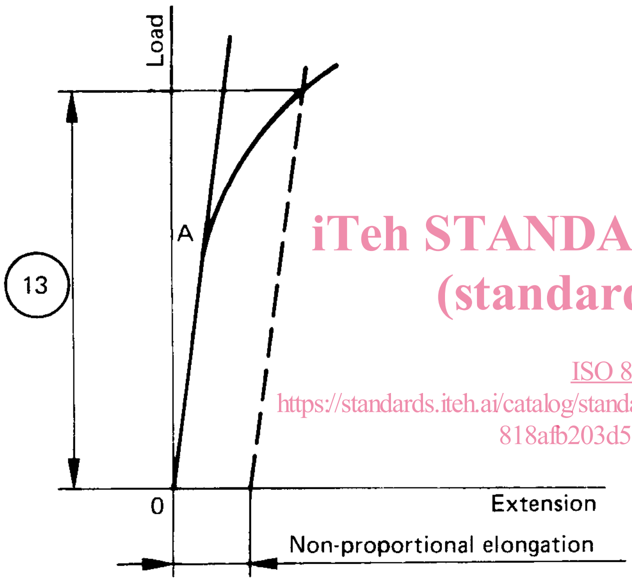

FIGURE 7

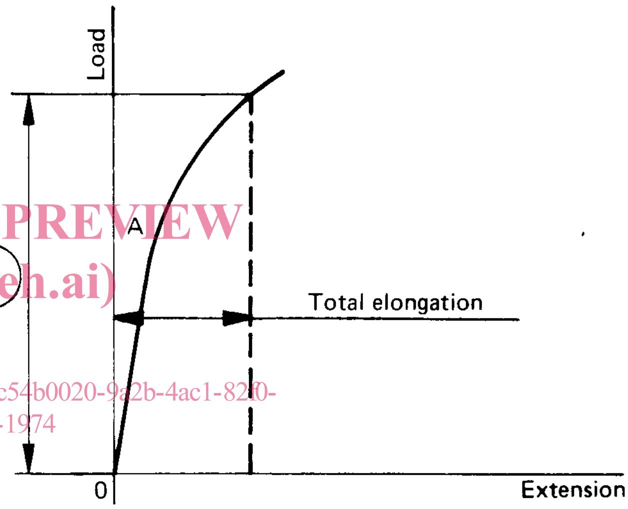

FIGURE 8

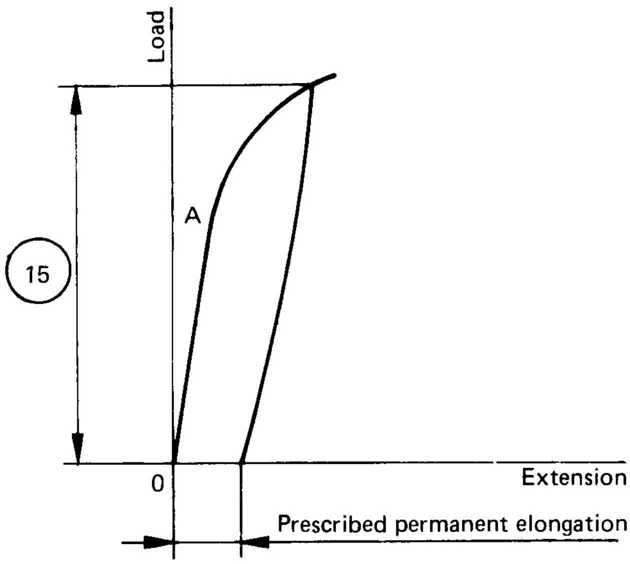

FIGURE 9

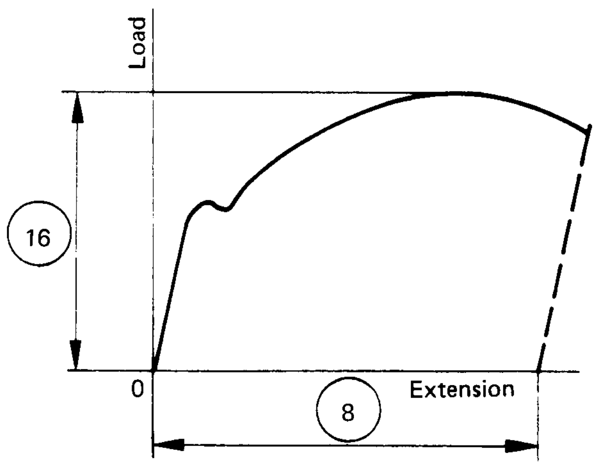

FIGURE 10

A = Elastic limit
B = Upper yield stress
BCD = Yield stress elongation

6 TEST PIECES

6.1 The test pieces shall be of full product thickness and of the form shown in figure 1. The transition radius at the ends of the parallel length is to be not less than 20 mm (3/4 in).

6.1.1 Alternatively, by agreement, the test piece may be a parallel sided strip. The free length between the grips is to be $L_o + 3b$ (see table 1).

6.2 Two sizes of test pieces are recommended, the dimensions of which are shown in table 1.

TABLE 1 — **Test piece dimensions** (millimetres)

Test piece	**Width** b	**Gauge length** L_o	**Parallel length**[1] L_c	**Parallel sided strip length** (See 6.1.1)
1	20 ± 1[2]	80 ± 0,8	120 ± 10	140 ± 10
2	12,5 ± 1	50 ± 0,5	75 ± 5	87,5 ± 5

1) To be parallel within 0,2 %.

2) For this width, a gauge length of 200 ± 2 mm may be used.

6.3 The test pieces shall be obtained and prepared according to the requirements of ISO/R 377.

7 DETERMINATION OF CROSS-SECTIONAL AREA

Error in determination of the cross-sectional area shall not exceed ± 2 %. Since most of this error will normally arise in the measurement of test piece thickness, error in the measurement of the width shall not exceed ± 0,2 %.

8 MARKING THE ORIGINAL GAUGE LENGTH

8.1 Gauge lengths shall be marked with an accuracy of ± 1 %.

8.2 Fine scribing is permitted for marking the gauge length but care must be taken to avoid unnecessary damage to the test piece by deep scoring.

9 METHOD OF GRIPPING

9.1 Every endeavour must be made to ensure that the test pieces are held in such a way that the load is applied as axially as possible.

9.2 Wedge grips may be used.

10 ACCURACY OF TESTING EQUIPMENT

10.1 The testing machine shall be calibrated in accordance with ISO/R 147, and shall be maintained to grade 1,0 except when grade 0,5 is required by the standard for the material.

10.2 Where appropriate (see also 12.2), the apparent elastic compliance (K) of the tensile testing system shall be determined in accordance with ISO 2573.

10.3 The instrument error of an extensometer or proof stress indicator shall not exceed 5 % of the value of the elongation for which the stress value is obtained.

11 DETERMINATION OF PROPERTIES

The appropriate properties to be determined are to be stated in the specification for the material and determined in accordance with the procedures described in clauses 12 to 18.

NOTE — Attention is drawn to 4.8, 4.9 and 4.10 regarding the yield stress and proof stresses to be stated.

12 TESTING TECHNIQUES

12.1 Factors affecting the rate of straining

It is necessary to take into account the wide variation of actual strain rate which can occur during a tensile test and which may affect the results obtained. The rate of straining during plastic deformation may be measured directly if suitable equipment is available. However, for most practical purposes the straining rate may be assessed in terms of loading rate, taking into account the following factors :

1) the apparent elastic compliance (K) of the testing machine and test piece assembly (see 12.3);

2) the area of cross-section of the test piece;

3) the parallel length of the test piece.

The first of these factors has to be established before testing.

12.2 Determination of testing system characteristics

The value of K is to be determined in accordance with ISO 2573. The value thereby obtained on the type of test piece normally used can be regarded as applicable to all tensile tests performed in the testing machine using the same type of attachments and under generally similar testing conditions.

12.3 Application of *K*

12.3.1 *Measurement of lower yield stress*

For the measurement of lower yield stress, a rate of strain during plastic deformation not exceeding 0,002 5/s is recommended.

In addition to the recommended rate of straining, an upper limit of 30 N/mm^2·s (1.9 tonf/in^2·s) on the elastic stress rate is imposed to avoid, amongst other things, errors due to inertia effects.

Table 2 gives the values of the maximum permitted initial stress rate for different test pieces and different *K*-values for use when the required plastic strain rate (not exceeding 0,002 5/s) cannot be achieved by direct control. A stressing rate not less than one-tenth of the elastic stressing rate determined from table 2 is permitted. This will result in a slightly lower value of yield stress being obtained.

In those cases where the *K*-value of the tensile testing system cannot be determined in accordance with ISO 2573, a *K*-value of 0,000 3 mm/N may be used subject to agreement between the interested parties.

NOTE — A "hard" machine having a low *K*-value will permit a larger range of cross-sectional areas to be tested at the maximum permitted elastic stressing rate without exceeding the straining rate of 0,002 5/s.

12.3.2 *Measurement of proof stress*

When a yield phenomenon is not present the strain rate imposed on the test piece in the vicinity of the proof stress may not be markedly dependent upon the value of *K* or the dimensions of the test piece. In proof stress determination a single maximum rate of application of stress of 30 N/mm^2·s (1.9 tonf/in^2·s) is, therefore, recommended.

13 OBSERVATIONS ON LOAD/EXTENSION DIAGRAMS

13.1 One of a variety of diagrams may be produced (for example figures 5 to 9). For many materials the initial part of such a load/extension diagram is straight (OA of figures 5 to 9). (Observations of extension made at a sequence of increasing loads during a tensile test may be used to derive corresponding values of stress and strain.)

13.2 As the load increases beyond point A in figure 5, the relationship between load and extension ceases to be linear. In some cases the load may attain a maximum, then decrease and remain sensibly constant while the extension increases markedly (BCD of figure 5). In other cases a maximum value is not obtained initially at the point where plastic deformation commences, and in such cases the level remains sensibly constant during yield while the extension increases markedly (CD of figure 6, curve X).

13.3 After yield is completed, further extension results only from increase in load.

13.4 Where the material does not show the yield type phenomenon, the extension will continue to increase non-proportionally to load after point A in figures 7, 8 and 9 has been reached. In such cases a proof stress or a permanent set stress should be measured (see clauses 15 and 16).

14 DETERMINATION OF YIELD STRESS (YIELD POINT)

14.1 The lower yield stress, R_{eL}, may be determined visually, or by a load/extension diagram or by similar means.

NOTE — When recording a load/extension diagram, it is permissible to record extension from the cross-head motion.

14.2 When determining the yield stress, the test piece shall be loaded so that the strain rate is controlled in accordance with the following conditions :

14.2.1 The rate of strain of the parallel length of the test piece at the time of yielding shall not exceed 0,002 5/s. If this rate of straining cannot be controlled directly, it shall be controlled by regulating the rate of loading just before yield commences. The controls of the testing machine shall not be adjusted after 90 % of the expected yield load has been reached.

14.2.2 The maximum value of the initial stressing rate to be used for test pieces of different dimensions and in testing machines of different elastic compliances is stated in table 2. See also note 4 to table 2.

14.2.3 Under no circumstances shall the elastic stress rate exceed 30 N/mm^2·s (1.9 tonf/in^2·s).

14.3 In cases where the upper and lower yield stresses as defined in 4.8 cannot be easily determined (see figure 6, curve Y), a 0,5 % total elongation proof stress (proof stress under load) may be determined and regarded as the value of lower yield stress if so permitted by the material specification or agreed between the interested parties.

15 DETERMINATION OF PROOF STRESSES (YIELD STRENGTHS)

15.1 For the determination of proof stress (non-proportional elongation), R_p, or proof stress (total elongation), R_t, the rate of application of stress in the elastic range shall not exceed 30 N/mm^2·s (1.9 tonf/in^2·s) — see 12.3.2 — and may be within the range 3 to 30 N/mm^2·s. For both methods an extensometer shall be used.

15.2 Proof stress (non-proportional elongation) (R_p) is determined from a load/extension diagram on which a line is drawn parallel to the straight portion of the curve and