INTERNATIONAL STANDARD ISO 3002/I

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

Geometry of the active part of cutting tools — Part I : General terms, reference systems, tool and working angles

Géométrie de la partie active des outils coupants — Partie I : Notions générales, systèmes de référence, angles de l'outil et angles en travail

First edition — 1977-06-15

UDC 621.9.01 : 001.4 : 003.62 Ref. No. ISO 3002/I-1977 (E)

Descriptors : tools, cutting tools, geometrical characteristics, cutting angle, definitions.

Price based on 46 pages

FOREWORD

ISO (the International Organization for Standardization) is a worlwide 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 3002/I (originally ISO/DIS 3002) was drawn up by Technical Committee ISO/TC 29, *Small tools*. It results from the merging into one single document of ISO/DIS 3002 and its draft Addendum 1 (now sub-clause 3.3).

ISO/DIS 3002 was circulated to the Member Bodies in June 1973, and has been approved by the Member Bodies of the following countries :

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

No Member Body expressed disapproval of the document.

Draft Addendum 1 to ISO/DIS 3002 was circulated to the Member Bodies in April 1975, and has been approved by the Member Bodies of the following countries :

Australia	Italy	Spain
Austria	Japan	Switzerland
Belgium	Mexico	Turkey
Czechoslovakia	Netherlands	United Kingdom
France	Poland	U.S.A.
Germany	Portugal	U.S.S.R.
Hungary	Romania	Yugoslavia
Israel	South Africa, Rep. of	

No Member Body expressed disapproval of the document.

Printed in Switzerland

CONTENTS

Geometry of the active part of cutting tools — Part I : General terms, reference systems, tool and working angles

SCOPE AND FIELD OF APPLICATION

This International Standard defines a nomenclature for certain basic concepts concerning cutting tools; it is applicable to the geometry of every kind of cutting tool and emphasizes a known terminology for them which is intended to provide a framework on which the nomenclature and appropriate standards for individual types of cutting tool, such as single-point tools, twist drills, milling cutters and hand tools, can be established. However, the standards for individual types of cutting tool will not each require or use the full range of terms and definitions set out in the basic nomenclature established in this International Standard.

The definitions are grouped into three clauses. After defining the general terms for surfaces on the workpiece, certain elements of the tool, surfaces on the tool, the cutting edges and the tool and workpiece motions in clause 1, this International Standard defines, in clause 2, reference systems of planes which are subsequently used to define the various angles which are included in clause 3. Two reference systems of planes are necessary : one, the tool-in-hand system, is used to define the geometry of the tool so that it can be manufactured and measured; the other, the tool-in-use system, is required to define the effective geometry of the tool when it is actually performing the cutting operation.

Additional terms will be given in an addendum.

ISO 3002/II will give general conversion formulae to relate tool and working angles.

1 GENERAL TERMS

1.1 SURFACES ON THE WORKPIECE

1.1.1 work surface (figure 1) : The surface on the workpiece to be removed by machining.

1.1.2 machined surface (figure 1) : The desired surface produced by the action of the cutting tool.

1.1.3 transient surface (figure 1) : The part of the surface which is formed on the workpiece by the cutting edge (1.4.1) and removed during the following cutting stroke, during the following revolution of the tool or workpiece, or by the following cutting edge.

1.2 TOOL ELEMENTS

1.2.1 body (figures 3 to 5) : That part of the tool which holds the cutting blades or inserts, or on which are formed the cutting edges (1.4.1).

1.2.2 shank (figures 2, 4 and 5) : That part of the tool by which it is held.

1.2.3 tool bore (figure 3) : That bore in a tool by which it can be located and fixed by a spindle, arbor or mandrel.

1.2.4 tool axis (figures 3, 4 and 5) : An imaginary straight line with defined geometrical relationships to the locating surfaces used for the manufacture and sharpening of the tool and for holding the tool in use. Generally, the tool axis is the centreline of the tool shank or bore; it is usually parallel or perpendicular to the locating surfaces, although it could be the centreline of a conical surface as in the case of a taper shank. When not obvious, the tool axis must be defined by the designer.

1.2.5 cutting part (figure 2) : The functional part or parts of the tool each comprised of chip producing elements; the cutting edges (1.4.1), face (1.3.1) and flank (1.3.2) are therefore elements of the cutting part.

In the case of a multi-toothed cutter, each tooth has a cutting part.

1.2.6 base (figures 2, 12 and 18) : A flat surface on the tool shank, parallel or perpendicular to the tool reference plane (2.1.1), useful for locating or orienting the tool in its manufacture, sharpening and measurement.

Not all tools have a clearly defined base.

1.2.7 wedge (figures 3 and 7) : The portion of the cutting part enclosed between the face (1.3.1) and the flank (1.3.2). It can be associated with either the major or minor cutting edge (1.4.1).

1.3 TOOL SURFACES

Each tool surface is provided with a symbol consisting of the letter A with a suffix indicating the identity of the surface (for example A_γ, the face). When it is necessary to distinguish clearly a surface associated with the minor cutting edge (1.4.1.2) the appropriate symbol bears a prime (for example A_α', the minor flank).

1.3.1 face A_γ (figures 2, 3, 4, 5 and 7) : The surface or surfaces over which the chip flows. When the face is composed of a number of surfaces inclined to one another, these are designated first face, second face, etc, starting from the cutting edge. These surfaces may be called lands and unless otherwise specified it is assumed that these are associated with the major cutting edge (1.4.1.1).

Where it is necessary to distinguish the faces associated with the major and minor cutting edges (1.4.1.1 and 1.4.1.2), that part of the face which intersects the flank (1.3.2) to form the major cutting edge is called the major face and that part of the face which intersects the flank to form the minor cutting edge is called the minor face, for example major first face, minor first face, etc.

1.3.2 flank A_α (figures 2, 3, 4, 5 and 7) : The tool surface or surfaces over which the surface produced on the workpiece passes. When a flank is composed of a number of surfaces inclined to one another, these are designated first flank, second flank, etc., starting from the cutting edge. These surfaces may be called lands and unless otherwise specified it is assumed that these are associated with the major cutting edge (1.4.1.1).

Where it is necessary to distinguish the flanks associated with the major and minor cutting edges (1.4.1.1 and 1.4.1.2), that part of the flank which intersects the face to form the major cutting edge is called the major flank and that part of the flank which intersects the face to form the minor cutting edge is called the minor flank, for example major first flank, minor first flank, etc.

1.4 CUTTING EDGES

1.4.1 cutting edge : That edge of the face which is intended to perform cutting.

1.4.1.1 tool major cutting edge S (figures 2, 3, 4, 5 and 7) : That entire part of the cutting edge which commences at the point where the tool cutting edge angle κ_r is zero (3.1.1.1) and of which at least a portion is intended to produce the transient surface on the workpiece. In the case of tools having a sharp corner (1.4.2) at which the value of κ_r may be considered to pass through zero, the major cutting edge commences at that corner. In the case of tools for which the value of κ_r does not decrease to zero at any point on the cutting edge, the entire cutting edge is the tool major cutting edge as, for example, in the case of a slab milling cutter.

1.4.1.2 tool minor cutting edge S' (figures 2, 3, 4 and 5) : The remainder of the cutting edge, if any, and where present commences at the point on the cutting edge where κ_r is zero (3.1.1.1) but extends from this point in a direction away from the tool major cutting edge. It is not intended to produce any of the transient surface on the workpiece. Some tools may have more than one tool minor cutting edge as, for example, in the case of a cutting-off tool.

1.4.1.3 working major cutting edge S_e : That entire part of the cutting edge which commences at the point where the working cutting edge angle κ_{re} is zero (3.2.1.1) and of which at least a portion produces the transient surface on the workpiece. In the case of tools having a sharp corner (1.4.2) at which the value of κ_{re} may be considered to pass through zero, the working major cutting edge commences at that corner. In the case of tools for which the value of κ_{re} does not decrease to zero at any point on the cutting edge, the entire cutting edge is the working major cutting edge as, for example, in the case of a slab milling cutter.

1.4.1.4 working minor cutting edge S_e' : The remainder of the cutting edge, if any, and where present commences at the point on the cutting edge where κ_{re} is zero (3.2.1.1) but extends from this point in a direction away from the working major cutting edge. It does not produce any of the transient surface on the workpiece. Some tools may have more than one working minor cutting edge as, for example, in the case of a cutting-off tool.

NOTE — A distinction must be made between the tool major cutting edge and the working major cutting edge because the points at which κ_r and κ_{re} can be considered to be zero are not, in general, coincident.

1.4.2 corner (figures 2 to 6) : The relatively small portion of the cutting edge at the junction of the major and minor cutting edges; it may be curved, straight or the actual intersection of these cutting edges.

1.4.2.1 rounded corner (figure 6) : A corner having a curved cutting edge.

1.4.2.2 chamfered corner (figure 6) : A corner having a straight cutting edge.

1.4.3 selected point on the cutting edge : A point selected on any part of the cutting edge in order to define, for example, the tool or working angles at that point (3). The selected point may be on the major cutting edge or on the minor cutting edge. When the selected point is so chosen as to be located on the minor cutting edge, the planes and angles associated with this point are so designated (2 and 3).

1.4.4 rounded cutting edge : A cutting edge which is formed by a rounded transition between the face, A_γ, and the flank, A_α.

1.5 DIMENSIONS

The dimensions of the cutting edges are measured in the conventional manner but additional definitions are required and are given below.

1.5.1 corner radius r_ϵ (figure 6) : The nominal radius of a rounded corner measured in the tool reference plane, P_r (2.1.1).

1.5.2 chamfered corner length b_ϵ (figure 6) : The nominal length of a chamfered corner measured in the tool reference plane P_r (2.1.1).

1.5.3 land width b_γ and b_α (figure 7) : The width of a land on the major face is designated by b_γ and the width of a land on the minor face is designated by b_γ'.

The width of a land on the major flank is designated by b_α and the width of a land on the minor flank is designated by b_α'.

The identification number of the land together with the suffix used to identify the plane of measurement may be added if necessary, for example, $b_{\gamma n 2}$, $b_{\alpha n 1}$, $b_{\alpha n 2}'$.

1.5.4 rounded cutting edge radius r_n : The nominal radius of a rounded cutting edge measured in the cutting edge normal plane, P_n (2.1.5).

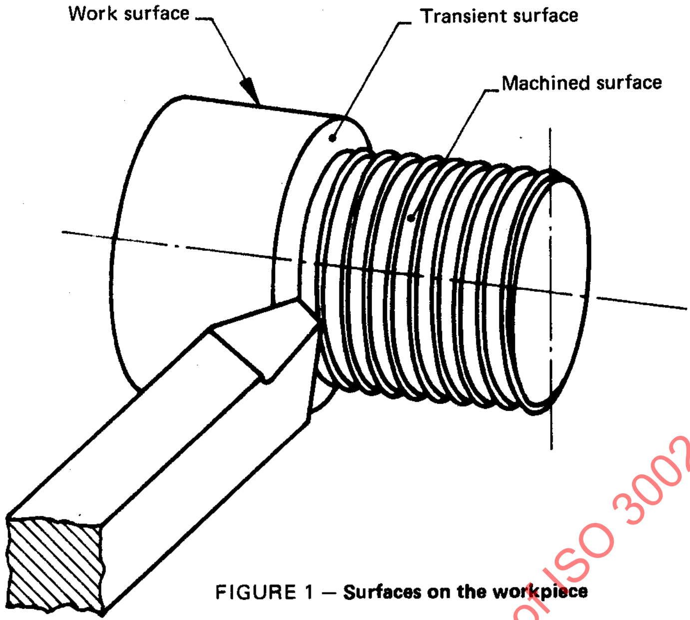


FIGURE 1 — **Surfaces on the workpiece**

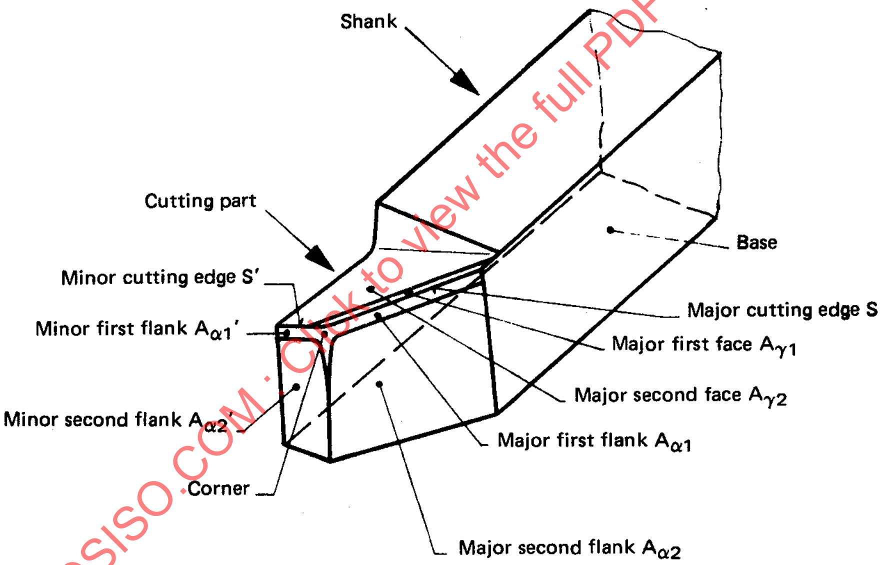


FIGURE 2a — **Cutting edges and surfaces on the cutting part of a turning tool**

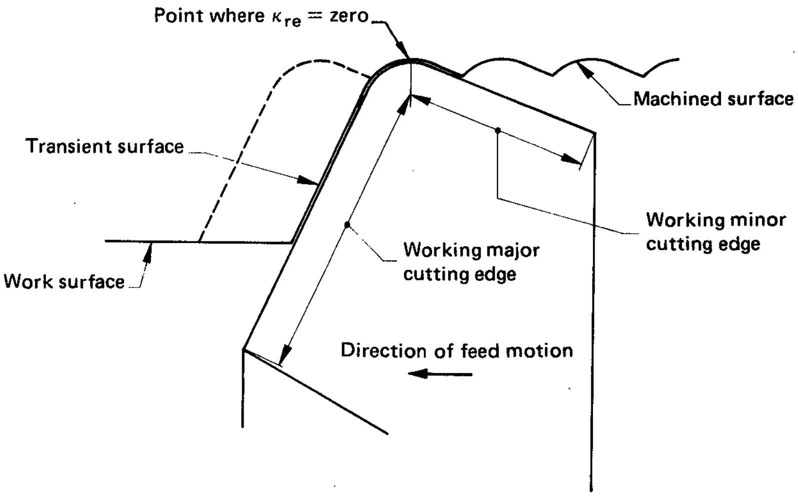


FIGURE 2b — **Illustration of various terms relating to the tool and workpiece**

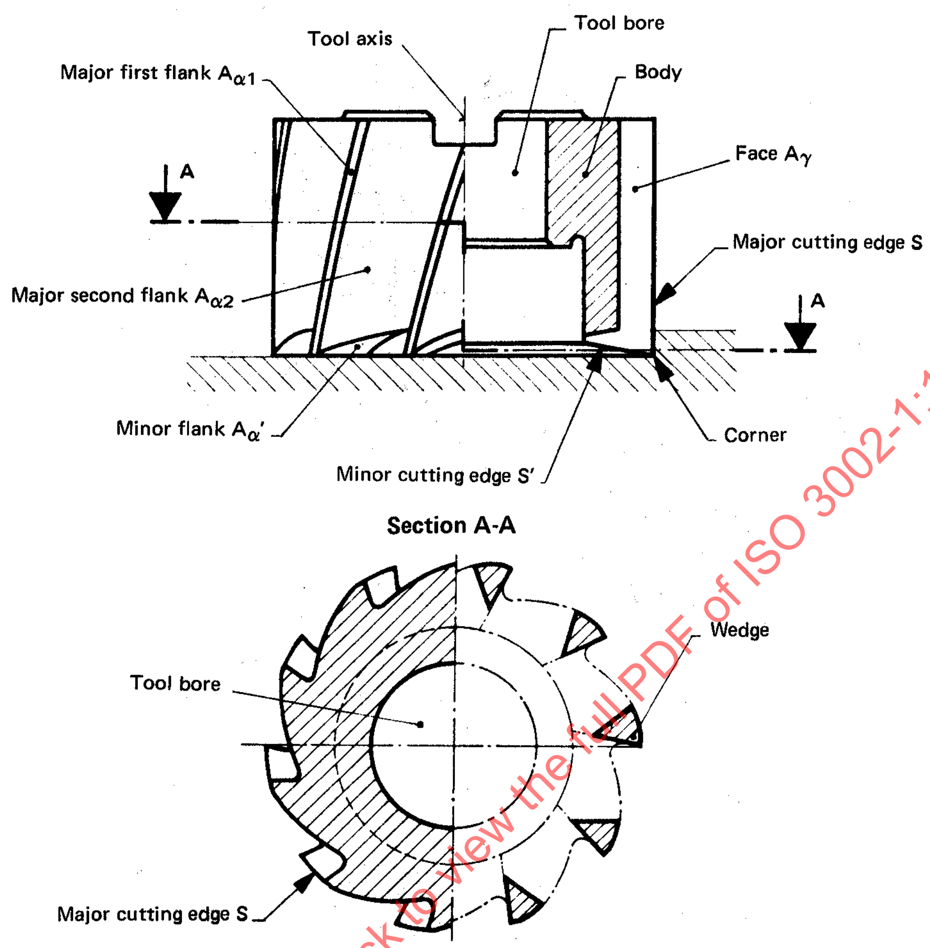


FIGURE 3 — **Cutting edges and surfaces on the cutting part of a shell end mill**

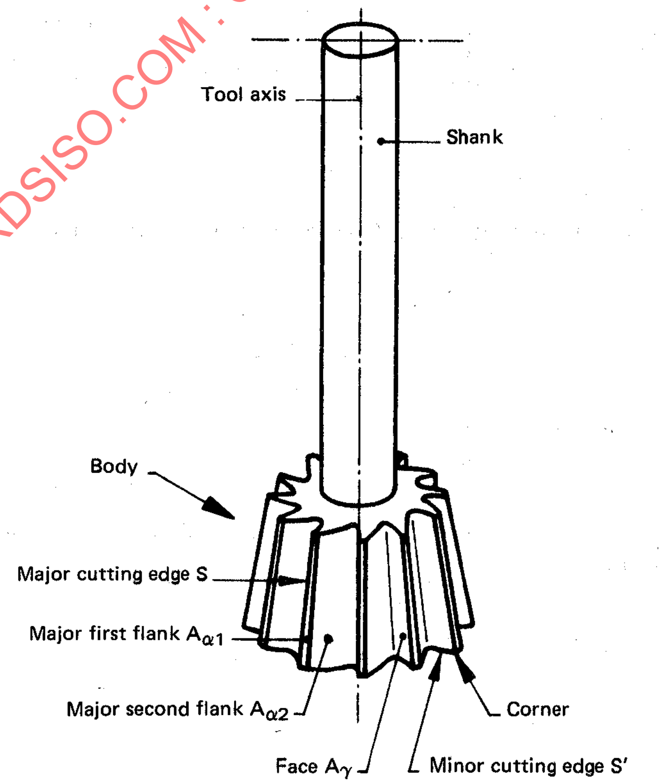


FIGURE 4 — **Cutting edges and surfaces on the cutting part of a single angle cutter with parallel shank**

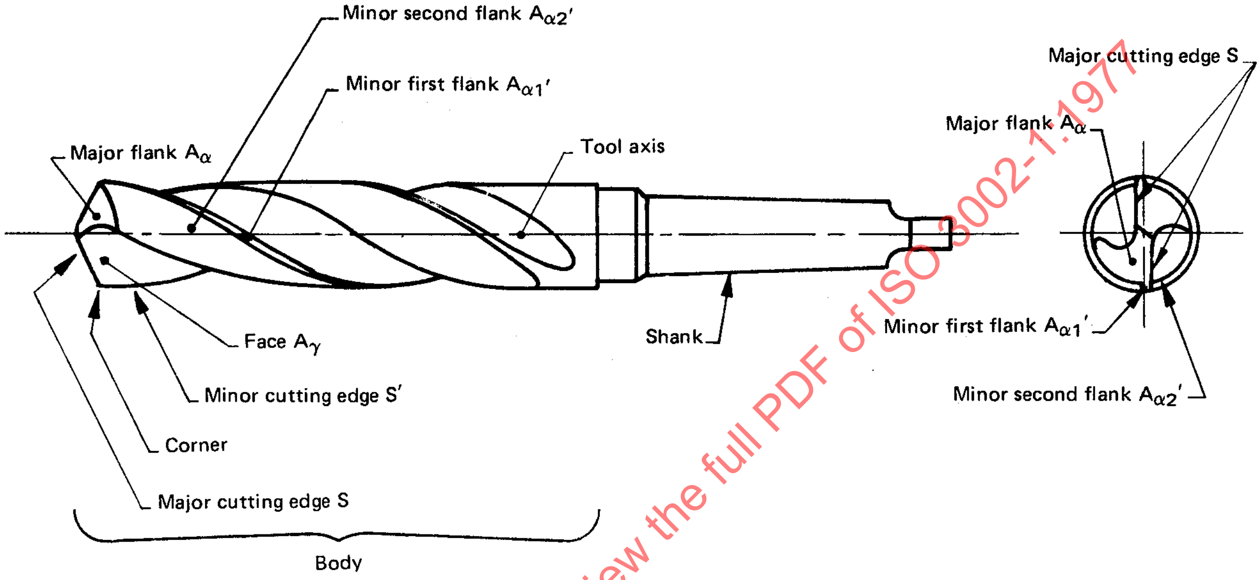


FIGURE 5 – **Cutting edges and surfaces on the cutting part of a twist drill**

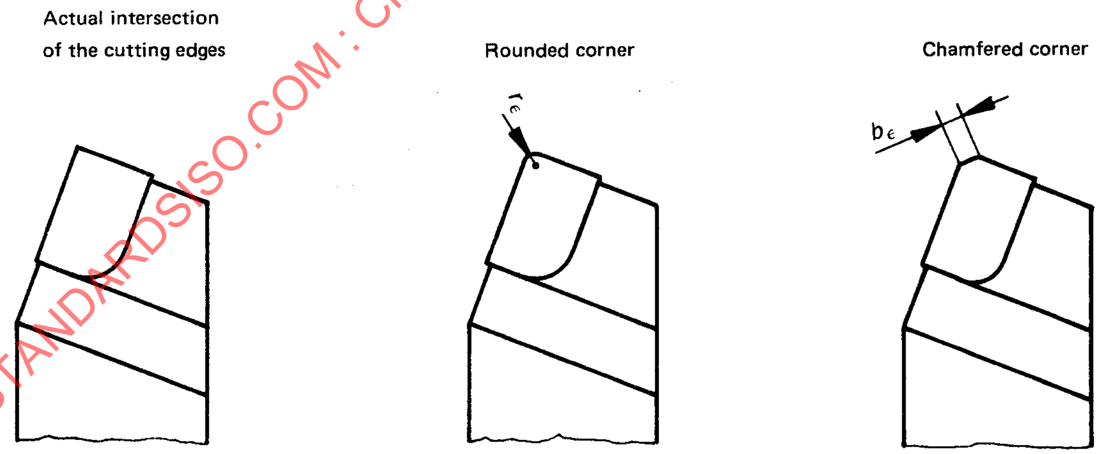


FIGURE 6 – **Corners viewed in the tool reference plane P_r (2.1.1)**

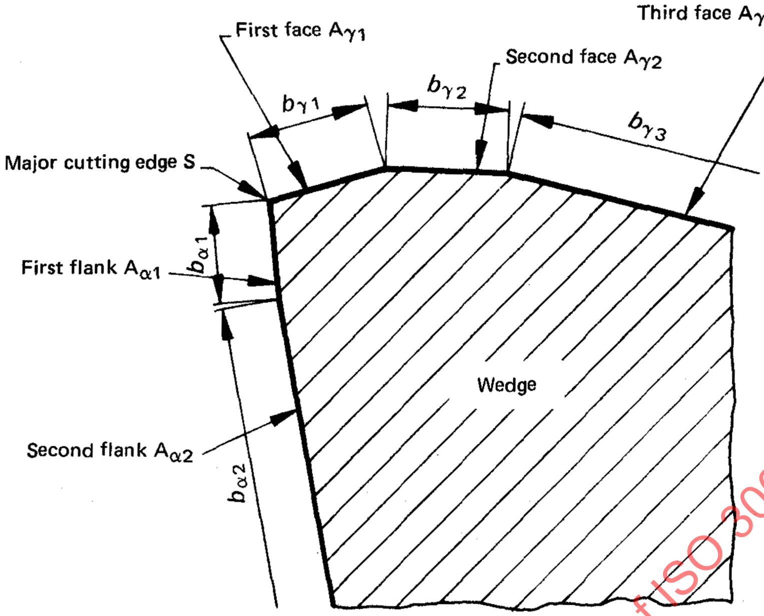


FIGURE 7 — **Wedge with lands**

1.6 TOOL AND WORKPIECE MOTIONS

All motions, directions of motions and speeds are defined relative to the workpiece.

1.6.1 primary motion : The main motion provided by a machine tool or manually, to cause relative motion between the tool and workpiece so that the face of the tool approaches the workpiece material. In a lathe, this motion is provided by the rotary motion of the workpiece; in drilling and milling machines, it is provided by the rotary motion of the tool; in a planing machine it is provided by the longitudinal motion of the table.

Usually, the primary motion absorbs most of the total power required to perform a machining operation.

1.6.1.1 direction of primary motion (figures 8 to 11) : The direction of instantaneous primary motion of the selected point on the cutting edge relative to the workpiece.

1.6.1.2 cutting speed v (figures 8 to 11) : The instantaneous velocity of the primary motion of the selected point on the cutting edge relative to the workpiece.

1.6.2 feed motion : A motion which may be provided to the tool or workpiece by a machine tool or manually which, when added to the primary motion, leads to a repeated or continuous chip removal and the creation of a machined surface with the desired geometric characteristics. This motion may proceed by steps or continuously; in either case it usually absorbs a small proportion of the total power required to perform a machining operation.

In certain machining operations, for example screw tapping and broaching, a feed motion as defined above is not required, the creation of the desired machined surface being achieved by the provision of an array of cutting edges which are arranged to approach the workpiece in an ordered manner. In such cases, the feed motion is defined as the motion which an imaginary single cutting edge would have to be given by the machine tool to produce the same result as the array of cutting edges with which the tool is actually provided.

1.6.2.1 direction of feed motion (figures 8 to 11) : The direction of instantaneous feed motion of the selected point on the cutting edge relative to the workpiece.

1.6.2.2 feed speed v_f (figures 8 to 11) : The instantaneous velocity of the feed motion of the selected point on the cutting edge relative to the workpiece.

When the feed is intermittent, for example in the case of a planing operation, the feed speed is not defined.

1.6.3 resultant cutting motion : The motion resulting from simultaneous primary motion and feed motion.

1.6.3.1 resultant cutting direction (figures 8, 9 and 11) : The direction of the instantaneous resultant cutting motion of the selected point on the cutting edge relative to the workpiece.

1.6.3.2 resultant cutting speed v_e (figures 8, 9 and 11) : The instantaneous velocity of the resultant cutting motion of the selected point on the cutting edge relative to the workpiece.

1.6.4 feed motion angle φ (figures 8 to 11) : The angle between the directions of simultaneous feed motion and primary motion. It is therefore measured in the working plane P_{fe} (2.2.2).

In certain machining operations such as in planing, shaping and broaching this angle cannot be defined.

1.6.5 resultant cutting speed angle η (figures 8, 9 and 11) : The angle between the direction of primary motion and the resultant cutting direction. It is therefore measured in the working plane P_{fe} (2.2.2).

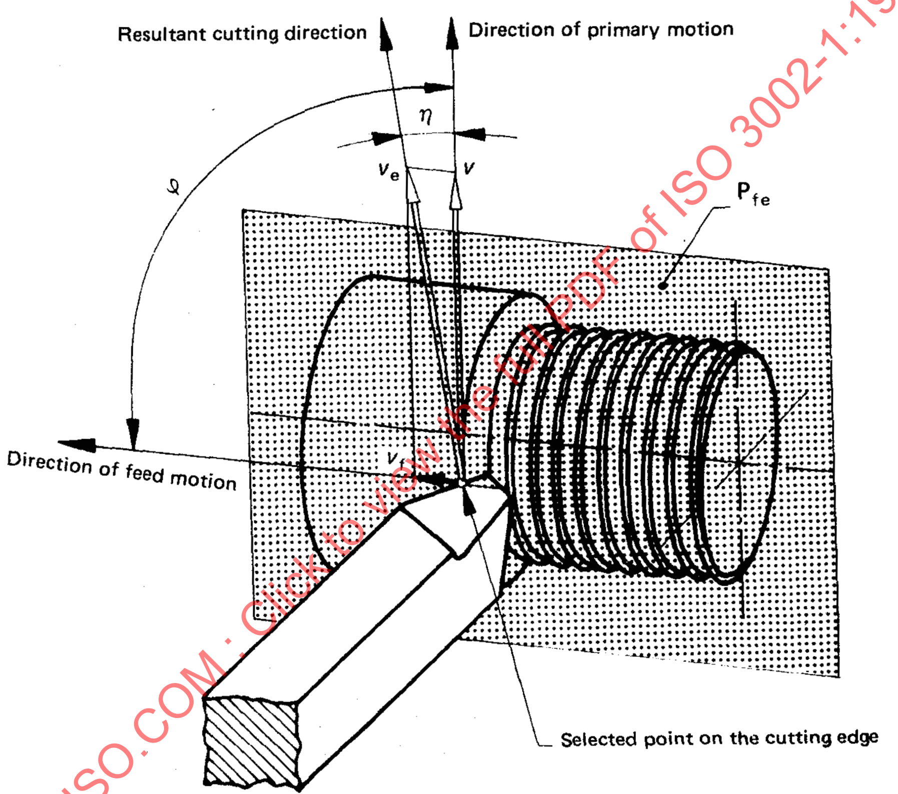
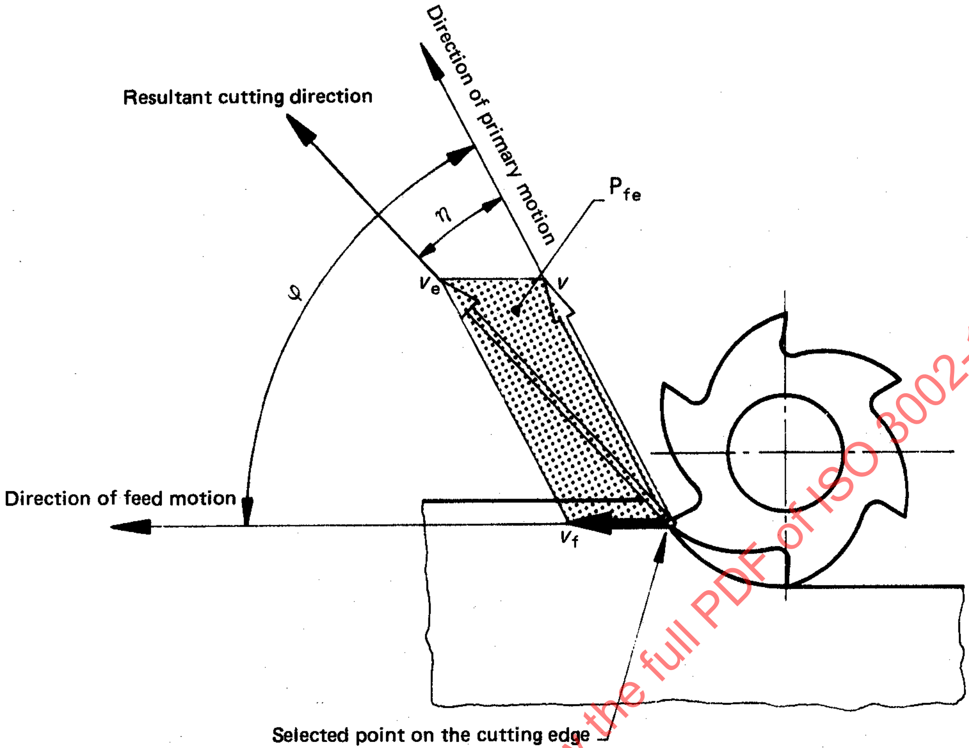


FIGURE 8 – **Tool and workpiece motions – Turning tool**



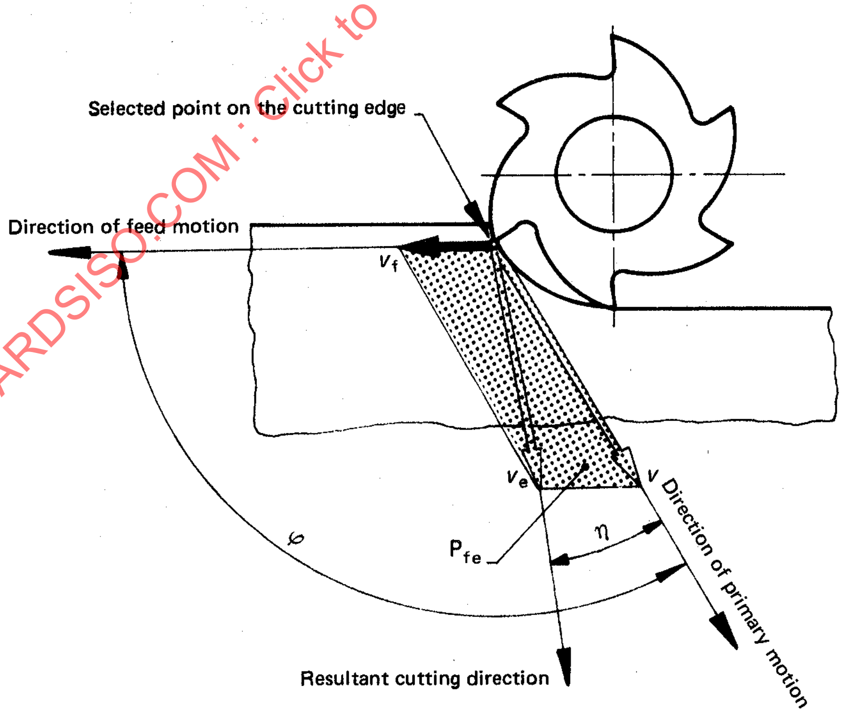


FIGURE 9 – **Tool and workpiece motions – Slab milling cutter**

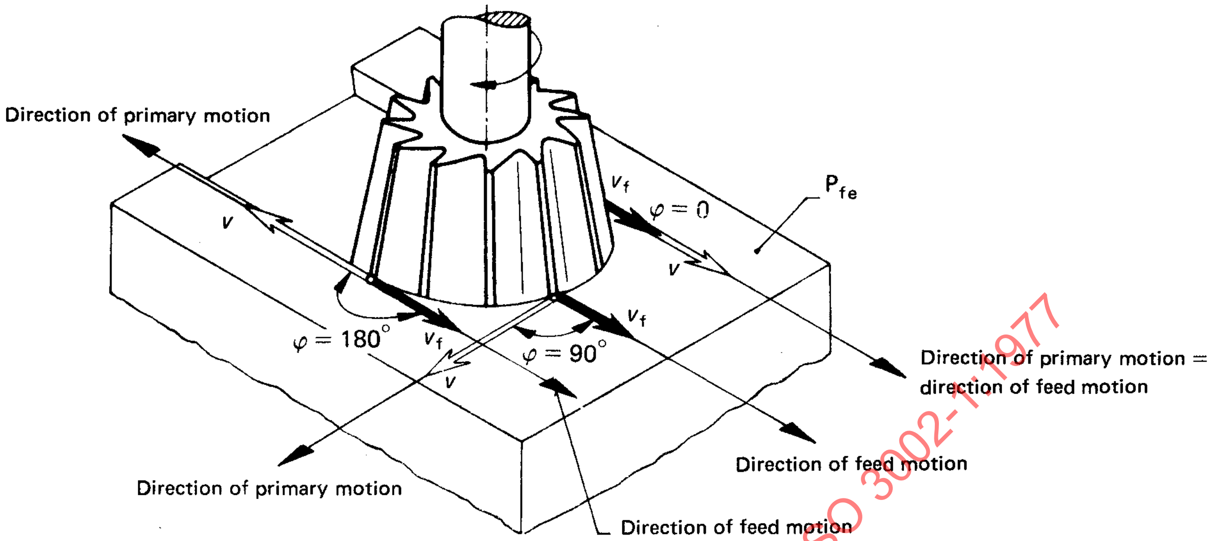


FIGURE 10 — **Tool and workpiece motions considered at three selected points on the cutting edge — Single angle cutter with parallel shank**

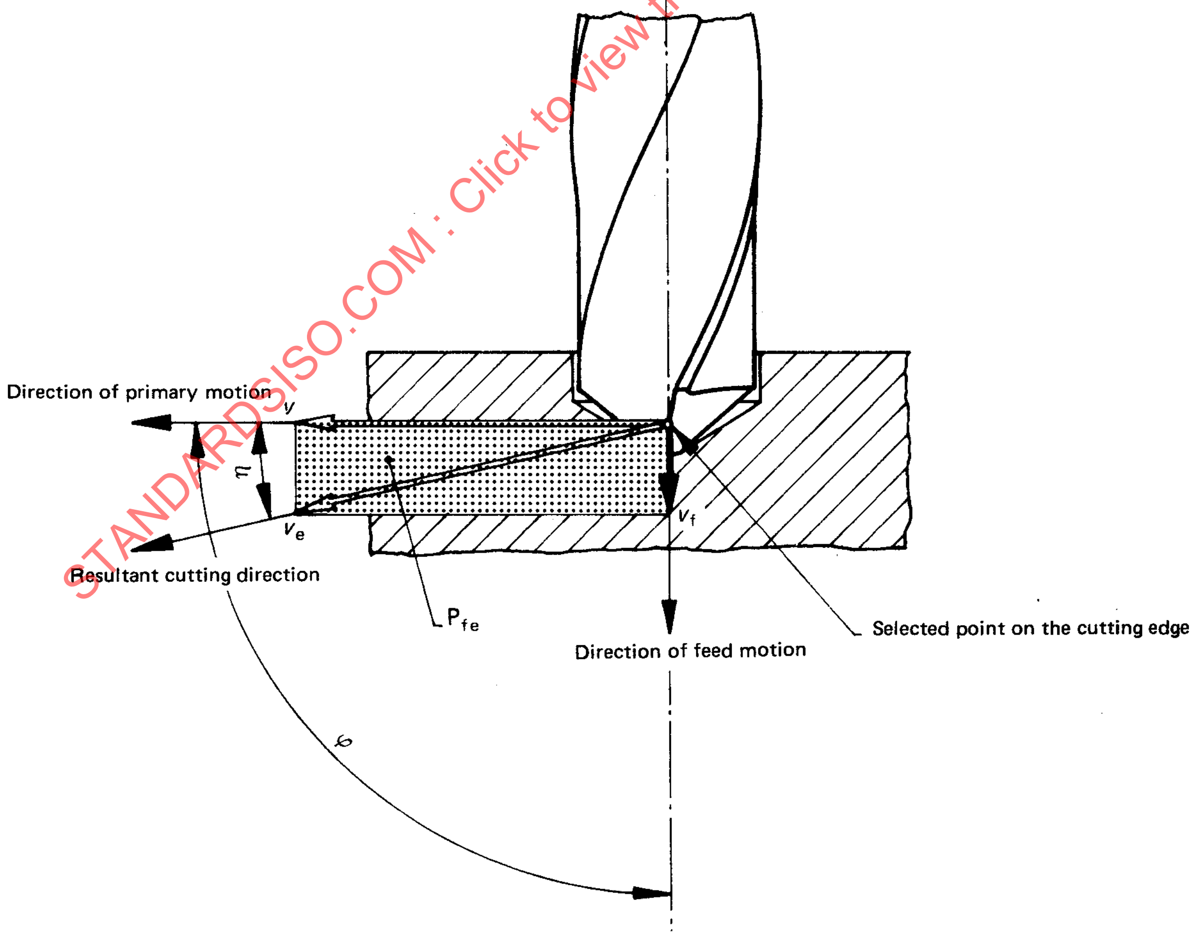


FIGURE 11 — **Tool and workpiece motions — Twist drill**

2 REFERENCE SYSTEMS

Reference systems of planes are necessary for defining and specifying the angles of a cutting tool. One system (the tool-in-hand system) is needed for defining the geometry of the tool for its manufacture and measurement. A second system (the tool-in-use system) is needed for specifying the geometry of the cutting tool when it is performing a cutting operation.

NOTE — A third reference system of planes (called the machine reference system) is required to define the orientation of a cutting tool with respect to the machine tool. This third reference system is defined in ISO 3002/II.

The planes used in the first system are termed tool-in-hand planes, their titles, with two exceptions (2.1.2 and 2.1.5) each include the word "tool". The planes used in the second system are termed tool-in-use planes; their titles, with one exception (2.2.5), all include the work "working".

Since angles and other geometric features vary from point to point along the cutting edge of a tool, it is necessary to locate the reference system at whatever point one desires to be able to define the tool geometry. Each plane is therefore defined, with respect to a selected point on the cutting edge. The title of the plane may include an indication of whether the selected point is located on the major or minor cutting edge (for example, at a selected point on the major cutting edge, there is the tool cutting edge plane (2.1.4) and at a selected point on the minor cutting edge, the corresponding plane is termed the tool minor cutting edge plane.

Each plane is provided with a symbol consisting of P with a suffix indicating the plane's identity (for example P_s, the tool cutting edge plane).

For the planes defined below the selected point on the cutting edge is considered to be located on the major cutting edge.

When it is necessary to distinguish clearly a plane passing through a selected point on the minor cutting edge, the appropriate symbol bears a prime (for example P_s', the tool minor cutting edge plane).

When the cutting edge, face or flank is curved, the tangents or tangential planes through the selected point should be used in the reference systems of planes.

The symbol used for a plane in the tool-in-use system bears the additional suffix e, for "effective" (for example P_{se}, the working cutting edge plane) to distinguish it from the corresponding tool-in-hand plane (for example P_s, the tool cutting edge plane).

2.1 TOOL-IN-HAND SYSTEM (figure 12)

2.1.1 tool reference plane P_r (figures 12 to 17) : A plane through the selected point on the cutting edge, so chosen as to be either parallel or perpendicular to a plane or axis of the tool convenient for locating or orienting the tool for its manufacture, sharpening and measurement.

The plane must be chosen and defined for each individual type of cutting tool so that it meets the conditions prescribed above and is generally oriented perpendicular to the assumed direction of primary motion.

For ordinary lathe, planer and shaper tools it is a plane parallel to the base of the tool. For a vertical shank or tangential tool or for a horizontal shank planer tool it is a plane perpendicular to the tool axis. For a side and face milling cutter, for drills and screwing taps it is a plane containing the tool axis.

2.1.2 assumed working plane P_f (figures 12 to 17) : A plane through the selected point on the cutting edge and perpendicular to the tool reference plane P_r and so chosen as to be either parallel or perpendicular to a plane or an axis of the tool convenient for locating or orienting the tool for its manufacture, sharpening and measurement.

The plane must be chosen and defined for each individual type of cutting tool so that it meets the conditions prescribed above and is generally oriented parallel to the assumed direction of feed motion.

For ordinary lathe tools and planer tools it is a plane perpendicular to the tool axis. For drills, broaches, facing tools, parting-off and cutting-off lathe tools it is a plane parallel to the tool axis. For milling cutters it is a plane perpendicular to the tool axis.

2.1.3 tool back plane P_p (figures 12 to 17) : A plane through the selected point on the cutting edge and perpendicular both to the tool reference plane P_r and to the assumed working plane P_f.

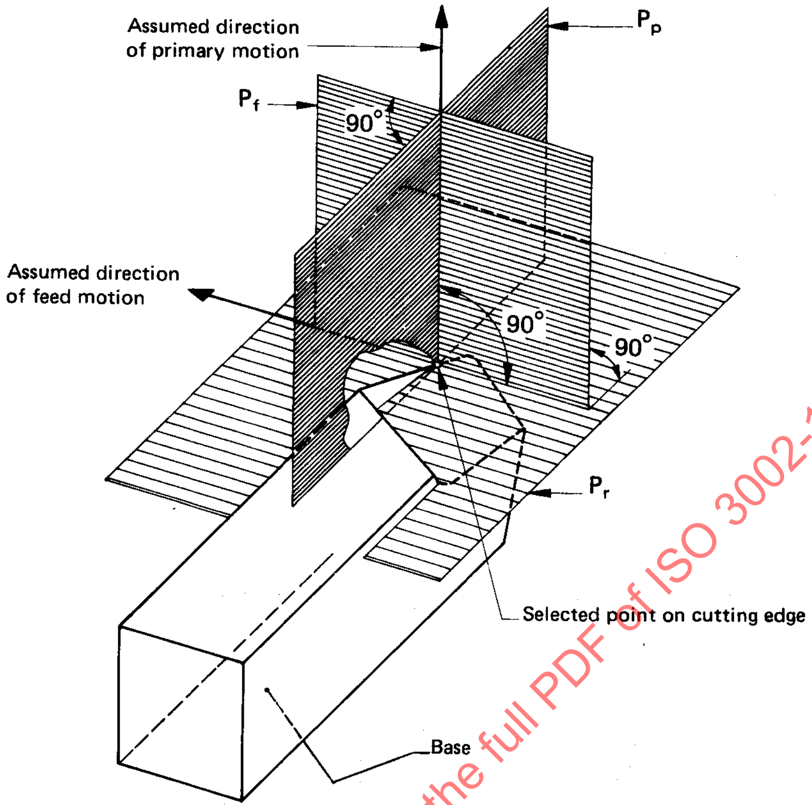
2.1.4 tool cutting edge plane P_s (figures 12 to 17) : A plane tangential to the cutting edge at the selected point and perpendicular to the tool reference plane P_r.

2.1.5 cutting edge normal plane P_n (figures 12 to 17) : A plane perpendicular to the cutting edge at the selected point on the cutting edge.

2.1.6 tool orthogonal plane P_o (figures 12 to 17) : A plane through the selected point on the cutting edge and perpendicular both to the tool reference plane P_r and to the tool cutting edge plane P_s.

2.1.7 tool face orthogonal plane P_g (figure 13) : A plane through the selected point on the cutting edge and perpendicular both to the face A_γ and to the tool reference plane P_r.

2.1.8 tool flank orthogonal plane P_b (figure 13) : A plane through the selected point on the cutting edge and perpendicular both to the flank A_α and to the tool reference plane P_r.



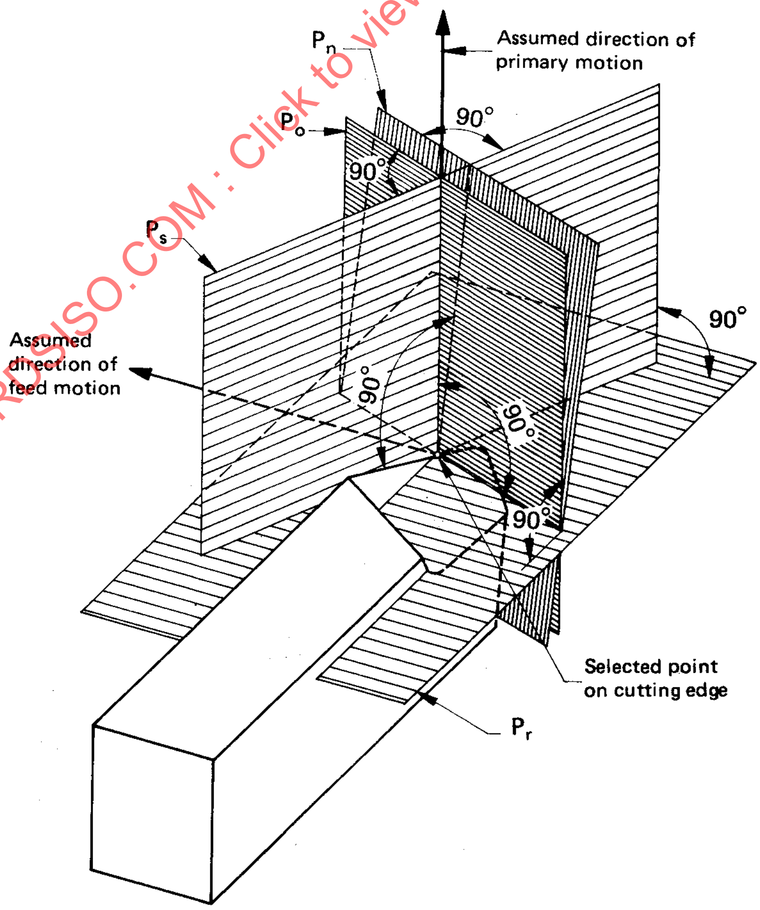


FIGURE 12 — **Planes in the tool-in-hand system**

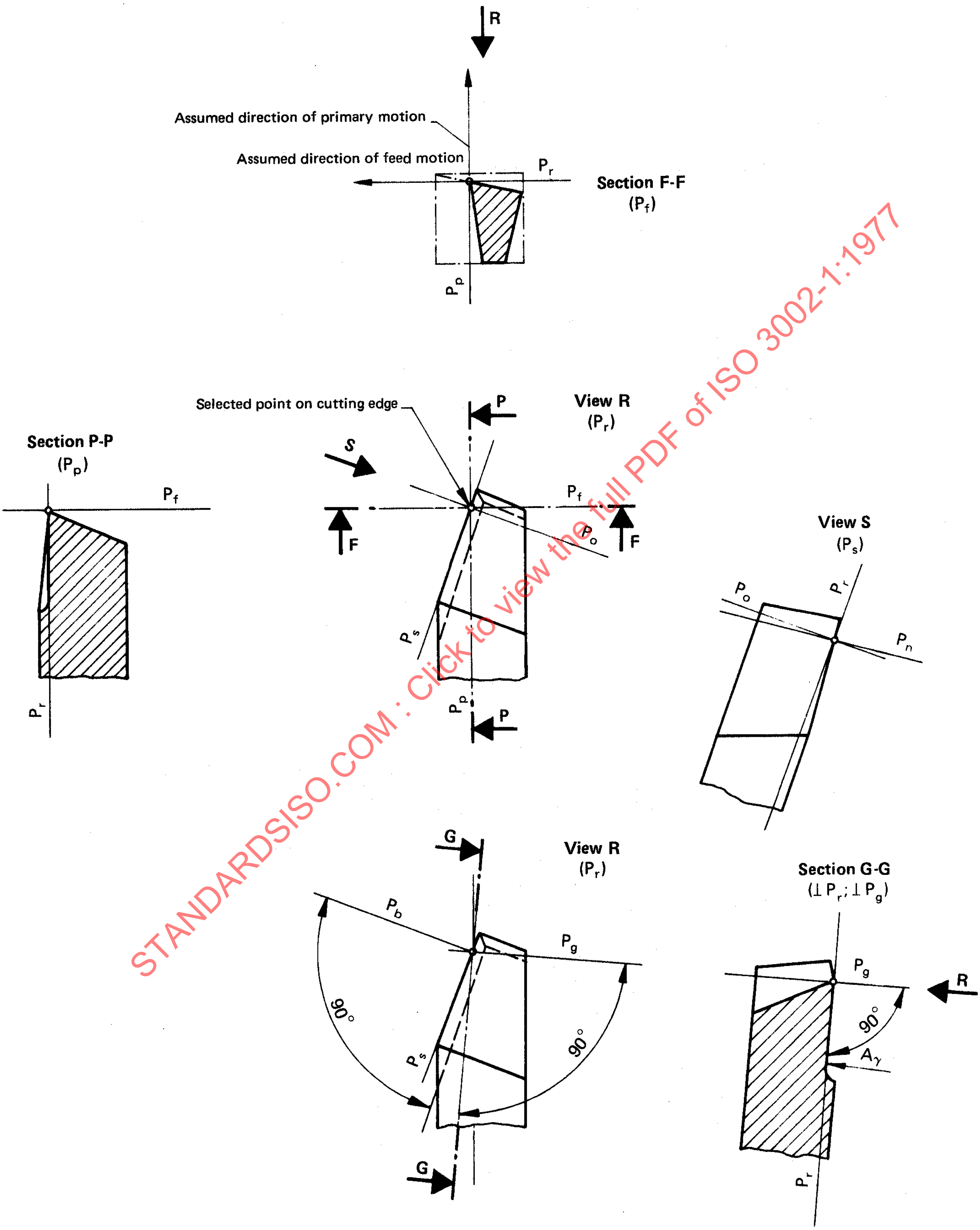


FIGURE 13 – **Planes in the tool-in-hand system – Turning tool**

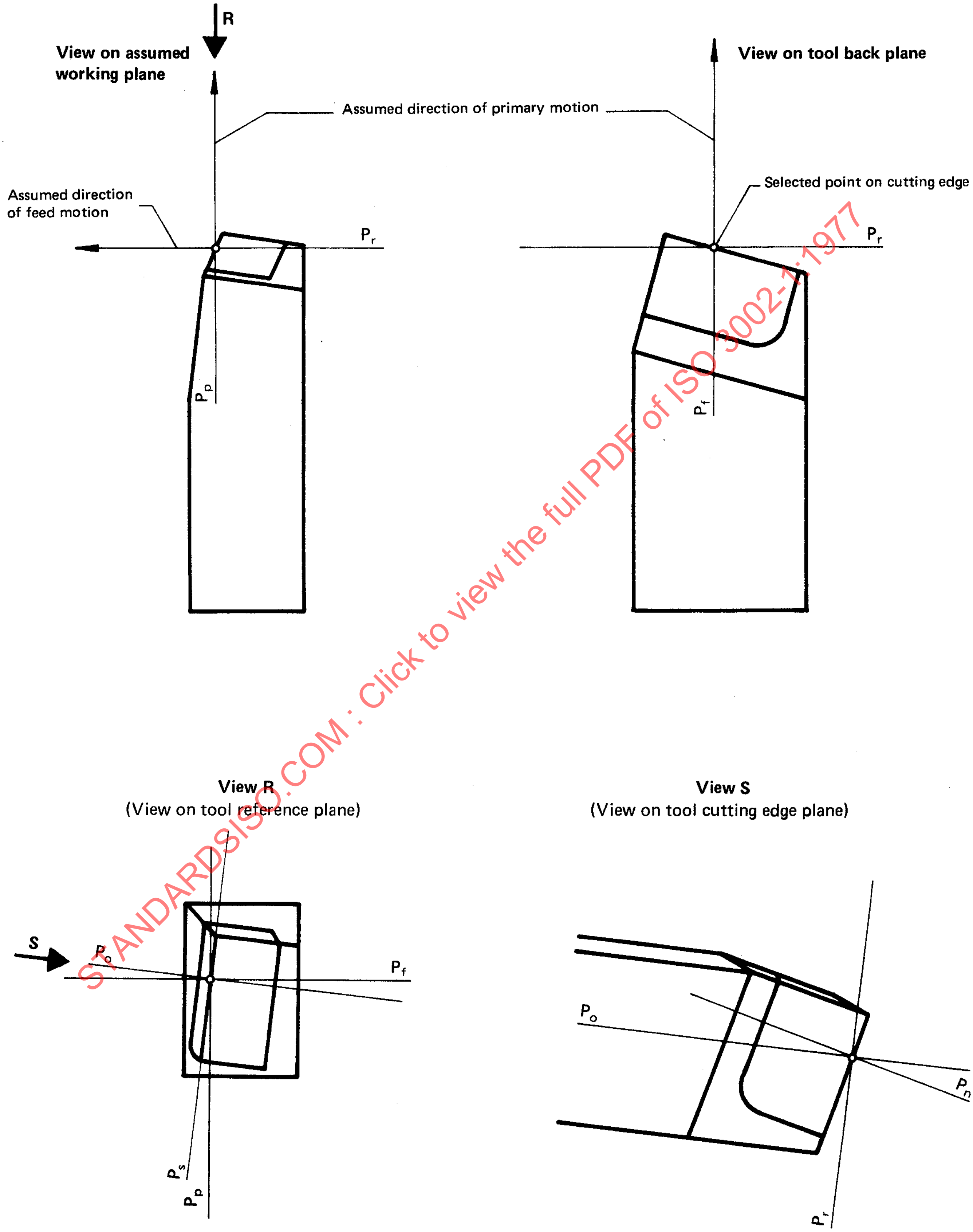


FIGURE 14 — **Planes in the tool-in-hand system — Tangential turning tool**

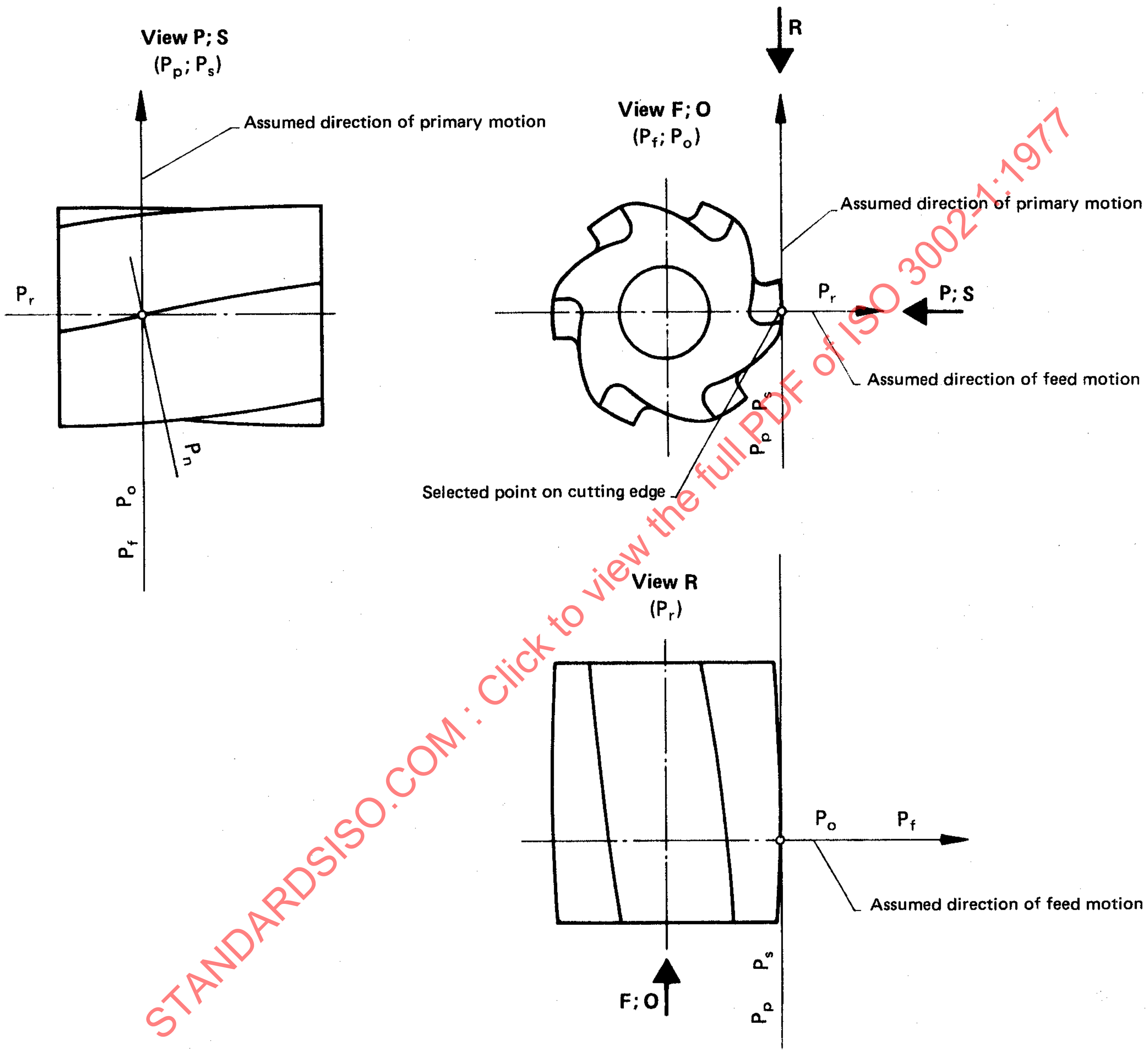


FIGURE 15 — **Planes in the tool-in-hand system — Slab milling cutter**

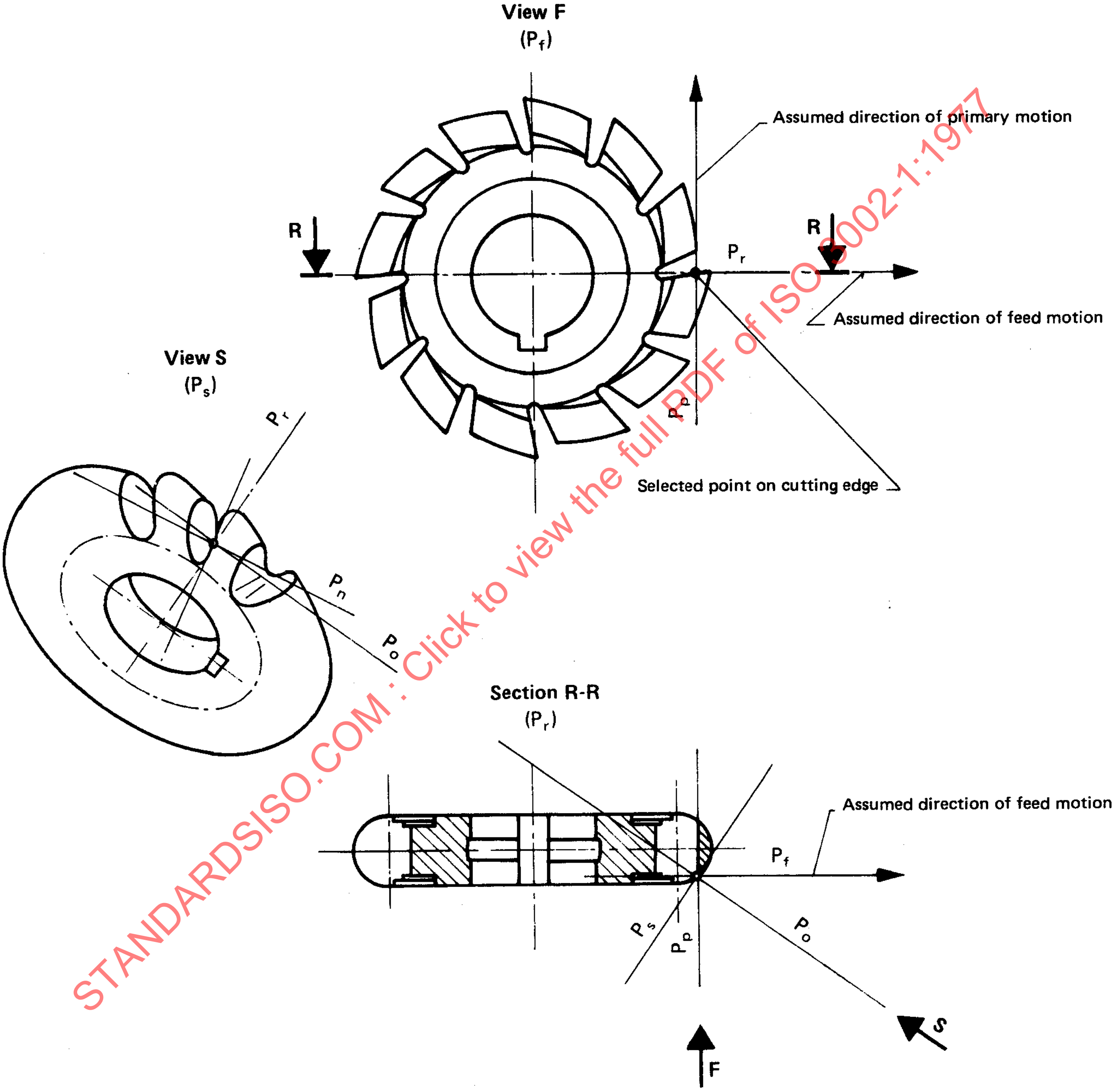


FIGURE 16 — **Planes in the tool-in-hand system — Convex milling cutter**

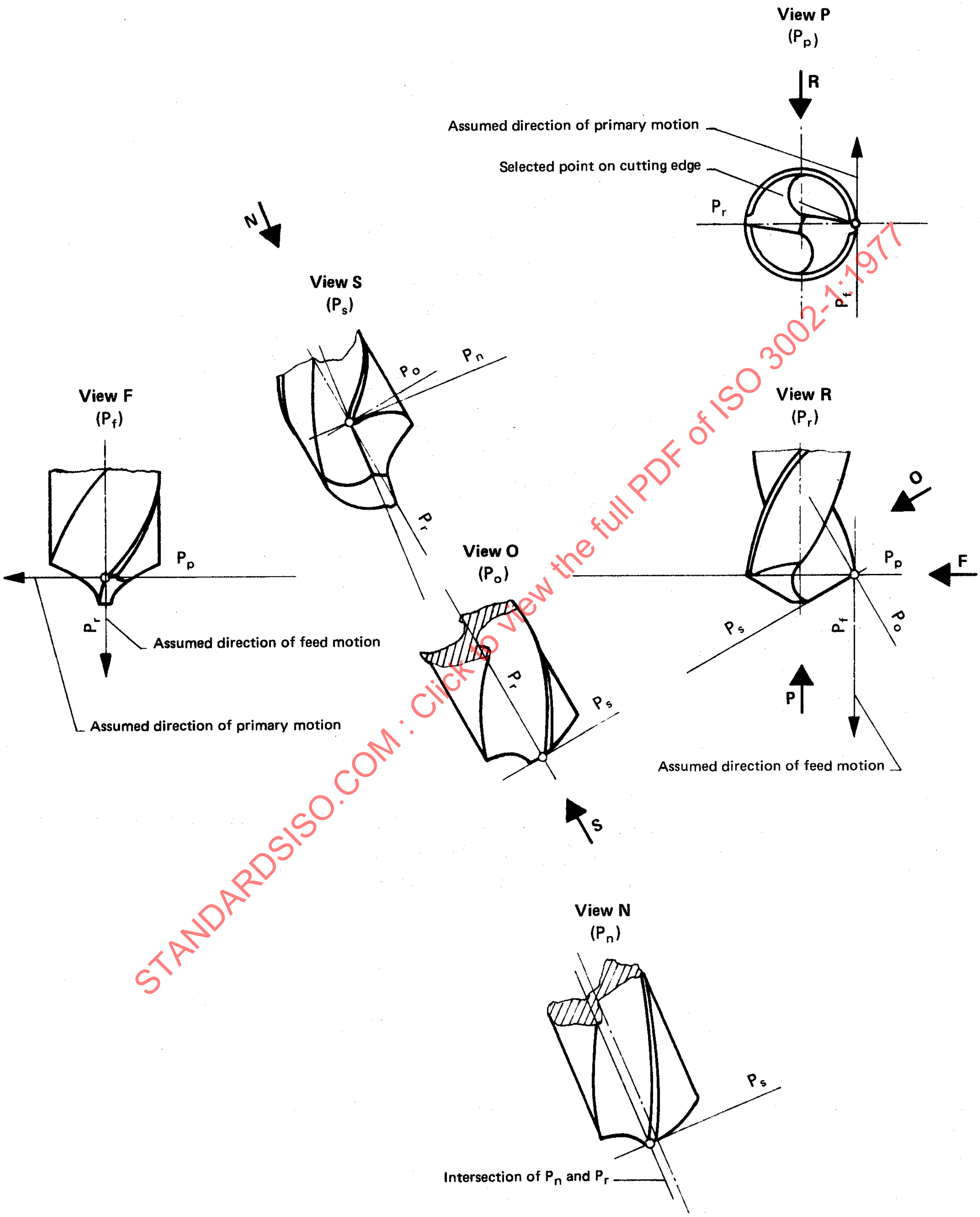


FIGURE 17 — **Planes in the tool-in-hand system — Twist drill**

2.2 TOOL-IN-USE SYSTEM

2.2.1 working reference plane P_{re} (figures 18 to 23) : A plane through the selected point on the cutting edge and perpendicular to the resultant cutting direction.

2.2.2 working plane P_{fe} (figures 18 to 23) : A plane through the selected point on the cutting edge and containing both the direction of primary motion and the direction of feed motion. This plane is thus perpendicular to the working reference plane P_{re}.

2.2.3 working back plane P_{pe} (figures 18 to 23) : A plane through the selected point on the cutting edge and perpendicular both to the working reference plane P_{re} and to the working plane P_{fe}.

2.2.4 working cutting edge plane P_{se} (figures 18 to 23) : A plane tangential to the cutting edge at the selected point and perpendicular to the working reference plane P_{re}. This plane thus contains the resultant cutting direction.

2.2.5 cutting edge normal plane P_{ne} (figures 18 to 23) : The cutting edge normal plane in the tool-in-use system is identical with the cutting edge normal plane defined in the tool-in-hand system, P_n.

$$P_{ne} \equiv P_n$$

2.2.6 working orthogonal plane P_{oe} (figures 18 to 23) : A plane through the selected point on the cutting edge and perpendicular both to the working reference plane P_{re} and to the working cutting edge plane P_{se}.

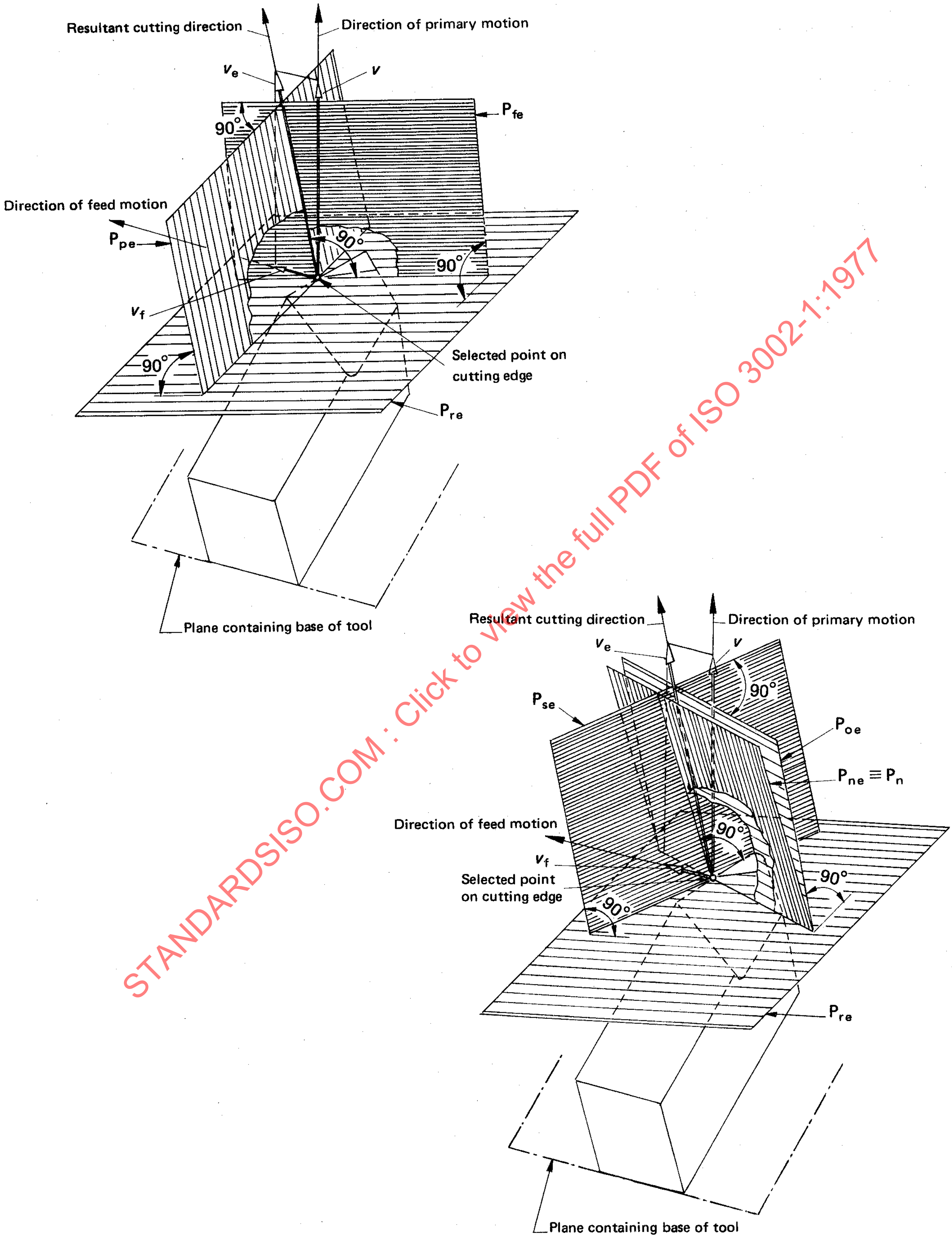


FIGURE 18 — **Planes in the tool-in-use system**

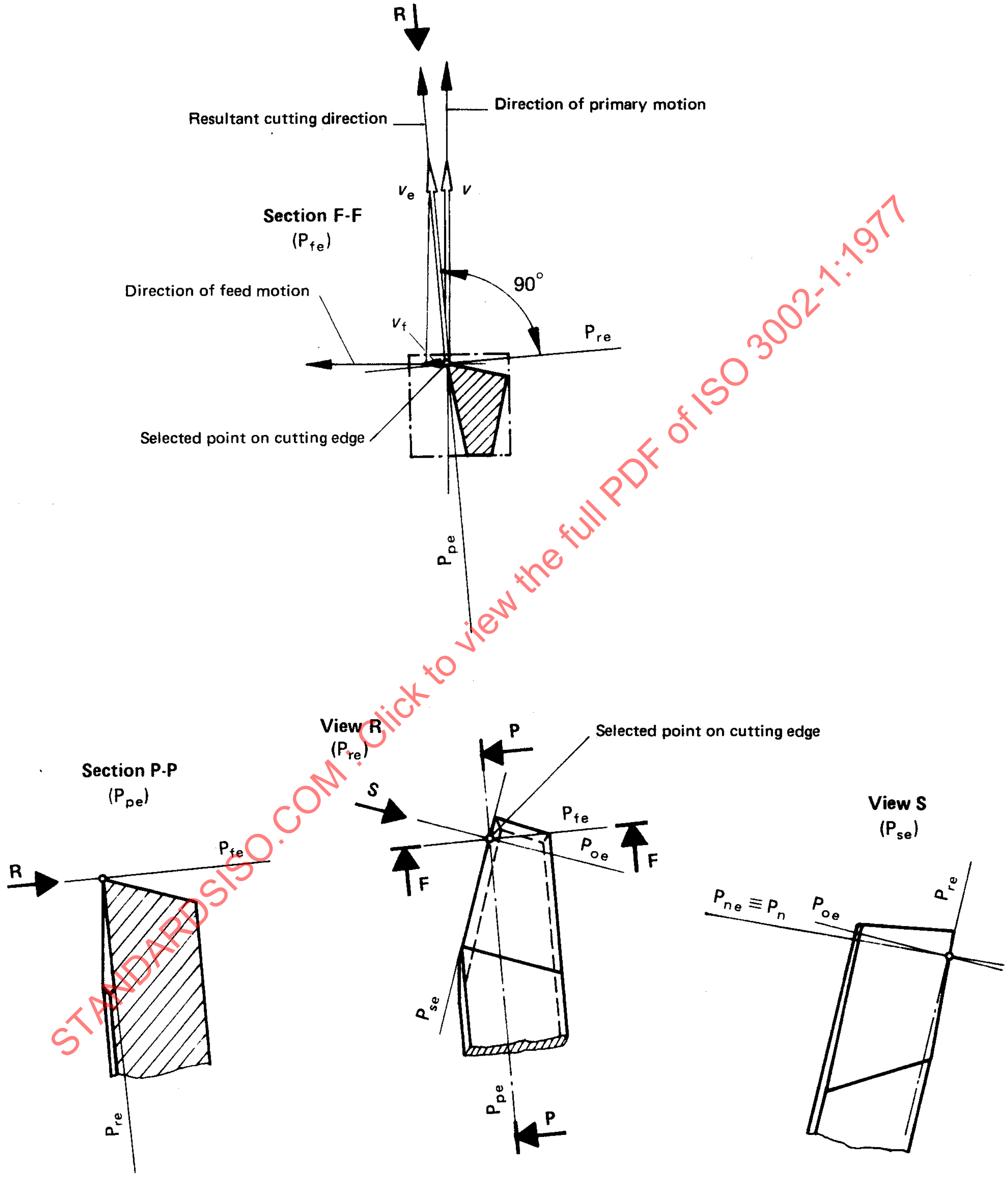


FIGURE 19 – **Planes in the tool-in-use system – Turning tool**

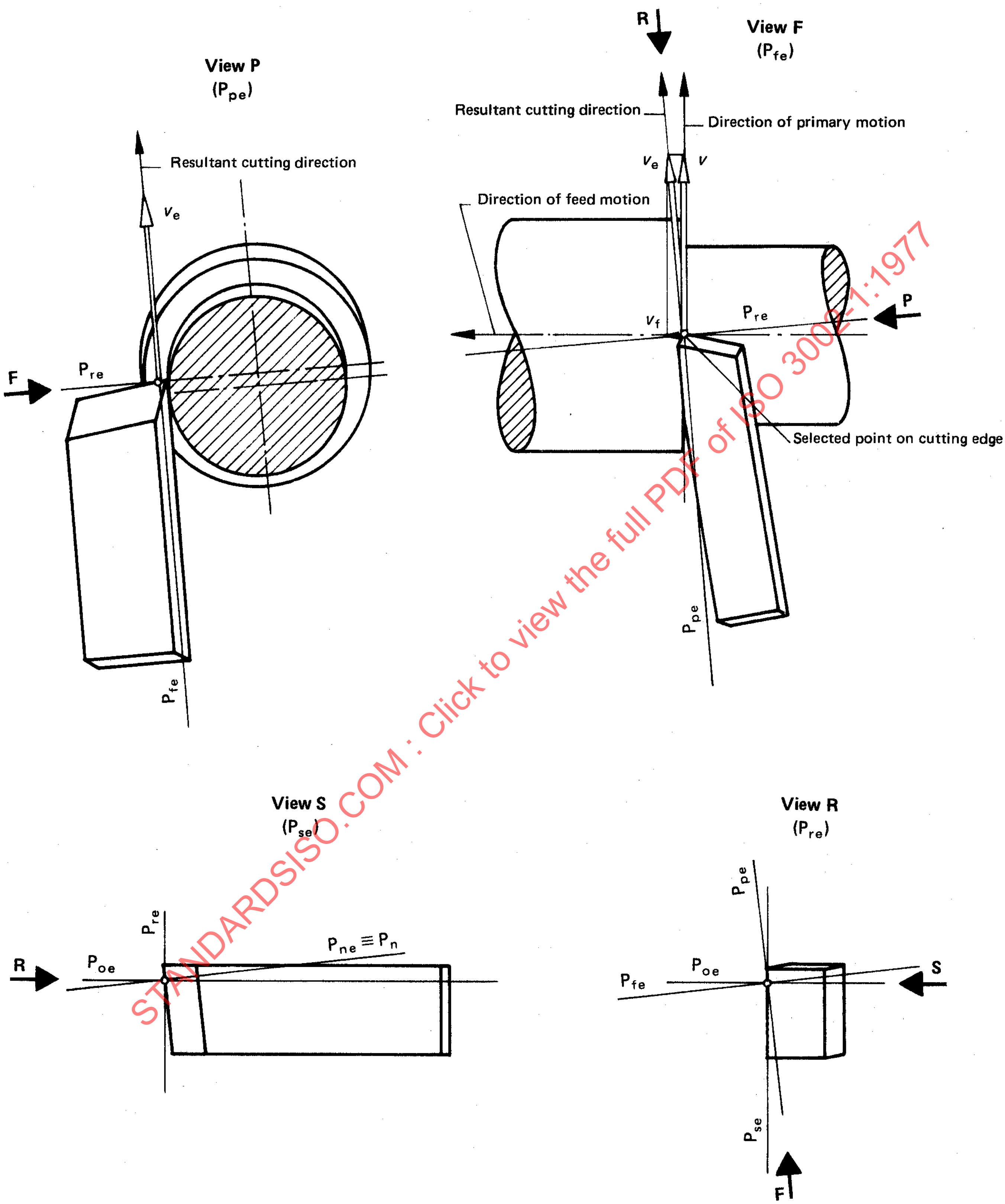


FIGURE 20 – **Planes in the tool-in-use system – Tangential turning tool**

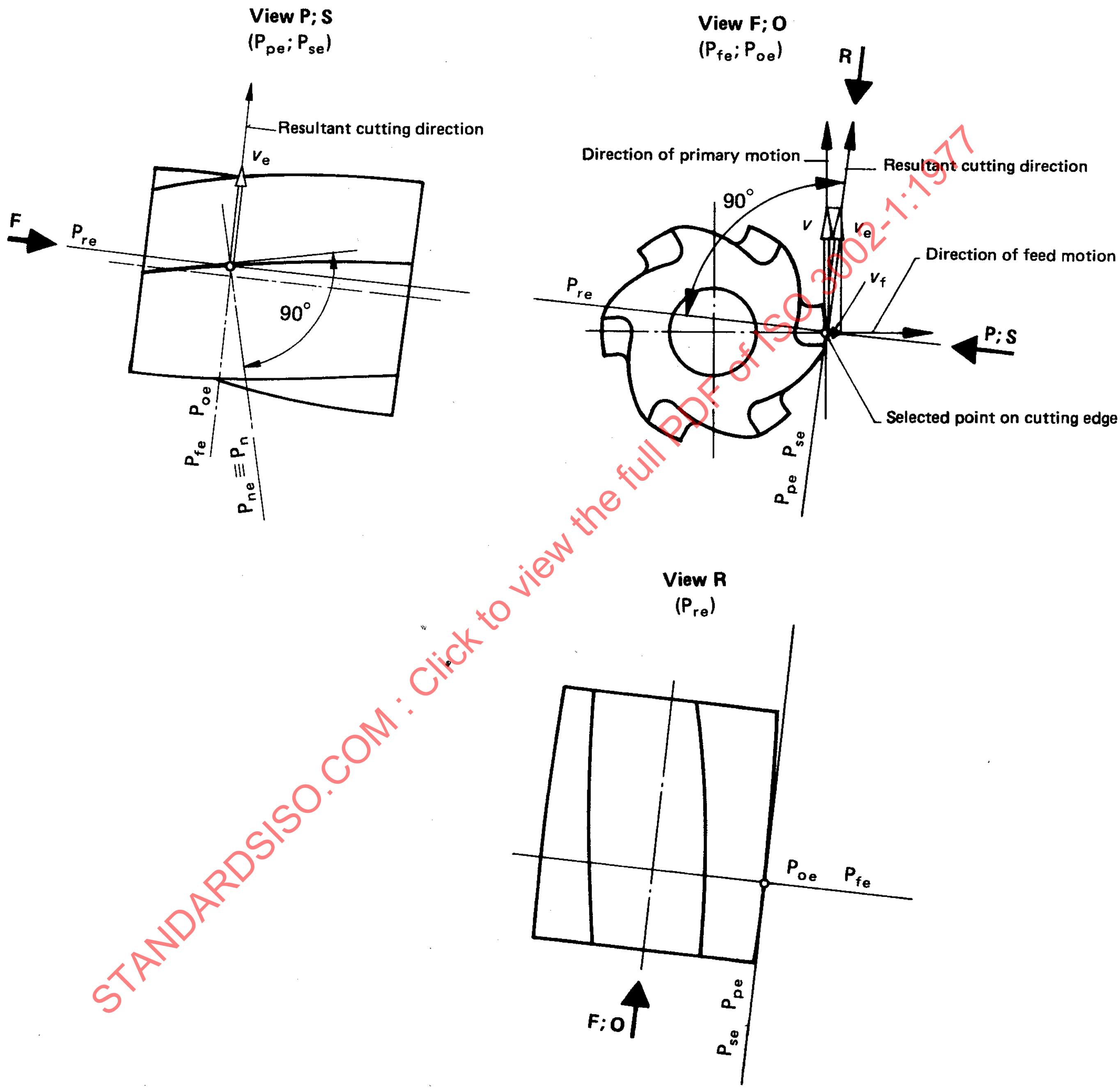


FIGURE 21 — **Planes in the tool-in-use system — Slab milling cutter**

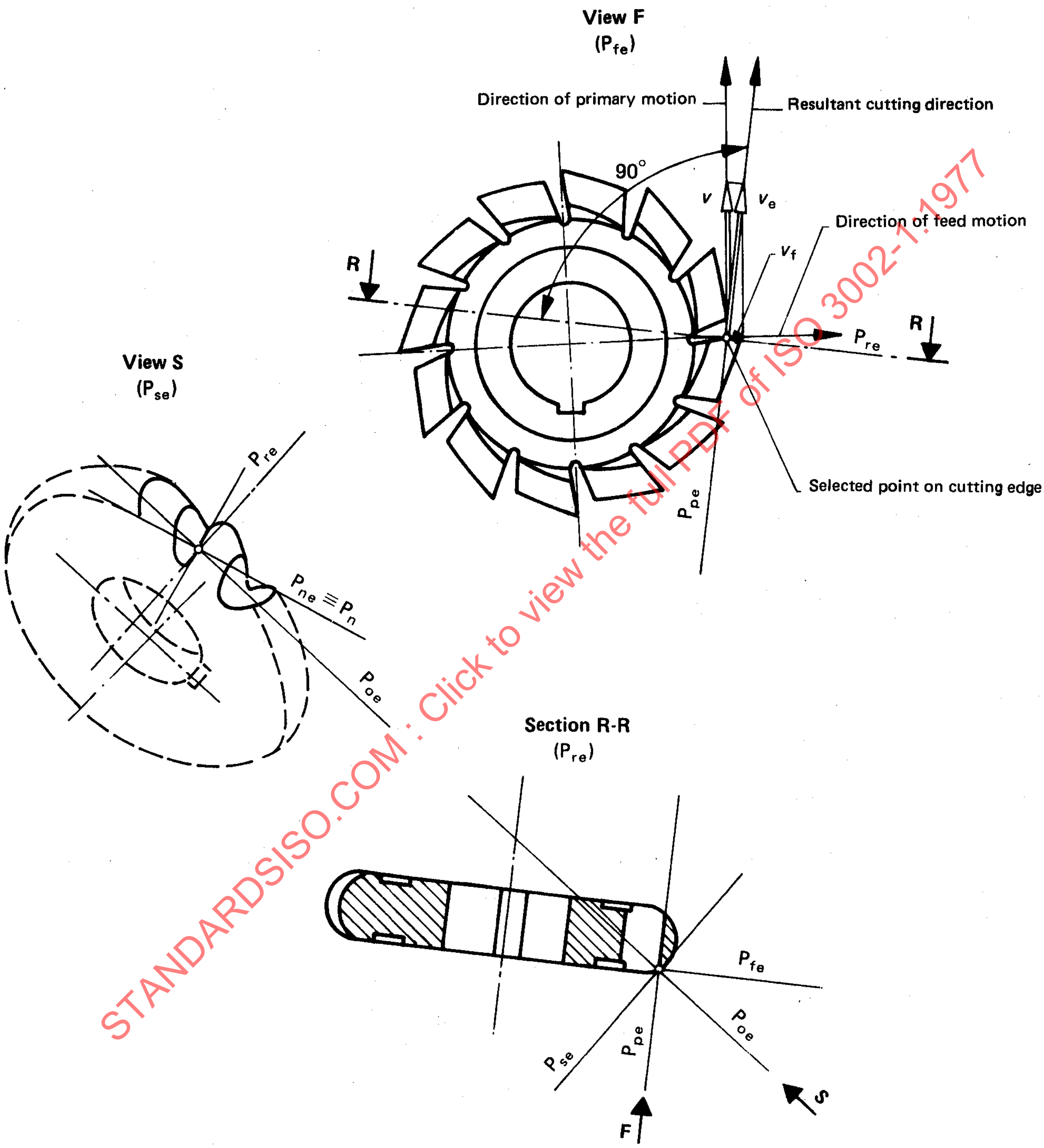


FIGURE 22 — **Planes in the tool-in-use system — Convex milling cutter**

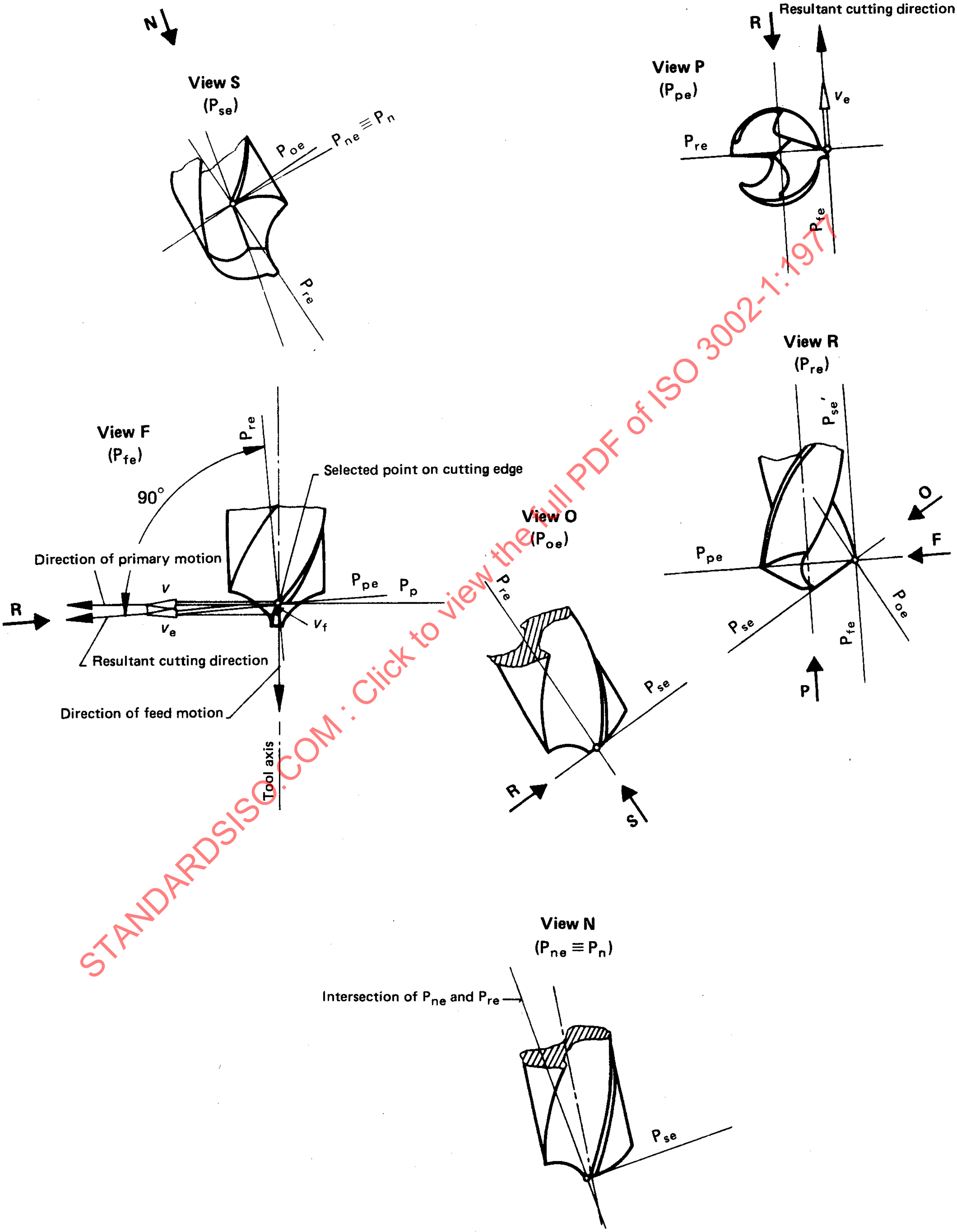


FIGURE 23 — **Planes in the tool-in-use system — Twist drill**

3 TOOL AND WORKING ANGLES

The angles are necessary for the determination of the geometrical position of the tool cutting edge, the face and the flank.

One set of angles is needed for defining the angles of the tool as an entity in itself, that is, for the tool-in-hand; these angles are designated tool angles and, with one exception (3.1.3.1), have the prefix "tool" in their titles. These angles are necessary for manufacturing, sharpening and measuring the tool.

A second set of angles is needed for defining the angles which affect the action of the tool in the cutting process, that is for the tool-in-use; these angles are designated working angles and, with one exception (3.2.3.1), have the prefix "working" in their title.

Since tool and working angles vary from point to point along the cutting edge, the definitions of the angles given below refer always to the angles at the selected point.

When the cutting edge, face or flank is curved the tangents or tangential planes through the selected point are used in the reference systems of planes used to define the angles.

Each angle is specified, where appropriate, with reference to a particular cutting edge on the tool, depending upon the location of the selected point on the cutting edge. The title of the angle may include an indication of whether the selected point is located on the major or minor cutting edge (for example, at a selected point on the major cutting edge, there is the tool normal rake and at a selected point on the minor cutting edge the corresponding angle is termed the tool minor cutting edge normal rake).

Each angle is provided with a symbol consisting of a Greek letter with a suffix, the suffix indicating the plane in which the angle is measured (for example γ_n, the tool normal rake).

For the angles defined below the selected point on the cutting edge is considered to be located on the major cutting edge. When it is necessary to distinguish clearly angles defined with respect to a selected point on the minor cutting edge, the appropriate symbols bear a prime (for example $\gamma_n{}'$, the tool minor cutting edge normal rake).

The symbol used for a working angle bears the additional suffix e for "effective" (for example γ_{ne}, the working normal rake) to distinguish it from the corresponding tool angle (for example γ_n, the tool normal rake).

When the face or flank is composed of a number of surfaces inclined to one another, these surfaces are numbered consecutively starting from the cutting edge. The number of the land is used as an additional suffix to the appropriate symbols to associate the rake or clearance angle with its particular land (for example γ_{n1}; γ_{n2}; $\gamma_{n1}{}'$; $\gamma_{n2}{}'$; α_{n1}; α_{n2}; $\alpha_{n2}{}'$; $\alpha_{n2e}{}'$).

When the face or flank has only one surface the suffixes 1, 2, etc, are not used.

The sign conventions of the various angles are given in 3.3.

3.1 TOOL ANGLES

The tool angles are defined with the aid of the tool-in-hand reference system of planes (2.1).

3.1.1 *Orientation of cutting edge*

3.1.1.1 tool cutting edge angle κ_r (figures 24, 26, 27 and 28) : The angle between the tool cutting edge plane P_s and the assumed working plane P_f measured in the tool reference plane P_r.

3.1.1.2 tool approach angle; tool lead angle /USA/ ψ_r (figures 24, 26, 27 and 28) : The angle between the tool cutting edge plane P_s and the tool back plane P_p measured in the tool reference plane P_r.

ψ_r is defined only for the major cutting edge. Thus at any selected point on the major cutting edge the sum of ψ_r and κ_r is always 90°.

3.1.1.3 tool cutting edge inclination λ_s (figures 24, 27 and 28) : The angle between the cutting edge and the tool reference plane P_r measured in the tool cutting edge plane P_s.

3.1.1.4 tool included angle ϵ_r (figures 24, 26, 27 and 28) : The angle between the tool cutting edge plane P_s and the tool minor cutting edge plane $P_s{}'$ measured in the tool reference plane P_r.

Thus, $\kappa_r + \epsilon_r + \kappa_r{}' = 180°$

3.1.2 *Orientation of face*

3.1.2.1 tool normal rake γ_n (figures 24, 27 and 28) : The angle between the face A_γ and the tool reference plane P_r measured in the cutting edge normal plane P_n.

3.1.2.2 tool side rake γ_f (figures 24, 27 and 28) : The angle between the face A_γ and the tool reference plane P_r measured in the assumed working plane P_f.

3.1.2.3 tool back rake γ_p (figures 24, 27 and 28) : The angle between the face A_γ and the tool reference plane P_r measured in the tool back plane P_p.

3.1.2.4 tool orthogonal rake γ_o (figures 24, 27 and 28) : The angle between the face A_γ and the tool reference plane P_r measured in the tool orthogonal plane P_o.

3.1.2.5 tool geometrical rake γ_g (figure 25) : The angle between the face A_γ and the tool reference plane P_r measured in the tool face orthogonal plane P_g. It is the maximum angle between the face A_γ and the tool reference plane P_r.

3.1.2.6 tool face orthogonal plane orientation angle δ_r (figure 25) : The angle between the assumed working plane P_f and the tool face orthogonal plane P_g measured in the tool reference plane P_r.

3.1.3 *Wedge angles*

3.1.3.1 normal wedge angle β_n (figures 24, 27 and 28) : The included angle between the face A_γ and the flank A_α measured in the cutting edge normal plane P_n.

3.1.3.2 tool side wedge angle β_f (figures 24, 27 and 28) : The angle between the face A_γ and the flank A_α measured in the assumed working plane P_f.

3.1.3.3 tool back wedge angle β_p (figures 24, 27 and 28) : The angle between the face A_γ and the flank A_α measured in the tool back plane P_p.

3.1.3.4 tool orthogonal wedge angle β_o (figures 24, 27 and 28) : The angle between the face A_γ and the flank A_α measured in the tool orthogonal plane P_o.

3.1.4 *Orientation of flank*

3.1.4.1 tool normal clearance α_n (figures 24, 27 and 28) : The angle between the flank A_α and the tool cutting edge plane P_s measured in the cutting edge normal plane P_n.

3.1.4.2 tool side clearance α_f (figures 24, 27 and 28) : The angle between the flank A_α and the tool cutting edge plane P_s measured in the assumed working plane P_f.

3.1.4.3 tool back clearance α_p (figures 24, 27 and 28) : The angle between the flank A_α and the tool cutting edge plane P_s measured in the tool back plane P_p.

3.1.4.4 tool orthogonal clearance α_o (figures 24, 27 and 28) : The angle between the flank A_α and the tool cutting edge plane P_s measured in the tool orthogonal plane P_o.

3.1.4.5 tool base clearance α_b (figure 25) : The angle between the flank A_α and the tool cutting edge plane P_s measured in the tool flank orthogonal plane P_b.

3.1.4.6 tool flank orthogonal plane orientation angle θ_r (figure 25) : The angle between the assumed working plane P_f and the tool flank orthogonal plane P_b measured in the tool reference plane P_r.

3.1.5 *Relationship between the tool angles*

The sum of the tool clearance, tool wedge angle and the tool rake measured in any one of the following tool-in-hand planes —cutting edge normal plane, tool back plane, tool orthogonal plane or assumed working plane— is equal to 90°.

$$\alpha_n + \beta_n + \gamma_n = 90^\circ$$

$$\alpha_p + \beta_p + \gamma_p = 90^\circ$$

$$\alpha_o + \beta_o + \gamma_o = 90^\circ$$

$$\alpha_f + \beta_f + \gamma_f = 90^\circ$$

In practice, the tool rake, tool clearance and tool cutting edge inclination are usually acute angles.

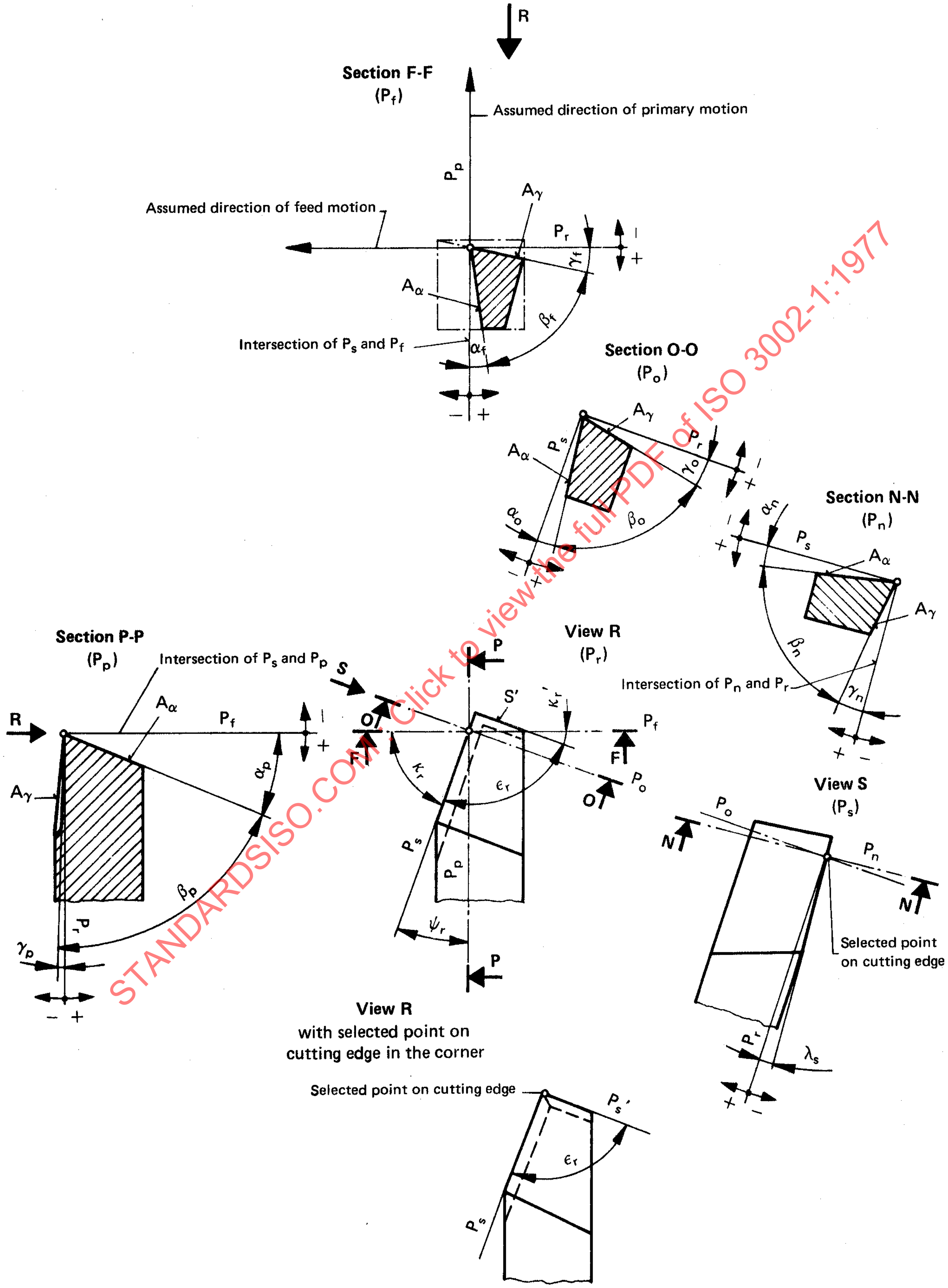


FIGURE 24 — **Tool angles — Turning tool**

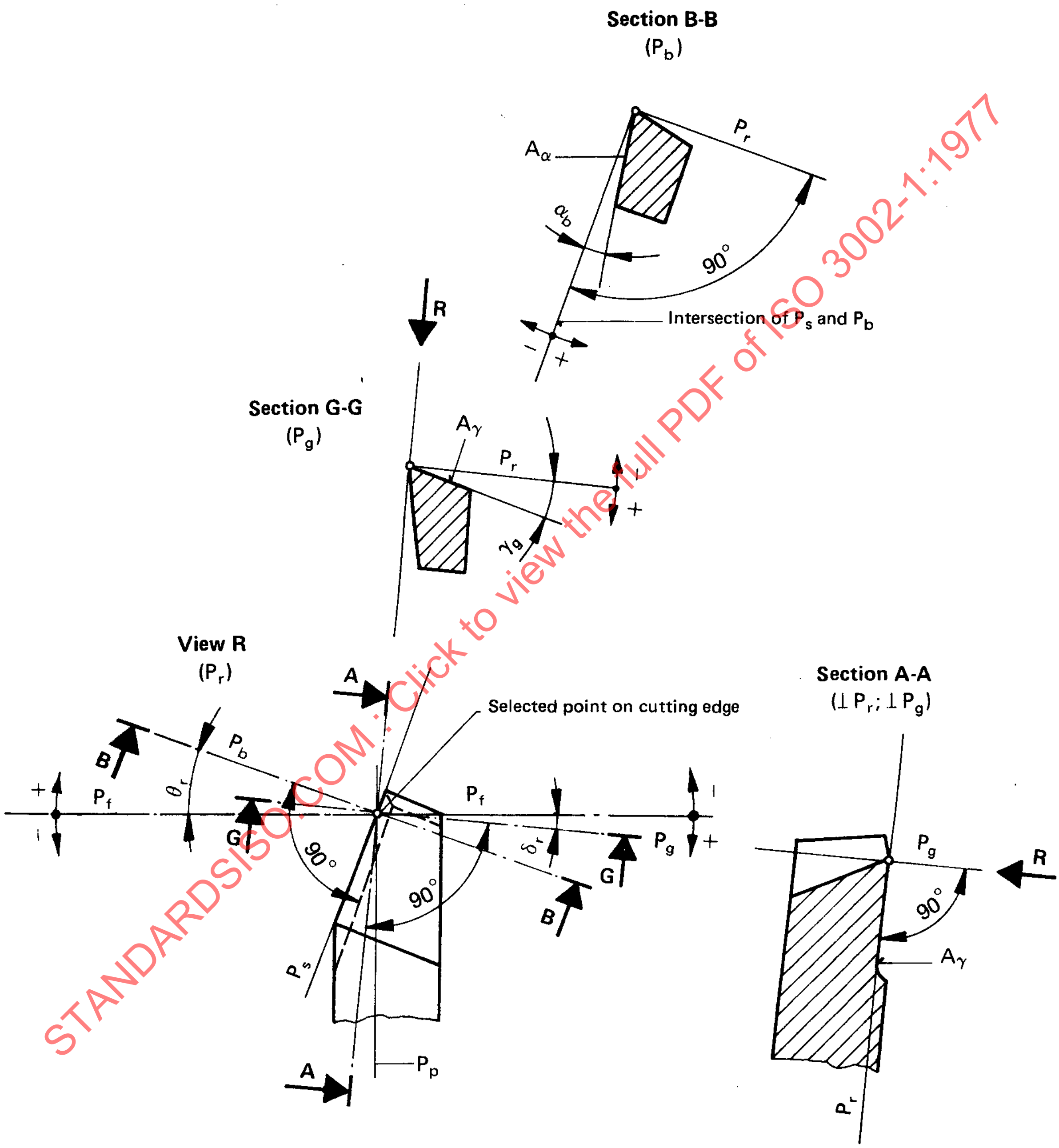
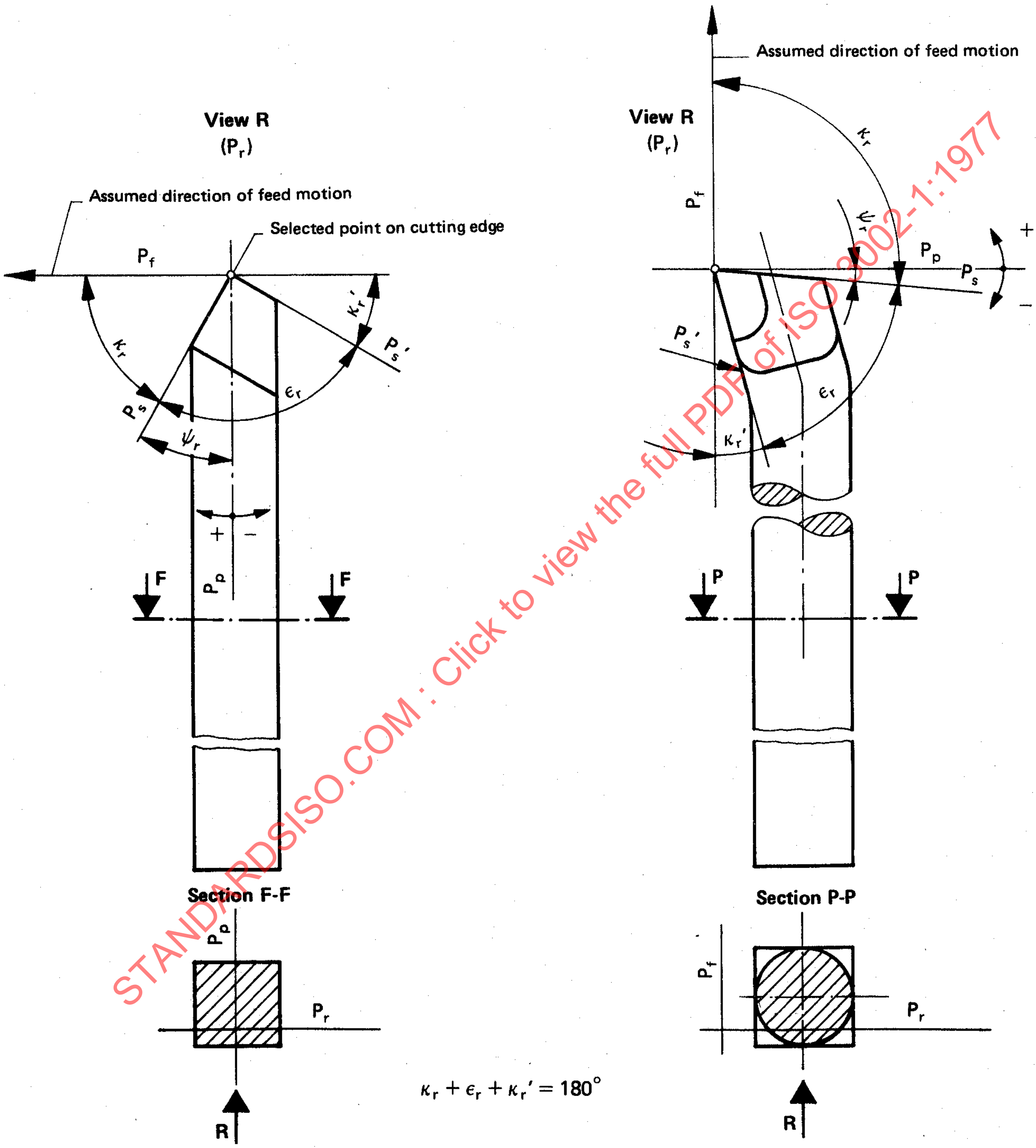


FIGURE 25 – **Tool geometrical rake γ_g and tool base clearance α_b – Turning tool**



$$\kappa_r + \epsilon_r + \kappa_r' = 180^\circ$$

FIGURE 26 – **Tool cutting edge angle κ_r and tool approach angle (tool lead angle) ψ_r**

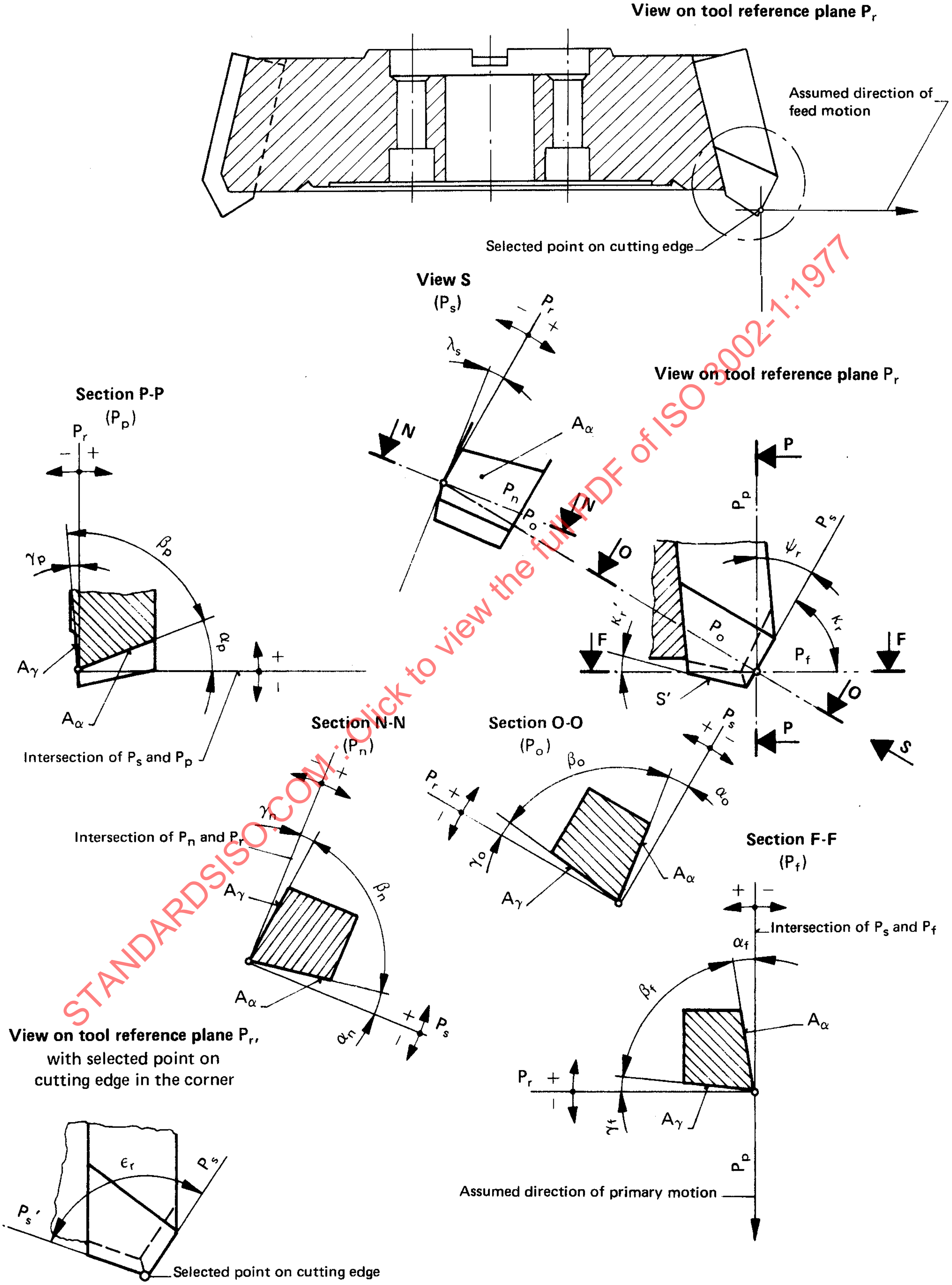


FIGURE 27 — **Tool angles — Milling cutter head**

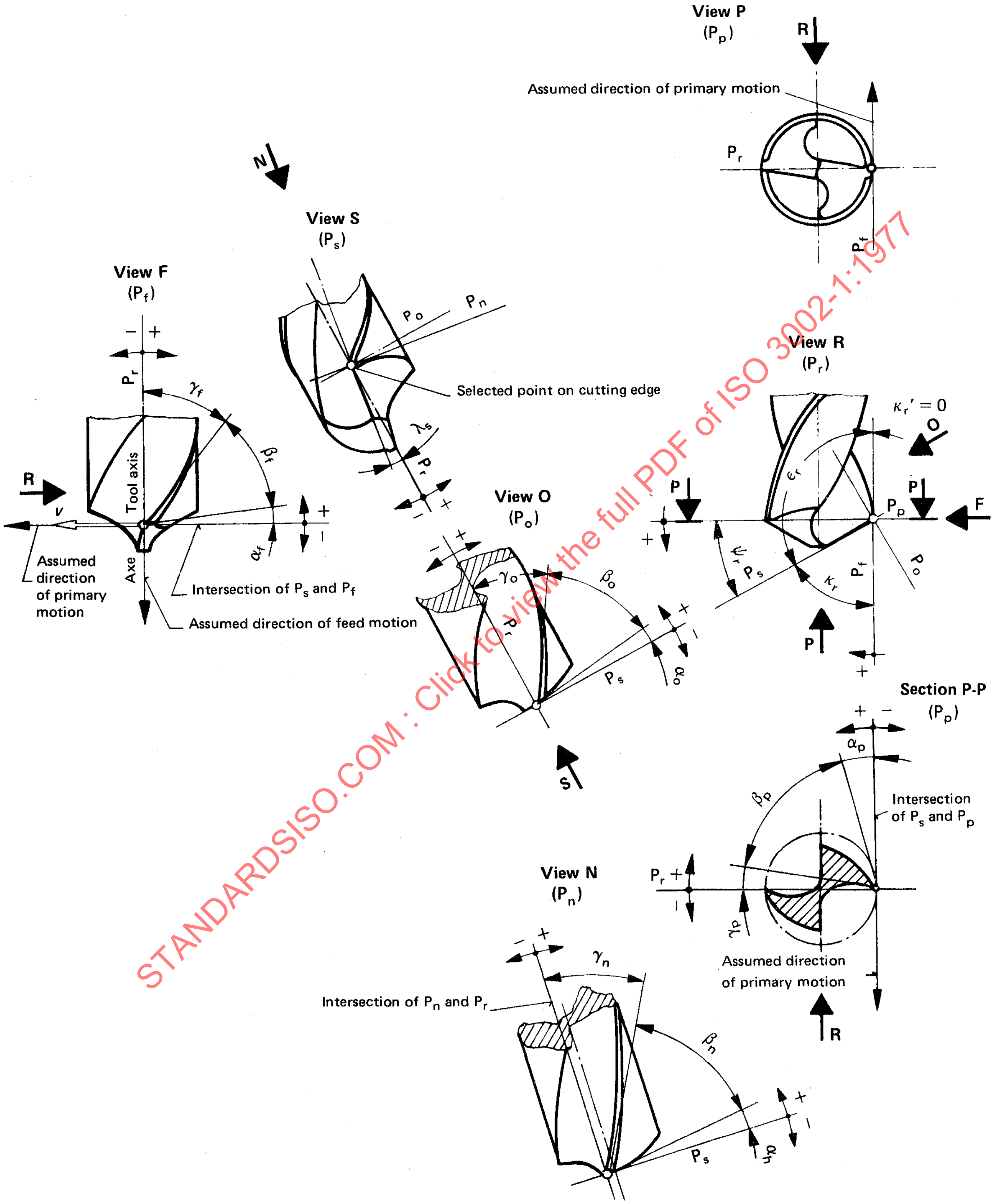


FIGURE 28 — **Tool angles — Twist drill**

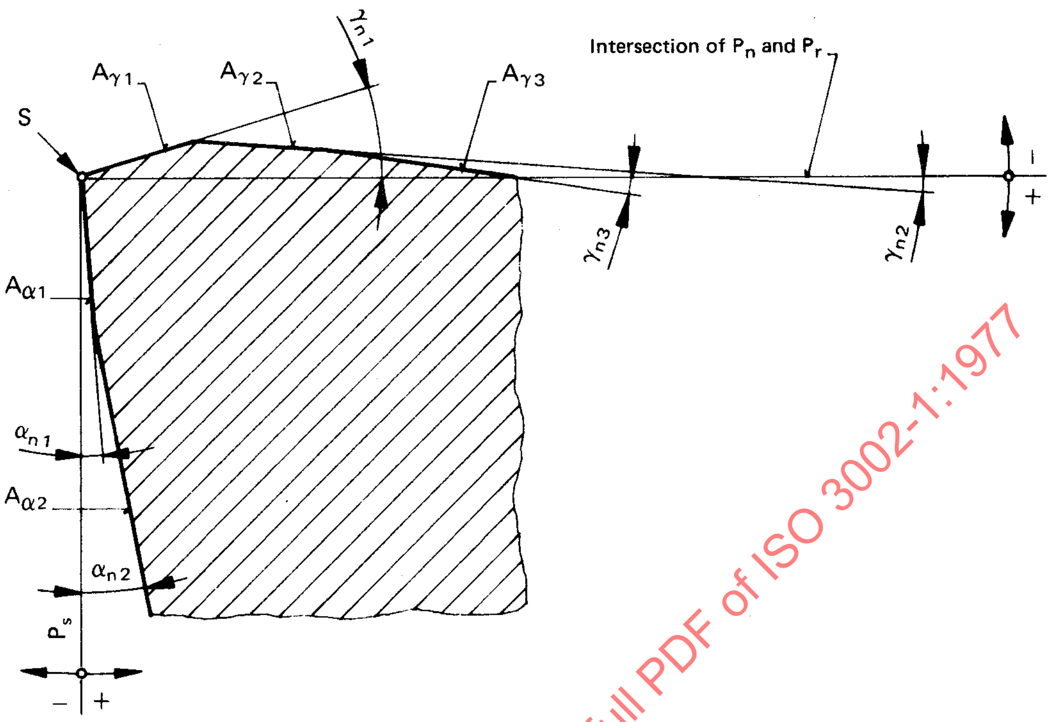


FIGURE 29 – **Tool normal rake and tool normal clearance angles on a wedge**

3.2 WORKING ANGLES

The working angles are defined with the aid of the tool-in-use reference system of planes (2.2).

3.2.1 *Orientation of cutting edge*

3.2.1.1 working cutting edge angle κ_{re} (figures 30, 31 and 32) : The angle between the working cutting edge plane P_{se} and the working plane P_{fe} measured in the working reference plane P_{re}.

3.2.1.2 working approach angle; working lead angle /USA/ ψ_{re} (figures 30, 31 and 32) : The angle between the working cutting edge plane P_{se} and the working back plane P_{pe} measured in the working reference plane P_{re}.

ψ_{re} is defined only for the major cutting edge. Thus at any selected point on the major cutting edge the sum of ψ_{re} and κ_{re} is always 90°.

3.2.1.3 working cutting edge inclination λ_{se} (figures 30, 31 and 32) : The angle between the working cutting edge and the working reference plane P_{re} measured in the working cutting edge plane P_{se}.

3.2.2 *Orientation of face*

3.2.2.1 working normal rake γ_{ne} (figures 30, 31 and 32) : The angle between the face A_γ and the working reference plane P_{re} measured in the cutting edge normal plane P_{ne}.

NOTE – $P_{ne} \equiv P_n$

3.2.2.2 working side rake γ_{fe} (figures 30, 31 and 32) : The angle between the face A_γ and the working reference plane P_{re} measured in the working plane P_{fe}.

3.2.2.3 working back rake γ_{pe} (figures 30, 31 and 32) : The angle between the face A_γ and the working reference plane P_{re} measured in the working back plane P_{pe}.

3.2.2.4 working orthogonal rake γ_{oe} (figures 30, 31 and 32) : The angle between the face A_γ and the working reference plane P_{re} measured in the working orthogonal plane P_{oe}.

NOTE – The geometrical rake is not defined in the tool-in-use system.

3.2.3 *Wedge angles*

3.2.3.1 normal wedge angle β_{ne} (figures 30, 31 and 32) : The normal wedge angle in the tool-in-use system is identical with the normal wedge angle defined in the tool-in-hand system.

$$\beta_{ne} \equiv \beta_n$$

3.2.3.2 working side wedge angle β_{fe} (figures 30, 31 and 32) : The angle between the face A_γ and the flank A_α measured in the working plane P_{fe}.

3.2.3.3 working back wedge angle β_{pe} (figures 30, 31 and 32) : The angle between the face A_γ and the flank A_α measured in the working back plane P_{pe}.

3.2.3.4 working orthogonal wedge angle β_{oe} (figures 30, 31 and 32) : The angle between the face A_γ and the flank A_α measured in the working orthogonal plane P_{oe}.

3.2.4 *Orientation of flank*

3.2.4.1 working normal clearance α_{ne} (figures 30, 31 and 32) : The angle between the flank A_α and the working cutting edge plane P_{se} measured in the cutting edge normal plane P_{ne}.

NOTE — $P_{ne} \equiv P_n$

3.2.4.2 working side clearance α_{fe} (figures 30, 31 and 32) : The angle between the flank A_α and the working cutting edge plane P_{se} measured in the working plane P_{fe}.

3.2.4.3 working back clearance α_{pe} (figures 30, 31 and 32) : The angle between the flank A_α and the working cutting edge plane P_{se} measured in the working back plane P_{pe}.

3.2.4.4 working orthogonal clearance α_{oe} (figures 30, 31 and 32) : The angle between the flank A_α and the working cutting edge plane P_{se} measured in the working orthogonal plane P_{oe}.

NOTE — The base clearance is not defined in the tool-in-use system.

3.2.5 *Relationship between the working angles*

The sum of the working clearance, working wedge angle and working rake measured in any one of the following tool-in-use planes — cutting edge normal plane, working back plane, working orthogonal plane or working plane — is equal to 90°.

$$\alpha_{ne} + \beta_{ne} + \gamma_{ne} = 90^\circ$$

$$\alpha_{pe} + \beta_{pe} + \gamma_{pe} = 90^\circ$$

$$\alpha_{oe} + \beta_{oe} + \gamma_{oe} = 90^\circ$$

$$\alpha_{fe} + \beta_{fe} + \gamma_{fe} = 90^\circ$$

In practice the working rake, working clearance and working cutting edge inclination are usually acute angles.

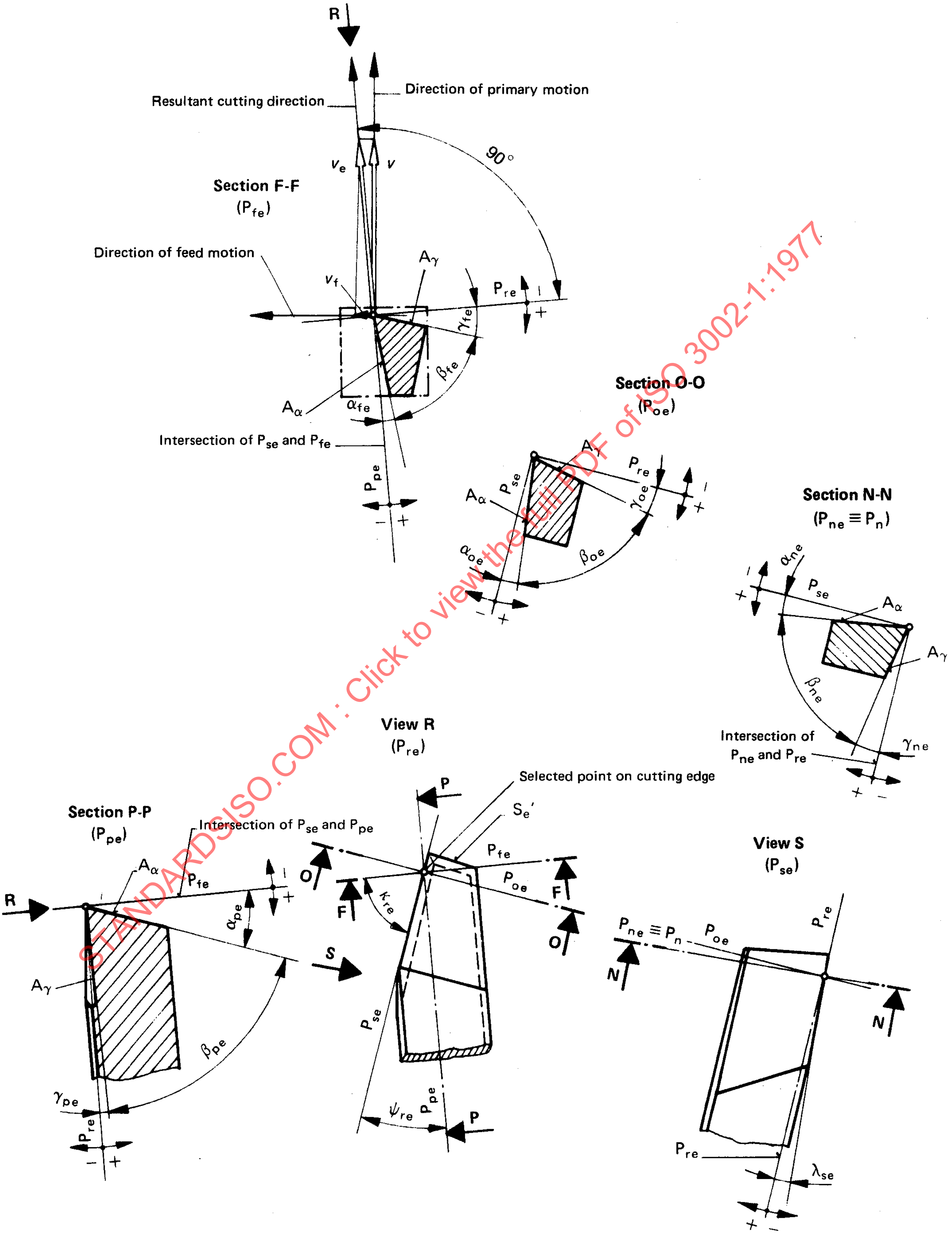


FIGURE 30 — **Working angles — Turning tool**

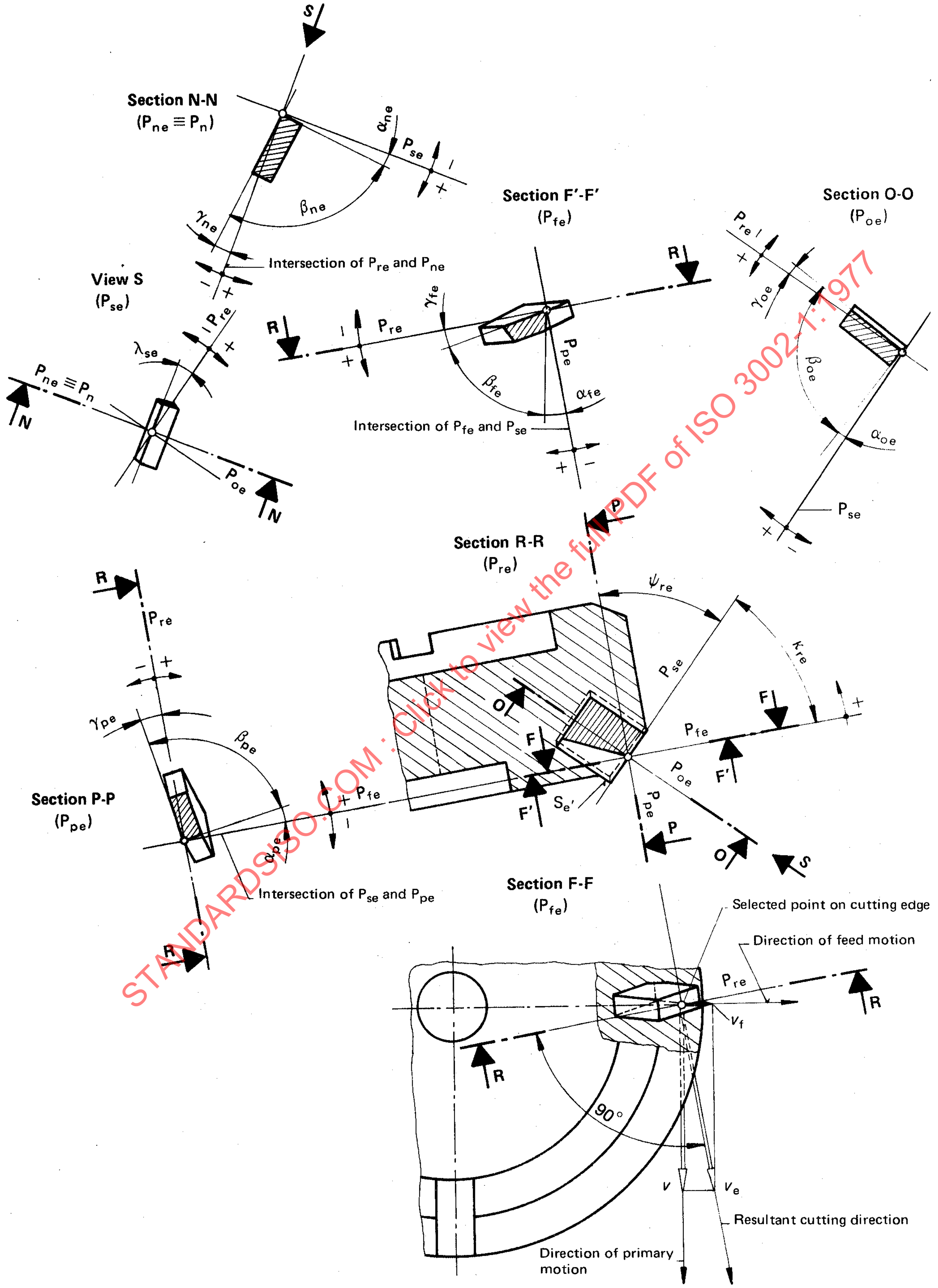


FIGURE 31 — **Working angles — Milling cutter head**

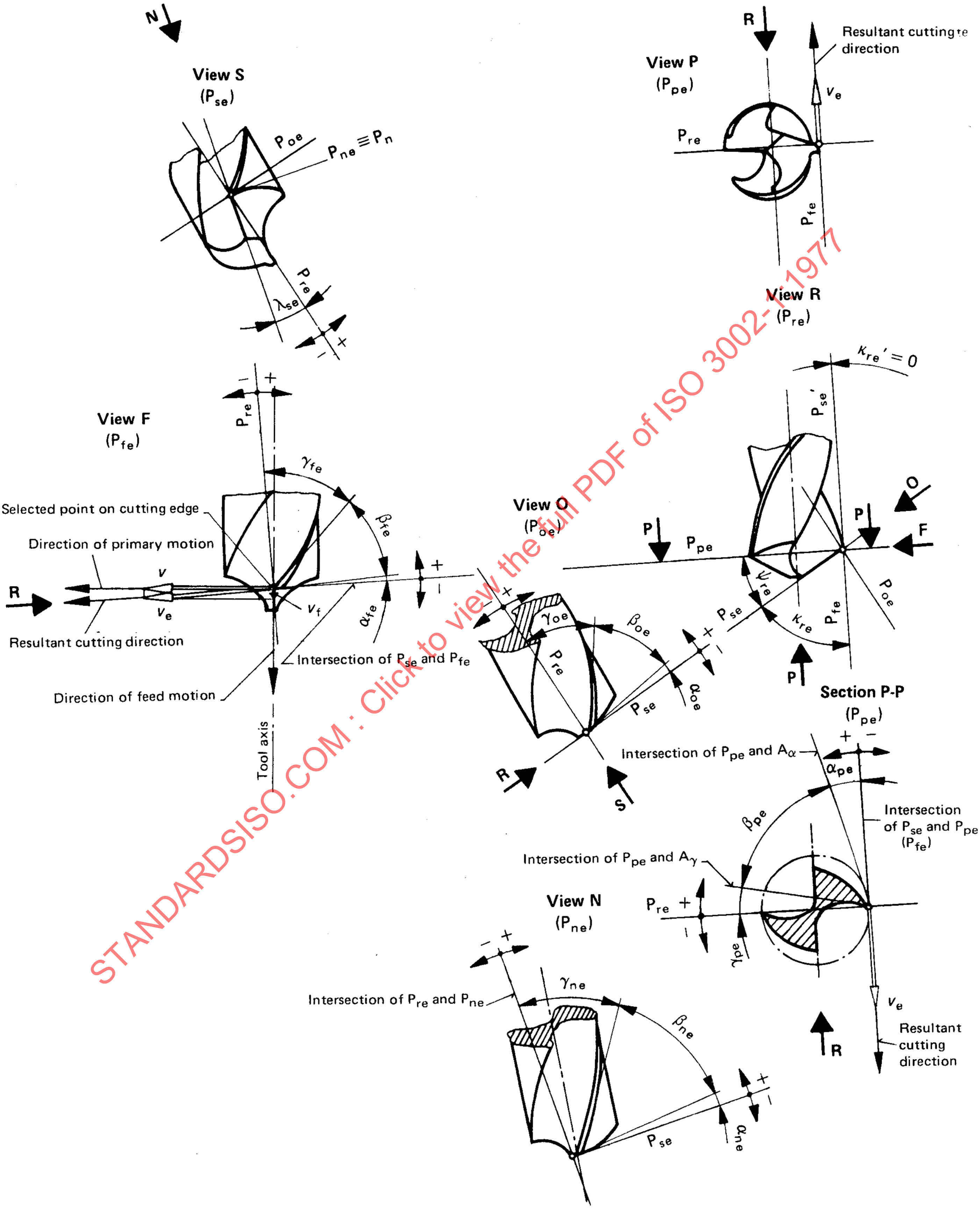


FIGURE 32 — **Working angles — Twist drill**

3.3 SIGN CONVENTIONS FOR ANGLES

The sign convention for tool cutting edge orientation angles is defined with respect to planes and directions of motion defined at a selected point on the cutting edge located at a corner which is assumed to be sharp.

When a tool has more than one corner (for example, a cutting off tool, certain broaches, slot milling cutters or slotting tools used in shaping or planing) the angles of the cutting edges and their sign must be defined in relation to the particular corner under consideration. At each corner there is a set of major and minor cutting edge angles and major and minor cutting edge inclinations. Each set of angles completely defines the cutting edge geometry at that particular corner.

When a cutting edge has no corner (for example, a slab milling cutter) then one end of the major cutting edge is taken as a reference. In such cases the reference end is that from which the rotation of the tool relative to the work-piece is seen to be clockwise.

In the case of a Vee-shaped threading tool, the point of intersection of the projection of the straight portions of the cutting edge can be regarded as the selected point at a sharp corner and the orientations of the straight portions of the cutting edge defined with respect to that point.

The sign convention for angles which define the orientation of the face and flanks is defined with respect to planes and directions of motion at a selected point on the cutting edge, located at any point where the face and flank orientation is required to be specified.

3.3.1 *Tool angle convention*

3.3.1.1 The **tool cutting edge angle** κ_r (see 3.1.1.1) is always positive. The appropriate angle of the two possible angles defined by the intersecting planes is the one which is measured from the portion of P_f containing the assumed direction of feed motion towards that part of the major cutting edge away from the tool corner being considered or away from the reference end of the major cutting edge in the case of a slab milling cutter (see 3.3).

The tool minor cutting edge angle κ_r' (see 3.1.1.1) is usually acute and its sign is determined from the relationship $\kappa_r + \epsilon_r + \kappa_r' = 180°$, where ϵ_r is always positive and measured within the boundaries of the cutting part.

3.3.1.2 The **tool approach angle** ψ_r (see 3.1.1.2) is always acute and its sign is determined from the relationship $\kappa_r + \psi_r = 90°$.

3.3.1.3 The **tool cutting edge inclination** λ_s (see 3.1.1.3) is always acute. The angle is positive if the cutting edge, when viewed in a direction away from the selected point at the tool corner being considered, lies on the opposite side of the tool reference plane P_r from the assumed direction of primary motion.

3.3.1.4 Tool rake angles γ_n, γ_f, γ_p, γ_o, γ_g (see 3.1.2.1 to 3.1.2.5) are always acute. The angle is positive if, when looking across the face from the selected point and along the line of intersection of the face and the plane of measurement, the viewed line of intersection lies on the opposite side of the tool reference plane P_r from the assumed direction of primary motion.

3.3.1.5 Tool clearance angles α_n, α_f, α_p, α_o, α_b (see 3.1.4.1 to 3.1.4.5) are always acute. The angle is positive if, when looking across the flank from the selected point and along the line of intersection of the flank and the plane of measurement, the viewed line of intersection lies on the opposite side of the tool cutting edge plane P_s from the assumed direction of feed motion.

Tool minor cutting edge clearance angles α_n', α_f', α_p', α_o', α_b' (see beginning of clause 3) are always acute. The angle is positive if, when looking across the minor flank from the selected point and along the line of intersection of the minor flank and the plane of measurement, the viewed line of intersection lies on the same side of the tool minor cutting edge plane P_s' as the line of intersection of the face and the plane of measurement.

3.3.2 *Working angle convention*

The same physical bases and directions of measurement which define the sign convention for tool angles must be maintained to define the convention for working angles, in conjunction with the tool-in-use reference system of planes and the directions of primary and feed motions.

4 SUMMARY OF ANGLES

4.1 Tool and workpiece motions

Angle	Definition			
	Angle between		Measured in plane	No.
Feed motion angle φ	direction of feed motion	direction of primary motion	P_{fe}	1.6.4
Resultant cutting speed angle η	direction of primary motion	resultant cutting direction	P_{fe}	1.6.5

4.2 Orientation of cutting edge

Angle		Definition			
Tool angle	Working angle	Angle between		Measured in plane	No.
Tool cutting edge angle κ_r		P_s	P_f	P_r	3.1.1.1
	Working cutting edge angle κ_{re}	P_{se}	P_{fe}	P_{re}	3.2.1.1
Tool approach angle (tool lead angle) ψ_r		P_s	P_p	P_r	3.1.1.2
	Working approach angle ψ_{re} (working lead angle)	P_{se}	P_{pe}	P_{re}	3.2.1.2
Tool cutting edge inclination λ_s		S	P_r	P_s	3.1.1.3
	Working cutting edge inclination λ_{se}	S_e	P_{re}	P_{se}	3.2.1.3
Tool included angle ϵ_r		P_s	P_s'	P_r	3.1.1.4

4.3 Orientation of face

Angle		Definition			
Tool angle	Working angle	Angle between		Measured in plane	No.
Tool normal rake γ_n		A_γ	P_r	P_n	3.1.2.1
	Working normal rake γ_{ne}	A_γ	P_{re}	$P_{ne} \equiv P_n$	3.2.2.1
Tool side rake γ_f		A_γ	P_r	P_f	3.1.2.2
	Working side rake γ_{fe}	A_γ	P_{re}	P_{fe}	3.2.2.2
Tool back rake γ_p		A_γ	P_r	P_p	3.1.2.3
	Working back rake γ_{pe}	A_γ	P_{re}	P_{pe}	3.2.2.3
Tool orthogonal rake γ_o		A_γ	P_r	P_o	3.1.2.4
	Working orthogonal rake γ_{oe}	A_γ	P_{re}	P_{oe}	3.2.2.4
Tool geometrical rake γ_g		A_γ	P_r	P_g	3.1.2.5
Tool face orthogonal plane orientation angle δ_r		P_f	P_g	P_r	3.1.2.6