# THE PESTICIDE MANUAL

## A World Compendium

SEVENTH EDITION

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## PREFACE

The continuing introduction of pesticidal chemicals and microbial agents, withdrawal of some earlier compounds, the adoption of many additional official common names and of some changes in the rules of chemical nomenclature recommended by the International Union of Pure and Applied Chemistry make this a suitable time to revise the *Pesticide Manual.*

The 6th edition published in 1979 and its reprint in 1980 have sold exceptionally well. Since then the Advisory Editorial Board has given considerable attention both to improving the information given in the text and to its presentation. Some of the changes made are obvious, others are less conspicuous.

The most significant change does not immediately affect the reader. The entire contents of the *Pesticide Manual* have been entered on a computer at the Commonwealth Agricultural Bureaux, Farnham Royal. The printed text and indexes have then been generated from the computer records. When necessary, individual entries can easily be retrieved and revised so that the preparation of future editions will be a much simpler process.

The intention has been to include all chemical and microbial agents used as active components of products to control crop pests and diseases, animal ectoparasites, and pests in public health. Details of herbicides and substances making them better able to be tolerated by crop plants are also included, together with plant growth regulators, pest repellents and synergists. Manufacturers were asked to update entries from previous editions, to add new compounds and to provide more precise values for physical properties and toxicological data. Thus phrases such as 'sparingly soluble in water' have often been replaced by expressions of the type 'solubility 1 mg/l water' or 'solubility $<1$ mg/l water'. Further progress can still be made, but in this regard this edition is a marked improvement over previous ones. Compounds of historic interest only, or those superseded by others of greater potential have been placed in a separate section but with fewer details.

Common names approved by the British Standards Insitution are correct up to May 1983; the French in addition to the English spellings of the common names approved by the International Organization for Standardization are included, as are modifications in the definition of some common names. Interpretations of the latest rules of chemical nomenclature have been incorporated. In general, methods of manufacture have been omitted. Methods are given in some patents and in *Pesticide Manufacturing and Toxic Materials Control Encyclopaedia.* The Advisory Editorial Board has evidence that, in some cases, methods other than those stated in previous editions are being used; the subject is also a sensitive one commercially. Fewer details of analytical methods are included than in previous editions, instead emphasis has been given to references on collaborative or other well-tried methods—for instance those recommended by the Collaborative International Pesticides Council Ltd or those listed in *Recommendations for Methods of Analysis for Pesticide Residues.* Chemical structures have been redrawn and presented more uniformly. No attempt has been made to include specific details, residue tolerances for individual crops, minimum intervals between treatment and harvest, or allowed uses. These details vary from country to country.

The collection of basic technical information on the chemicals included here is a task requiring the collaboration of the industrial laboratories in which they were developed or are being manufactured. In general, the response from manufacturers for the required information has been excellent though a prompter reply would have been appreciated in some cases. It is gratifying to add entries from additional manufacturers and we hope this trend will continue.

It is impossible to list here the many friends, spread over several continents, who have helped in supplying details or in placing us in contact with firms that have changed their address or ownership. To them and to the readers who notified us of errors in previous editions, we say a very sincere 'Thank you'.

In particular we wish to thank The Advisory Editorial Board for guidance and help, Dr E. K. Woodford, Managing Editor of The British Crop Protection Council (BCPC), for his patience and understanding, and Dr D. Rudd-Jones, Chairman of the Publications Committee of the BCPC, for his sympathetic help and support. We greatly appreciate the collaboration of the Systems Group of the Commonwealth Agricultural Bureaux, especially that of P. G. Beckingsale for his invaluable advice on entering data on the computer. We also thank M. J. Bone for expert presentation of chemical structures, Dr J. N. Davies for checking the original computer printouts of the entries, D. G. Sweeney for advice on the preparation of a computerised list of actual and potential entries and C. Waterhouse, of the Laboratory of the Government Chemist, for expert interpretation of the complicated rules of chemical nomenclature; and last, but far from least, the skill of Mrs W. E. Cossins, Mrs D. J. Crane, Mrs J. van de Poll and Mrs P. Uprichard for typing the entries and entering the records on the computer.

As in the 6th edition, four indexes are included (a) for the Wiswesser Line-Formulae, (b) for Molecular Formulae, (c) for code numbers given to the compounds by the manufacturers, licensees or official bodies such as WHO or USDA and (d) a name index covering chemical names, recognised common names, trade marks, and trivial names. Note that all these indexes refer to the entry numbers, *not* to the page on which the entry is sited.

We must stress that any factual errors, arising during transcription of the information supplied by the manufacturers are our responsibility. We should be grateful if readers would draw our attention to any errors or omissions so they can be corrected in the next edition.

Charles R. Worthing *Editor*
S. Barrie Walker *Assistant Editor*

Every effort has been made to ensure that the statements made in this Manual are correct but neither The British Crop Protection Council nor the Editors accept responsibility for any loss, damage or other accident arising from any error in the Manual.

## ABBREVIATIONS

The following abbreviations have been used, some being SI units.

ACS ..... American Chemical Society

ADI ..... acceptable daily intake

a.e. ..... acid equivalent — active ingredient expressed in terms of parent acid

AG ..... Aktiengesellschaft (Company)

a.i. ..... active ingredient

ANSI .... American National Standards Institute

AOAC ... Association of Official Analytical Chemists or, before 1966, Association of Official Agricultural Chemists

*AOAC Methods*.. Official Methods of Analysis of The Association of Official Analytical Chemists

ATP ..... Austrian Patent

AUP .... Australian Patent

BCPC ... British Crop Protection Council

BEP ..... Belgian Patent

BIOS .... British Intelligence Objective Sub-Committee

b.p. ..... boiling point at stated pressure

BPC ..... British Pharmocopoeia Commission

BSI ..... British Standards Institution

B.V. ..... Beperkt Vennootschap (Limited)

*c.* ..... *circa* (about)

*C.A.* ..... *Chemical Abstracts*

CAP ..... Canadian Patent

*cf* ..... compare

CHP ..... Swiss Patent

CIPAC .. Collaborative International Pesticides Analytical Committee Limited

Co. ..... Company

COLUMA . Comité de Lutte Contre les Mauvaises Herbes

Corp. .... Corporation

d ..... day(s)

$d_x^t$ ..... specific gravity (density of compound at t °C compared to that of water at x °C)

DDRP ... Democratic Republic of Germany Patent

DEAS ... Deutsche Auslegeschrift (an intermediate stage towards DEP which retains the same number)

decomp. .. with decomposition

DEOS ... Deutsche Offenlegungsschrift (the first stage towards DEP which retains the same number)

DEP ..... Federal Republic of Germany Patent

d.p. ..... dispersible powder

DRP ..... German Patent (before 1945)

e.c. ..... emulsifiable concentrate

| | |
|---|---|
| ECD ..... | electron-capture detection |
| ed. ..... | editor |
| Ed. ..... | Edition |
| *e.g.* ..... | for example |
| E-ISO .... | ISO name (English spelling) |
| EPA ..... | Environmental Protection Agency (of USA) |
| EPPO .... | European and Mediterranean Plant Protection Organisation |
| ESA ..... | Entomological Society of America |
| *et al.* ..... | and others (authors) |
| EUP ..... | European Patent (retains same number) |
| EUPA .... | European Patent Application |
| EWRC ... | European Weed Research Council |
| FAO ..... | Food and Agriculture Organization (of the United Nations) |
| FID ..... | flame-ionisation detection |
| F-ISO .... | ISO name (French spelling) |
| FP ..... | French patent |
| f.p. ..... | freezing point |
| FPD ..... | flame-photometric detection |
| FTP ..... | flame thermionic detection |
| g ..... | gram(s) |
| GBP ..... | British patent |
| gc-ms .... | combined gas chromatography-mass spectrometry |
| GIFAP .... | Groupement International des Associations Nationales de Fabricants de Produits Agrochimiques |
| glc ..... | gas-liquid chromatography |
| h ..... | hour(s) |
| ha ..... | hectare(s) ($10^4 m^2$) |
| HMSO ... | Her Majesty's Stationery Office |
| hplc ..... | high performance liquid chromatography (also known as high pressure liquid chromatography) |
| *ibid.* ..... | in the journal last mentioned |
| *idem* ..... | by the author(s) last mentioned |
| *i.e.* ..... | that is |
| Inc. ..... | Incorporated |
| i.r. ..... | infrared |
| ISO ..... | International Standardization Organization |
| ITP ..... | Italian Patent |
| ITPA .... | Italian Patent Application |
| i.u. ..... | international unit (measure of activity of micro-organisms) |
| IUPAC ... | International Union of Pure and Applied Chemistry |
| JMAF ... | Japanese Ministry for Agriculture, Forestry and Fisheries |
| JMPR ... | Joint meeting of the FAO Panel of Experts on Pesticide Residues and the Environment and the WHO Expert Group on Pesticide Residues |

| | |
|---|---|
| JPP ..... | Japanese Patent |
| JPPA .... | Japanese Patent Application (Kokai) |
| k ..... | kilo, multiplier $10^3$ (1000) for SI units |
| kg ..... | kilogram(s) |
| kPa ..... | 1000 Pa |
| l ..... | litre(s) |
| $LC_{50}$ ..... | concentration required to kill 50% of the test organism |
| $LD_{50}$ ..... | dose required to kill 50% of test organism |
| Ltd ..... | Limited |
| m ..... | metre; milli, multiplier $10^{-3}$ (0.001) for SI units |
| M ..... | mega, multiplier $10^6$ (1000000) for SI units |
| M ..... | molar |
| MAFF ... | Ministry of Agriculture Fisheries and Food (England and Wales) |
| MCD .... | microcoulometric detection |
| mg ..... | milligram(s), $10^{-3}$ g, 0.001g |
| mm ..... | millimetre(s), $10^{-3}$m, 0.001m |
| *m/m* .... | proportion by mass |
| mmHg ... | pressure equivalent to 1 mm of mercury (133.3 Pa) |
| m.p. ..... | melting point |
| mPa ..... | millipascal, $10^{-3}$ Pa (0.001 Pa) |
| MPa ..... | megapascal, $10^6$ Pa (1000000 Pa) |
| n ..... | nano, multiplier $10^{-9}$ for SI units |
| $n_D^t$ ..... | refractive index for the sodium D lines at a temperature of t °C |
| NEL ..... | no-effect level |
| NLP ..... | Netherlands Patent |
| nm ..... | nanometre(s), $10^{-9}$ m |
| NMR .... | nuclear magnetic resonance |
| nPa ..... | nanopascal, $10^{-9}$ Pa |
| NRDC ... | National Research and Development Corporation |
| N.V. ..... | Naamloze Vennotschap (Limited) |
| OCLALAV | Organisation Commune de Lutte Antiacridienne et de Lutte Antiaviaire |
| o.m. ..... | organic matter |
| OMS ..... | Organisation Mondiale de la Santé = WHO |
| *op. cit.* ... | in the book cited previously |
| p ..... | pico, multiplier $10^{-12}$ for SI units |
| Pa ..... | pascal |
| pH ..... | $-\log_{10}$ hydrogen ion concentration |
| $pK_a$ ..... | $-\log_{10}$ acid dissociation constant |
| *PMn* .... | *Pesticide Manual* nth edition |
| post-em ... | after emergence |
| pPa ..... | picopascal, $10^{-12}$ Pa |
| pre-em .... | before emergence |
| Reg. No. | *Chemical Abstracts* Registry Number |

r.h. ..... relative humidity

s ..... second(s)

S.A. ..... Société Anonyme (Company)

s.c. ..... suspension concentrate ('flowable')

s.p. ..... soluble powder

sp. ..... species (singular)

S.p.A. .... Société par Actions (Company)

spp. ..... species (plural)

t ..... tonne, 1000 kg

TD ..... toxic dose (lowest observed dose producing toxicity in stated species)

tech. ..... technical grade

TID ..... thermionic detection

tlc ..... thin-layer chromatography

UK ..... United Kingdom

ULV ..... ultra-low volume

USA ..... United States of America

USAID .. United States Agency for International Development

USDA ... United States Department of Agriculture

USP ..... United States of America Patent

u.v. ..... ultraviolet

v.p. ..... vapour pressure

WHO .... World Health Organisation (of the United Nations) = OMS

w.p. ..... wettable powder

w.s.c. .... water-soluble concentrate

WSSA ... Weed Science Society of America

y ..... year(s)

$[\alpha]_D^t$ ..... specification rotation (degrees) for sodium D lines at temperature t °C

$\mu$ ..... micro, multiplier ($10^{-6}$) for SI units

$\mu$g ..... microgram ($10^{-6}$ gram)

$\mu$l ..... microlitre ($10^{-6}$ litre)

$\mu$Pa ..... micropascal ($10^{-6}$ pascal)

$\varrho$ ..... density

t °C ..... temperature of t degrees Celsius (formerly Centigrade)

$>$ ..... greater than

$\geqslant$ ..... greater than or equal to

$<$ ..... less than

$\leqslant$ ..... less than or equal to

## THE WISWESSER LINE-FORMULA NOTATION SYMBOLS

All the international atomic symbols are used except K, U, V, W, Y, Cl and Br. Two-letter atomic symbols in organic notations are enclosed between hyphens. Single letters preceded by a blank space indicate ring positions.

Numerals preceded by a space are multipliers of preceding notation suffixes or within ring signs L...J and T...J show the number of multicyclic points in the ring structure.

Numerals not preceded by a space show ring sizes if within the ring signs—elsewhere numerals show the length of internally saturated, unbranched alkyl chains and segments.

Single letters not preceded by a blank space have the following meanings:

A Generic alkyl.
B Boron atom.
C Unbranched carbon atom multiply bonded to an atom other than carbon, or doubly bonded to two other carbon atoms.
D Proposed symbol for a chelate bond and initial symbol of a chelate notation.
E Bromine atom.
F Fluorine atom.
G Chlorine atom.
H When preceded by a locant within ring signs, shows the position of a carbon atom bonded to four other atoms—elsewhere H means hydrogen atom.
I Iodine atom.
J Sign for the end of a ring description.
K Nitrogen atom bonded to more than three other atoms.
L First symbol of a carbocyclin ring notation.
M Imino or imido -NH- group.
N Nitrogen atom, hydrogen free, attached to no more than three other atoms.
O Oxygen atom, hydrogen free; note that Ø represents the numeral zero.
P Phosphorus atom.
Q Hydroxyl group, -OH.
R Benzene ring.
S Sulphur atom.
T First symbol of a heterocyclic ring notation—or within ring signs indicates a ring containing two or more carbon atoms each bonded to four other atoms.
U Double bond; UU shows an acetylenic triple bond.
V Carbonyl connective, -CO- (carbon attached to three other atoms).
W Nonlinear (branching) dioxo group (as in $-NO_2$ or $-SO_2-$).
X Carbon atom attached to four atoms other than hydrogen.
Y Carbon atom attached to three atoms other than hydrogen or doubly bonded oxygen.
Z Amino or amido $-NH_2$ group.
& Punctuation mark showing the end of a side chain—or preceded by a space, sign of ionic salt, addition compound or suffixed information—or within ring signs indicates a ring not containing two or more carbon atoms that are bonded to four other atoms —or following a hyphen, shows certain spiro ring connections.
- Separator or connective or other special uses.
/ Encloses polymer notations; precedes each non-consecutive locant pair.
* (1) Points of attachment in polymer repeat units; (2) coincident atoms in polymer notations; (3) a multiplier symbol in inorganic notations.
. Space-filling symbol for inorganic notations.
Ø Zero.

## NOTES ON THE WISWESSER LINE-FORMULA NOTATION (WLN)

For most of the chemical compounds in this manual, the structures and molecular formulae are shown, together with the Wiswesser Line-Formula Notations. These Notations are strings of symbols constructed by strict rules to provide a compact, unique and unambiguous description of the molecular structure in linear form. The notations can be used in manual and computer-based indexing and retrieval systems.

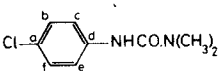
Although the principles of encoding structures into WLNs require some weeks of training, any chemist can quickly learn to decode most notations. The list of notation symbols opposite will aide this process and the reader may like to practise on the notations in this manual. Salts have been coded using space && after the main structure notation. Thus the sodium salt of an organic acid is coded with the **-Na** atom replaced by **-H**.

For example sodium trifluoroacetate has been coded as QVXFFF &&Na SALT.

This technique helps to bring similar molecules closer together in Index I.

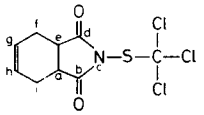
As a first example of a WLN code, consider monuron whose WLN is GR DMVN1&1. From the list opposite, it is seen that **G** is chlorine, **R** a benzene ring, **M** an NH group, **V** a carbonyl, **N** a branched nitrogen, 1 and **1** carbon alkyl chain. The **D** with a space in front indicates a ring position, and the **&** shows the end of the first alkyl chain. When these fragments are put together in the order shown by the notation, the structure is shown to be:

WLN characters




G R MVN:

The notations for more complex cyclic compounds begin with a description of the ring system. As a second example take captan, T56 BVNV GUTJ CSXGGG




T56 BVNV GUT J CSXGGG

The opening **T** indicates a heterocyclic ring system. The two numerals following show a 5-membered and 6-membered ring fused together. In such bicyclic systems, the ring positions are lettered in order from the fusion point round the smaller and then the larger ring. The letter **B** with a space in front indicates the ring position of the following **V** or carbonyl group; immediately adjacent in the ring is a nitrogen **N** and then another carbonyl **V**. The position of the unsaturation **U** is shown preceded by its locant **(g)** and the second **T** means that the rings are otherwise saturated. The **J** closes the ring description. Finally the position and nature of the substituent group is shown: **S** stands for sulphur, **X** for a four-branched carbon, and the three **G** symbols for the three chlorines attached to it.

As a further example take the compound fluazifop-butyl.

The notation starts by describing the heterocyclic ring (T...J). In this case a pyridine ring **(T6NJ)**. Locants are given to the substituents a **(b)** locant to the phenoxy group and an **(e)** locant to the trifluoromethyl group.

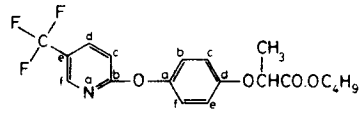
As the notation first proceeds into the phenoxy group, a new set of locants are ascribed to the atoms of the benzene ring, starting with an implied **a** locant where the ring is entered and leaving with a (**d**) locant into the **O** atom of the oxypropionate group.

Thus T6NJ BOR DOY1&VO4

The **Y** atom shows a branching aliphatic chain and the **1&** a terminal methyl, the **&** returning the path to the **Y** atom and proceeding into the carboxylic ester group **VO4.** A further **&** is needed to return the locant path to the original pyridine ring, then completing the notation with the trifluoromethyl group at the (**e**) locant (**EXFFF**).

Thus the full notation T6NJ BOR DOY1&VO4& EXFFF.

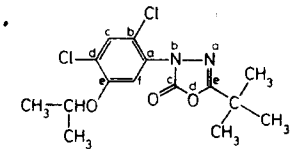
In notations where salts or stereochemistry is involved a suffix can be added after a breaking sequence to show extra, non-WLN characteristics of the molecule. Thus in this case &&(RS) FORM



giving a final notation of

T6NJ BOR DOY1&VO4& EXFFF &&(RS) FORM

As a final example consider the compound oxadiazon.



Again the notation starts by describing the ring system. In this example the hetero atoms (including the carbonyl) are adjacent in the ring and are thus strung together (**T5NNVOJ**). Note that bonding cannot be completed until the substituents are shown. Substituents are shown with the appropriate locants, the benzene ring being cited first. The simpler substituents, the chlorines are cited first along with their appropriate locants (**b** and **d**) in the benzene ring. The more complex isopropoxy group is cited last followed by an **&** to return the locant path to the original heteterocyclic ring. The notation is completed by citing the notation characters that form the *tert*-butyl group at the (**e**) locant **(EX1&1&1)**.

Thus the final notation is

T5NNVOJ BR BG DG EOY1&1& EX18181

## GUIDE TO THE USE OF PART I OF THE MANUAL

**Entries**
Each compound or biological agent is described on a separate page or pages. Entries are arranged alphabetically in both the Main and Superseded Compounds Sections. The required compound is best located from the entry numbers which are in non-consecutive numerical order in both sections. These numbers are easily obtained from the following indexes:- **Index 1** Wiswesser Line-Formula Notation (explained on pp. xiii-xv), **Index 2** molecular formulae, **Index 3** official or manufacturers' code numbers, **Index 4** common names, trade marks or chemical names.

For ease of reference the information about each entry is grouped under the following sub-heads (see example on the facing page, in which the numbers refer to the paragraph numbers below).

**Heading**

**1** Entry number.

**2** Entry name, preferably the BSI common name. If the compound has no BSI common name then the names given by ISO (English spelling), ANSI, WSSA, BPC or ESA are used in that order of priority. Otherwise a well-known trival name (*e.g.* tar oils), chemical name (*e.g.* copper oxychloride) or IUPAC name (*e.g.* 1,3-dichloropropene) is used.

**3** Chemical structure.

**4** Molecular formula and relative molecular mass.

**5** Wiswesser Line-Formula Notation. A hyphen (-) is part of the notation and must be included but an equals sign ( = ) means run on to the next line *without* a space but omit the sign.

**6** Important derivatives of the title compound.

**Nomenclature and development**

**7** Common names recommended by BSI, E-ISO, F-ISO, ANSI, WSSA, BPC, ESA and JMAF are stated; national name or major spelling variations (excluding the addition or omission of a terminal 'e', accents or the use of 't' for 'th) are listed. The phrases 'draft E-ISO' and 'draft F-ISO' refer to names that, having passed the preliminary enquiry stage, are likely to be adopted but have not been ballotted by member bodies of ISO/TC 81. BSI and ISO names are correct up to at least May 1983.

**8** Preferred and alternative IUPAC names. A hyphen (-) at the end of a line is an essential part of the name and must be included; it, an opening parenthesis ( or bracket [ mean run straight on to the next line *without* a space. An equals sign ( = ) also means run on to the next line *without* a space but omit the = sign. In other cases a word ends on a line.

**9** **Chemical Abstracts** names under rules used for the 9th and 10th Collective Index periods, using the same conventions about continuation at the end of lines as in paragraph 8. *C.A.* Registry Number(s).

**10** Trivial names. Code numbers used by WHO (prefix OMS) and by USDA (prefix ENT, A13 or AN4).

**11** Type of biological activity with first scientific reference using *Chemical Abstracts* style for journal abbreviations—see *Chemical Abstracts Service Source Index.*

**12** Discovering organisation or person (with protecting patents—which may have expired); code number(s) and principal trade mark(s) of manufacturing and marketing companies. Well-known trade marks of withdrawn formulations are shown in *italics.*

**Properties**

**13** Physical and chemical properties of the active ingredients and/or the technical product; also those of derivatives (salts and esters) used commercially.

**Uses**

**14** Principal uses.

**Toxicology**

**15** Oral and dermal $LD_{50}$ values. Chronic toxicity. Toxicity to wildlife.

**Formulations**

**16** Principal formulations, including mixtures with other active ingredients.

**Analysis**

**17** Methods, generally with relevant references, for product and residue analysis.

**18** Addresses of the leading chemical manufacturers or suppliers are given on pp.

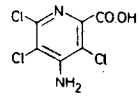
**19** Page number.

**Note.** This specimen entry has been deliberately shortened and modified so that it illustrates the principles without unnecessary duplication. It is *not* the complete entry on picloram.

① → 9750 — Picloram ← ②

$C_6H_3Cl_3N_2O_2$ (241.5) ← ④
T6NJ BVQ CG DZ EG FG ← ⑤

③ →




*picloram-potassium* ← ⑥
$C_6H_2Cl_3KN_2O_2$ (280.6) ← ④
T6NJ BVQ CG DZ EG FG ← ⑤
&&K SALT

## Nomenclature and development

⑦ → Common name picloram (BSI, E-ISO, ANSI); piclorame (F-ISO).
⑧ → Chemical name (IUPAC) 4-amino-3,5,6-trichloropyridine-2-carboxylic acid; 4-amino-3,5,6-trichloropicolinic acid (I). (*C.A.*) 4-amino-3,5,6-tri = chloro-2-pyridinecarboxylic acid (9CI); (I) (8CI); Reg. No. ← ⑨
⑩ → *[1918-02-1]*. ENT 12 345. Its herbicidal properties were described
⑪ → by J. W. Hamaker *et al.* (*Science*, 1963, **141**, 363). Introduced by ← ⑫ Dow Chemical Co. (USP 3 285 925) as code no. 'D-000'; trade mark 'Tordon'.

## Properties

⑬ → Picloram is a colourless powder, decomposing at *c.*215 °C without melting; v.p. 82 μPa at 35 °C. Solubility at 25 °C: 430 mg/l water; 19.8 g/l acetone. It is acidic, p$K_a$ 3.6, and forms water-soluble alkali metal salts, *e.g.* picloram-potassium, Reg. No. *[2545-60-0]*, solubility at 25 °C 400 g/l water.

## Uses

⑭ → Picloram and its salts are herbicides which are rapidly absorbed by leaves and roots and translocated, accumulating in new growth. Most broad-leaved crops, except crucifers, are sensitive; most grasses are resistant. It is used at 2.2-3.3 kg a.e./ha alone or at 0.3-1.8 kg/ha in combination with 2,4-D against deep-rooted perennials. At the higher doses 50% loss from soil occurs in 30-330 d, depending upon soil conditions.

## Toxicology

⑮ → Acute oral $LD_{50}$: for rats 8200 mg/kg; for mice 2000-4000 mg/kg. Acute percutaneous $LD_{50}$ for rabbits >4000 mg/kg. In 2-y feeding trials NEL for rats was 150 mg/kg daily. $LC_{50}$ (96-h) for rainbow trout is 19.3 mg/l. $LC_{50}$ for honeybees >1000 mg/kg.

## Formulations

⑯ → These include: pellets (20 or 100 g a.i./kg); aqueous concentrates (240 g a.e. picloram-potassium/l). Mixtures include aqueous concentrates of salts: picloram + 2,4-D + dichlorprop; picloram + 2,4-D + MCPA + mecoprop.

## Analysis

⑰ → Product analysis is by hplc (*CIPAC Handbook*, 1983, **1B**, in press). Residues may be determined by glc of derivatives (*AOAC Methods*, 1980, 26.000). Details of methods are available from Dow Chemical Co. ← ⑱

⑲ → *page* 441 **9750** ← ①

# PART I

# Compounds in Use

## Main Entries

This, the main part of *The Pesticide Manual*, lists pesticides in current use.

It includes all chemicals and microbial agents used as active ingredients of products for the control of crop pests and diseases, animal ectoparasites and pests in public health. It also contains plant growth regulators, pest repellants, synergists and substances (crop safeners) that reduce the phytotoxicity of herbicides to crop plants.

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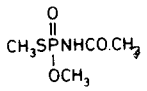
$C_4H_{10}NO_3PS$ (183.2)
1VMPO&S1&O1



**Nomenclature and development.**

Common name acephate (BSI, E-ISO, F-ISO, ANSI, JMAF). Chemical name (IUPAC) *O,S*-dimethyl acetylphosphoramidothioate (I). (*C.A.*) (I) (8 & 9CI); Reg. No. *[30560-19-1]*. ENT 27 822. Its insecticidal properties were described by J. M. Grayson (*Pest Control*, 1972, **40**, 30). Chemical structure-biological activity relationships of analogues were summarised by P. S. Magee (*Residue Rev.*, 1974, **53**, 3). Introduced by Chevron Chemical Co. (USP 3 716 600; 3 845 172) as code no. 'Ortho 12 420'; trade mark 'Orthene'.

**Properties.**

Technical grade acephate (purity 80-90%) is a colourless solid; m.p. 82-89 °C; v.p. 226 μPa at 24 °C; *d* 1.35. Solubility at room temperature: *c.* 650 g/l water; >100 g/l acetone, ethanol; <50 g/l aromatic solvents.

**Uses.**

It is a systemic insecticide of moderate persistence with residual activity lasting *c.* 10-15 d. It is effective against a wide range of aphids, leaf miners, lepidopterous larvae, sawflies and thrips at *c.* 50-100 g a.i./100 l, and is non-phytotoxic on many crop plants.

**Toxicology.**

Acute oral $LD_{50}$: for female rats 866 mg tech./kg, for males 945 mg/kg; for mice 361 mg/kg; for mallard ducks 350 mg/kg; for chickens 852 mg/kg; for ringneck pheasants 140 mg/kg. Acute percutaneous $LD_{50}$ for rabbits >2000 mg/kg; no irritation or sensitisation was observed in skin tests on guinea-pigs. In 2-y feeding trials: dogs showed depression of cholinesterase at 100 mg/kg diet (maximum dose level) but no other significant effect; rats showed depression of cholinesterase but no effect on weight gain or pathological effect at 30 mg/kg diet. No teratogenic, mutagenic or carcinogenic effect was observed. $LC_{50}$ (96-h) is: for rainbow trout >1000 mg/l; for bluegill 2050 mg/l; for largemouth black bass 1725 mg/l; for channel catfish 2230 mg/l; for goldfish 9550 mg/l.

**Formulations.**

These include: s.p. (250, 500 or 750 g a.i./kg); pressurised sprays (2.5 or 10 g/l); granules.

**Analysis.**

Product analysis is by glc (J. B. Leary, *Anal. Methods Pestic. Plant Growth Regul.*, 1973, **7**, 363). Residues may be determined by glc (*idem, ibid.*; *Pestic. Anal. Man.*, 1979, **I**, 201-H, 201-I). Particulars are available from Chevron Chemical Co.