XIV. APPENDIX VI

CLINICAL CLASSES OF MALATHION POISONING

Class	Criteria
I Clinically insignificant exposure	No significant signs or symptoms, vital signs normal, physical examination negative; history of minimal exposure-inhalations, skin contact, mouth-rinse or ingestion - some malingerers - sometimes no malathion odor
II Mild nonspecific clinical symptoms	Nausea, vomiting, dizziness; malathion odor detected
III Mild to moderately severe specific clinical symptoms	Sialorrhea, with foaming if taken po, few rales of rhonchi, pupils small (sometimes not pinpoint); conscious, sometimes stuporous; glycosuria not infrequent
IV Severe specific clinical symptoms	As above, but more marked, including hypotension; Cheyne-Stokes respirations, involuntary defecation, coma, cyanosis, areflexia, and convulsions or fasciculations

From Nalin [50]

XV. TABLES AND FIGURES

TABLE XV-1

PHYSICAL PROPERTIES OF MALATHION

Chemical name	O,O-dimethyl S-(1,2-dicarboethoxyethyl) dithiophosphate
Common name	Malathion (ISO)
Molecular formula	C10H1906PS2
Molecular weight	330.36
Color and form	Colorless to light amber liquid
Odor	Penetrating (garlic)
Vapor pressure	0.00004 mmHg at 30 C
Boiling point	156-157 C at 0.7 mmHg
Melting point	2.85 C
Specific gravity	1.232 at 25 C
Solubility	Slightly soluble in water (145 ppm) at 25 C, miscible with many organic solvents
Flash point	Above 325 F TOC
Conversion factors at 25 C and 760 mmHg	1 mg/cu m = 0.075 ppm 1 ppm = 13.333 mg/cu m

Adapted from 11 and 17

TABLE XV-2

TRADE NAMES AND SYNONYMS FOR MALATHION

S-(1,2-bis(aethoxycarbonyl)-aethyl)-0,0-dimethyl-dithiophasphat (Ger)

S-(1,2-bis(ethoxy-carbonyl)-ethyl)-0,0-dimethyl-dithiofosfaat (Ned)

S-(1,2-bis(ethoxycarbonyl)ethyl,0,0-dimethyl phosphorodithioate

S-(1,2-bis(etossi-carbonil)-etil)-0,0-dimetil-ditiofosfato (It)

S-1,2-bis(ethoxycarbonyl)ethyl-0,0-dimethyl thiophosphate

Dicarboethoxyethyl 0,0-dimethyl phosphorodithioate

S-(1,2-di(ethoxycarbonyl)ethyl dimethyl phosphorothiolothionate

1,2-di(ethoxcarbonyl)ethyl 0,0-dimethyl phosphorodithioate

Diethyl mercaptosuccinate, 0,0-dimethyl dithiophosphate, S-ester

Diethyl mercaptosuccinate, 0,0-dimethyl phosphorodithioate

Diethyl mercaptosuccinate, 0,0-dimethyl thiophosphate

0,0-dimethyl S-(1,2-bis(ethoxycarbonyl)ethyl)dithiophosphate

0,0-dimethyl-S-(1,2-dicarbethoxyethyl)dithiophosphate

0,0-dimethyl S-(1,2-dicarbethoxyethyl)phosphorodithioate

0,0-dimethyl S-(1,2-dicarboethoxyethyl) dithiophosphate

0,0-dimethyl S-1,2-di(ethoxycarbamyl)ethyl phosphorodithioate

0,0-dimethyldithiophosphate diethylmercaptosuccinate

TABLE XV-2 (CONTINUED)

TRADE NAMES AND SYNONYMS FOR MALATHION

Dithiophosphate de 0,0-dimethyle et de S-(1,2-dicarboethoxyethyle) (Fr)

Phosphorodithioic acid, 0,0-dimethyl ester, S-ester with diethyl mercaptosuccinate

American Cyanamid 4,049
Carbetox
Carbophos
Chemathion
Compound 4049
Cythion
ENT 17,034
Ethiolacar
Fosfothion
Fosfotion
Four thousand forty-nine
Insecticide No. 4049
Karbofos
Malacide
Malakill
Malagran
Malamar 50
Malaphos
Malaspray
Malathion
Malathion LV concentrate
Malathion (Pol)
Malatol
Malatox
Mercaptothion
Oleophosphothion
Phosphothion
Sadofos
Sadophos
SF 60
Siptox 1

Adapted from Registry of Toxic Effects of Chemical Substances 1975 Edition [12]

TABLE XV-3

PARTITION COEFFICIENTS OF MALATHION AND MALAOXON

Malathion and:	
Carbon tetrachloride	34
Chloroform	37
Hexane	27
Malaoxon and:	
Carbon tetrachloride	2.9
Chloroform	5.8
Hexane	0.42

From O'Brien and Dannelley [71] and O'Brien [206]

TABLE XV-4

SOME METABOLITES OF MALATHION

Product	Species	Location	Reference
Dimethyl phosphate	Cow	Feces	186
	Human	Urine	207
Dimethyl phosphorothioate	Human	Urine	200
Dimethyl phosphorodithioate	"	"	200
Dimethyl thiophosphate	"	"	200
Dimethyl dithiophosphate	"	Urine and serum	207
Desmethyl malathion	Cow	"	64
	Rat	"	64
	Dog	"	64
	Mouse	"	64
Malathion diacid	Cow	"	64
	Rat	"	64
	Dog	"	64
Phosphatase products	Mouse	"	76
Malaoxon	Mammal	Tissue	64

TABLE XV-5

LD50's (MG/KG) FOR RATS, MICE, AND GUINEA PIGS

Species	Exposure Route			Reference
	Oral	Dermal	ip	
Rats	1,400 - 1,500 M			208
"	1,401 M			105
"	1,375 M 1,400 F	Exceeds 4,400 M and F		109
"	480 M			209
"			750 adult M 340 weanlings	103
"			619.4 F	211
"	200 F		136 F	
"	200 F		136 F	210
Mice	885 M			209
"	775 M			208
"			193 M	211
Guinea pigs			500 F	208
Dogs			1,400 M	211

TABLE XV-6

EFFECTS ON HUMANS FROM MALATHION EXPOSURE

Routes of Exposure	Subjects	Exposure Concentration and Duration	Effects	Reference
Dermal, oral, respiratory	3 men	(Unknown conc) 35 - 40 d 4.5 mo	No signs or symptoms, no ChE activity changes	17
"	"	(Unknown conc) 3 d	Symptoms of ChE poisoning in 2 for 3 days, in 1 for 1 day	182
"	1 man	(Unknown conc) 10 d	"Obvious manifestations of organo-phosphorus intoxication"	38
Respiratory, possibly oral and dermal	12 men	5.3 mg/cu m 21.2 mg/cu m 84.8 mg/cu m 84 hourly over 42 d	No changes in ChE activity; no cholinergic signs or symptoms	56
Dermal	30-40 men	0 % in talc 1 % " 5 % " 10 % " 5 d/wk*	No changes (1 and 5%), nonsignificant decrease (10%), in erythrocyte ChE activity; no illness	32
Oral	1 man	120 ml (Spray 50%)	Coma, bronchial hypersecretion, miosis, diarrhea, areflexia, fasciculations, reduced erythrocyte ChE activity, ECG changes	39
"	"	50 - 90 ml (Spray 50%)	Nausea, vomiting, diarrhea, incontinence, bronchial hypersecretion, areflexia, altered sensorium, blepharoptosis, reduced erythrocyte ChE activity	91

TABLE XV-6 (CONTINUED)

EFFECTS ON HUMANS FROM MALATHION EXPOSURE

Routes of Exposure	Subjects	Exposure Concentration and Duration	Effects	Reference
Oral	1 man	Appr 120 ml	Bronchial hypersecretion, coma, fasciculations, areflexia, miosis, excessive sweating, blepharoptosis	20
"	10 men	16 mg/d x 47 d	No signs or symptoms; reduced ChE activity only after termination of study	21
"	5 men	24 mg/d x 56 d	"	55
"	264 humans	-	Vomiting, sweating, bronchorrhea, miosis, incontinence, areflexia, fasciculations, hypotension, stupor, death	50
"	1 child	8 ml (50% in xylene)	Excessive mucus secretion, hypersalivation, vomiting, incontinence, miosis, absence of deep tendon reflexes, stupor	47
"	1 woman	-	Miosis, coma, areflexia, pulmonary edema, respiratory and cardiac arrest, death	40
"	1 man	0.84 mg/kg	No effects; 23% recovered from ether-extractable urine fraction	55
"	1 woman	0.7 g/kg (liquid 57%)	Sweating, cyanosis, salivation, miosis, fasciculations	46

TABLE XV-6 (CONTINUED)

EFFECTS ON HUMANS FROM MALATHION EXPOSURE

Routes of Exposure	Subjects	Exposure Concentration and Duration	Effects	Reference
Oral	1 woman	0.6 g/kg (liquid 55% in 35% naphtha extract)	Cyanosis, respiratory distress, miosis, diarrhea, fasciculations	44
"	1 man	0.5 g/kg (liquid 57%)	Cyanosis, incontinence, respiratory distress, miosis, hypotension	46
"	"	0.5 g/kg (liquid 50% in 42.4% xylene and 7.6% inert ingredients)	Coma, respiratory distress, hypertension, bronchial hypersecretion and constriction, areflexia, miosis, vomiting, incontinence, reduced ChE activity, ECG abnormal, death	25
"	1 woman	0.5 g/kg (liquid 50%)	Cyanosis, respiratory distress	45

*For an estimated whole body maximum of 28 g

TABLE XV-7

EFFECTS ON ANIMALS FROM MALATHION EXPOSURE

Routes of Exposure	Species	No.	Exposure Concentration and Duration	Effects	Reference
Respiratory	Rabbits	6 M	128 mg/cu m 6% aerosol in No. 2 fuel oil 6 hrs	Respiratory distress, death: 1 dead immediately after exposure, 4 dead by 24 hrs, 1 dead by 72 hrs, all dead by 7 d	83
"	"	"	123 mg/cu m 95% aerosol 6 hrs	Plasma ChE inhibition of 32% by 24 hrs, 35% by 72 hrs, normal by 7 d; erythrocyte ChE inhibition of 34% by 24 hrs, 51% by 72 hrs, 45% by 7 d	83
"	"	"	66 mg/cu m 6% aerosol in No. 2 fuel oil 6 hrs	Respiratory distress during and for 7 d after exposure, 1 dead after exposure, 1 dead by 72 hrs	83
"	"	"	65 mg/cu m	No significant inhibition of blood ChE; no toxic signs	83
		"	34 mg/cu m 95% aerosol 6 hrs		
"	"	"	30 mg/cu m	"	83
		"	24 mg/cu m 6% aerosol in No. 2 fuel oil 6 hrs		
"	"	"	6 mg/cu m 95% aerosol 6 hrs	"	83

TABLE XV-7 (CONTINUED)

EFFECTS ON ANIMALS FROM MALATHION EXPOSURE

Routes of Exposure	Species	No.	Exposure Concentration and Duration	Effects	Reference
Respiratory	Quail	20	128 mg/cu m 6% aerosol in No. 2 fuel oil 6 hrs	All dead at end of exposure	83
"	"	20	123 mg/cu m 95% aerosol 6 hrs	Significant plasma ChE inhibition, 95% immediately after exposure, 75% at 24 hrs, normal by d 7	83
"	"	20	66 mg/cu m 6% aerosol in No. 2 fuel oil 6 hrs	Death of 14 during exposure, 4 by 24 hrs; 2 survivors	83
"	"	20	65 mg/cu m 95% aerosol 6 hrs	Significant plasma ChE inhibition, 84% immediately after exposure, 63% at 24 hrs, normal by d 7	83
"	"	20	34 mg/cu m 95% aerosol 6 hrs	Significant plasma ChE inhibition, 51% immediately after exposure, normal by 24 hrs	83
"	"	20	30 mg/cu m 6% aerosol in No. 2 fuel oil 6 hrs	Significant plasma ChE inhibition, 54% immediately following exposure, 28% at 24 hrs, normal by 7 d	83

TABLE XV-7 (CONTINUED)

EFFECTS ON ANIMALS FROM MALATHION EXPOSURE

Routes of Exposure	Species	No.	Exposure Concentration and Duration	Effects	Reference
Respiratory	Quail	20	24 mg/cu m 6% aerosol in No. 2 fuel oil 6 hrs	Significant plasma ChE inhibition, 45% immediately after exposure, normal by 24 hrs	83
"	"	20	6 mg/cu m 95% aerosol 6 hrs	No significant inhibition of blood ChE	83
"	Rabbits Guinea pigs Rats Mice	- - - -	60 ppm 90% aerosol 6 hrs/d x 2 d	Normal brain, plasma, and erythrocyte ChE activity in guinea pigs and rats; pulmonary hyperemia all species; no "gross pathology"	10
"	Guinea pigs Rats Mice Dogs	- - - 1	5 ppm 90% aerosol 8 hrs/d 5 d/wk x 4 wks	No deaths; no signs of ChE inhibition	10
"	Guinea pigs	-	5 ppm 5% dust 7 hrs/d 5 d/wk x 6 wks	No inhibition of brain, plasma, or erythrocyte ChE	10
"	Rats	-	5 ppm 5% dust 7 hrs/d 5 d/wk x 6 wks	Moderate inhibition of brain, plasma, and erythrocyte ChE	10

TABLE XV-7 (CONTINUED)

EFFECTS ON ANIMALS FROM MALATHION EXPOSURE

Routes of Exposure	Species	No.	Exposure Concentration and Duration	Effects	Reference
Respiratory	Dogs	-	5 ppm 5% dust 7 hrs/d 5 d/wk x 6 wks	"Mild" ChE inhibition in 1; no inhibition of plasma or erythrocyte ChE in 1	10
Oral	Rats	388	200 - 2,000 mg/kg x 28 d	Decreased toxicity with increased dietary protein	106
"	"	21 F	900 mg/kg in corn oil d 9 or d 10, d 8 - d 12, or d 12 - d 15 of gestation	No dose-related effects	116
"	"	5 M	500 ppm or 100 ppm 8 wks	No significant effects	86
"	"	5 M	500 ppm with 25 ppm EPN* 8 wks	Whole blood ChE inhibition of 79%	86
"	"	5 M	100 ppm with 5 ppm EPN 8 wks	No significant effects	86
"	"	192 M	1,600 mg/kg	LD50 reduced to 20-35 mg/kg by previous administration of 0.5 g tri-o-tolyl phosphate	62

TABLE XV-7 (CONTINUED)

EFFECTS ON ANIMALS FROM MALATHION EXPOSURE

Routes of Exposure	Species	No.	Exposure Concentration and Duration	Effects	Reference
Oral	Rats	6	275 mg/kg/d 68 - 70 wks	Body weight of 2 survivors 36% below controls	33
"	"	17 M 17 F	240 mg/kg 5 mos	Significant decrease in cold temperature survival time	107
"	"	8 M 8 F	100 mg/kg/d x 5 d	Average total urinary excretion of 24% (M) and 48% (F)	55
"	"	-	77.9 mg/kg/d x 63 wks	Body weight 12% below controls	33
"	"	10 M 10 F	62 mg/kg/d 4 - 6 wks 68 mg/kg/d 4 - 6 wks	Minimum 50% brain, plasma, and erythrocyte ChE inhibition; 100% erythrocyte ChE inhibition in 5	33
"	"	2 M	40 mg/kg on d 4 and d 5 of age or 20 mg/kg on d 4 - d 24 of age	Reductions in testicular weight, tubular diameter, number of Leydig cells; all cell counts normal by d 24 of age; reversal of all effects by d 50	111
"	Rats Mice Dogs	- 15 -	5 ml/kg 99.6% in corn oil	Significant increase in hexobarbital sleeping time	101

TABLE XV-7 (CONTINUED)

EFFECTS ON ANIMALS FROM MALATHION EXPOSURE

Routes of Exposure	Species	No.	Exposure Concentration and Duration	Effects	Reference
Oral	Mice	42 M	1,400 - 1,500 mg/kg 95% in corn oil	Decrease in toxicity after 4-d pretreatment with SKF-525A, chlorcyclizine, cyclizine, or phenobarbital; no deaths	66
"	Mice	10 M	500 mg/kg in corn oil followed 30 min later by 200 or 250 mg/kg of hexobarbital ip	Toxicity of hexobarbital not altered at either dose; all dead in 30 min	100
"	Rabbits	6 M	1,200 mg/kg 95% in corn oil	Death	83
"	"	"	600 mg/kg 95% in corn oil	Rapid, shallow breathing; miosis	84
"	"	"	300 mg/kg 95% in corn oil	Same degree of erythrocyte ChE inhibition as respiratory exposure to 123 mg/cu m x 6 hrs	83
"	"	"	120 mg/kg 95% in corn oil	Inhibition of plasma (41%) and erythrocyte (32%) ChE after 6 hrs	83
"	Dogs	1 M 1 F	250 ppm 100 ppm 12 wks	No effects on plasma ChE; slight but significant erythrocyte ChE inhibition at 250 ppm	86

TABLE XV-7 (CONTINUED)

EFFECTS ON ANIMALS FROM MALATHION EXPOSURE

Routes of Exposure	Species	No.	Exposure Concentration and Duration	Effects	Reference
Oral	Dogs	1 M 1 F	250 ppm with 50 ppm EPN 12 wks	Up to 60% inhibition of plasma ChE and 93% inhibition of erythrocyte ChE	86
"	"	1 M 1 F	100 ppm with 20 ppm EPN 12 wks	Questionable inhibition of plasma ChE; up to 68% erythrocyte ChE inhibition	86
"	"	1 M 1 F	8 ppm with 3 ppm EPN 12 wks	Significant inhibition up to 24% of erythrocyte ChE at wk 8; incomplete recovery to pretreatment level	86
"	Chickens	-	up to 10,000 ppm 15 wks	No nerve damage, muscle weakness in 1; death of all	110
ip	Rats	16 F	900 mg/kg or 600 mg/kg on d 11 of gestation	No toxic effects; no fetal malformations	115
"	"	18 M	750 mg/kg	LD50 (adults)	103
"	"	20 M	340 mg/kg	LD50 (weanlings)	103
"	Rats	8 M 8 F	25 mg/kg x 5 d	Average total urinary excretion 42%	55

TABLE XV-7 (CONTINUED)

EFFECTS ON ANIMALS FROM MALATHION EXPOSURE

Routes of Exposure	Species	No.	Exposure Concentration and Duration	Effects	Reference
ip	Mice	4	1,500 mg/kg 99.5% in corn oil	Death of 2 in 2 hr	5
"	"	4	1,000 mg/kg 99.5% in corn oil	No deaths	5
"	"	4	500 mg/kg 99.5% in corn oil	"	5
"	Chickens	2	500 mg/kg 99.5% in corn oil	Death of 1 in 2 hr	5
"	"	4	250 mg/kg 99.5% in corn oil	No deaths	5
"	Sunfish	4	400 mg/kg 99.5% in corn oil	Death of 1 in 2 hr	5
"	Bullheads	4	400 mg/kg 99.5% in corn oil	"	5
iv	Dogs	-	250 mg/kg	Death	33
"	"	-	200 mg/kg	"Severe symptoms"; marked ChE inhibition	33
"	"	-	100 mg/kg	No effects	33
Subcutaneous	Chickens	24	50 - 1,600 mg/kg	Acute cholinergic signs in 21; immediate muscle weakness in 8; 4 deaths	108
"	"	-	100 mg/kg	Leg weakness for d 4-14	109

TABLE XV-7 (CONTINUED)

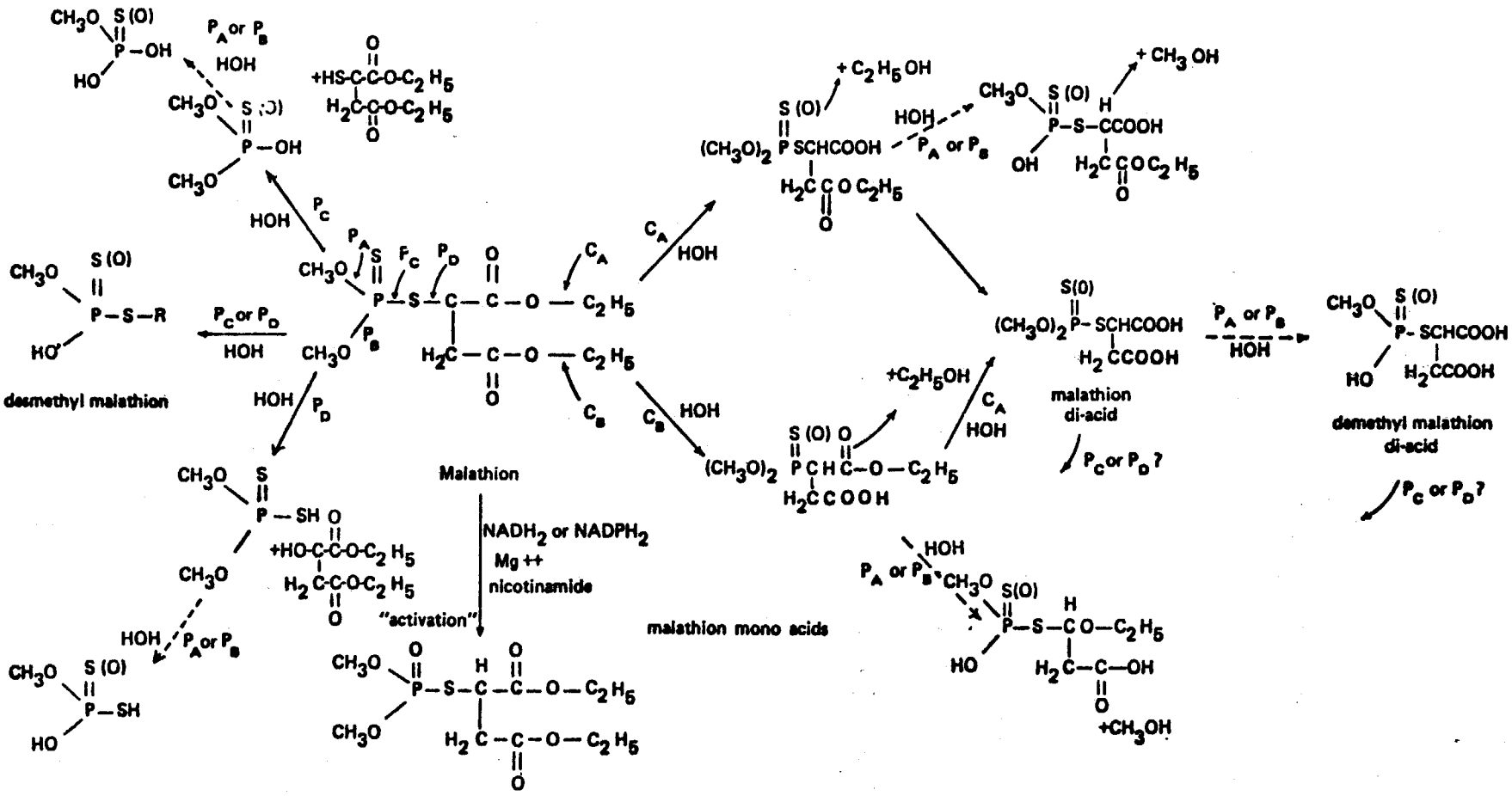
EFFECTS ON ANIMALS FROM MALATHION EXPOSURE

Routes of Exposure	Species	No.	Exposure Concentration and Duration	Effects	Reference
Injection into yolk sac	Chick embryo	25 25	6.42 mg/egg at d 5 3.99 mg/egg at d 4 95% in corn oil	Sparse plumage, micromelia, overall growth retardation, beak defects in 15 d	120

*O-ethyl O-p-nitrophenyl phenylthiophosphonate

FIGURE XV–1

MALATHION METABOLISM



Malaoxon may undergo the same metabolism as malathion, shown above, and is indicated by (O) in the pathway scheme.

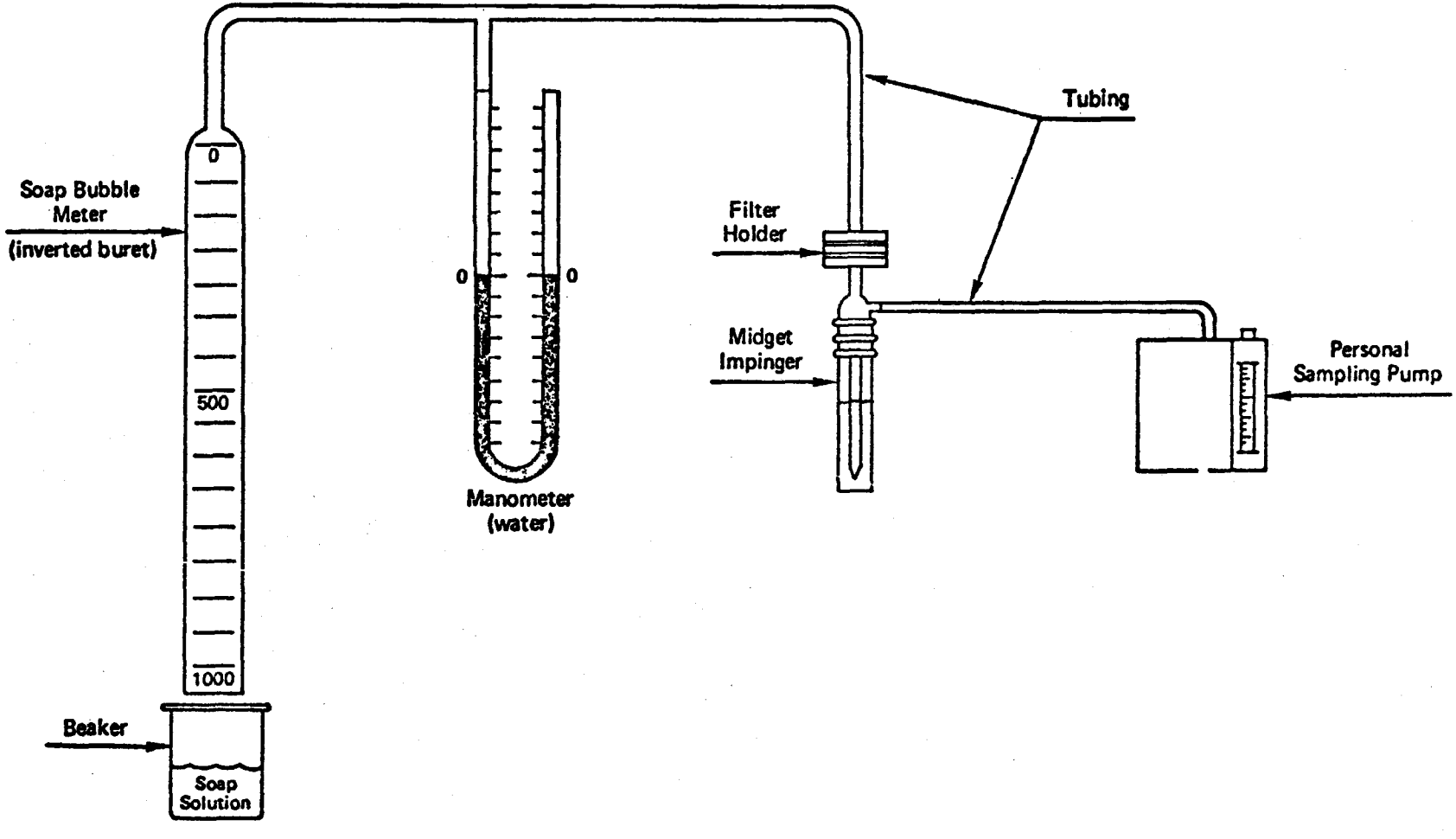
P = "phosphatases"
C = "carboxyesterases" } have not been specifically identified

Aliesterase(s) may act at the same sites as both P and C.

Adapted from Mattson and Sedlak [@65], Main and Braid [@62], Matsumura and Ward [@63], Walker et al [@65], and Welch and Coon [@66]

FIGURE XV-2

CALIBRATION SETUP FOR PERSONAL SAMPLING
PUMP WITH FILTER HOLDER AND MIDGET IMPINGER



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