AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 69

1. SUBJECT CLASSIFICATION

A. PRIMARY
Health — NS00-0000-0000

B. SECONDARY
Tropical diseases

2. TITLE AND SUBTITLE
A standard and rapid method for determining nozzle-tip abrasion

3. AUTHOR(S)
Jensen,J.A.; Taylor,J.W.; Pearce,G.W.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1969	4p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
HEW/PHS/CDC

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(In Bul.World Health Org.,v.41,p.937-940)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAE-575

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Equipment
Insecticides
Spraying

13. PROJECT NUMBER

14. CONTRACT NUMBER
PASA RA(HA)-7-00 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

PASA RA(HA)-7-02 R-REPRINT NUMBER
HEW/PHS

Bull. Org. mond. Santé
Bull. Wld Hlth Org. } 1969, **41**, 937-940

470

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A Standard and Rapid Method for Determining Nozzle-Tip Abrasion *

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The wear resistance of nozzle tips used in malaria eradication programmes has, in the past, been measured with water suspensions of a variety of wettable powder insecticides. The abrasive powers of these suspensions vary greatly, and it is therefore impossible to relate the results of one test to those of another. A standard method has been devised in which a suspension of a standard synthetic powder with a high silica content is forced through nozzles, once, at 40 lbf/in² (2.81 kgf/cm²). The method is reliable, reproducible, and rapid, and it may also be used to evaluate the abrasiveness of water-wettable insecticide powders.

The diluents in most of the water-dispersible insecticide powders used throughout the world in malaria eradication programmes cause severe abrasion [4] of nozzle-tip orifices commonly used in hand compression sprayers. It is important for economic reasons to improve the wearability of these orifices in order to prevent overspraying and to reduce the rate of replacement of worn tips. Furthermore, it is very desirable to have a standard method for the assessment of nozzle-tip orifice wear. Such a method is needed not only in equipment specifications but also as an aid to the development of tips with improved abrasion resistance.

The principal factors governing the abrasive effects of diluents are (1) the hardness of the materials; (2) their particle size and shape; (3) the velocity of the particles through the orifices; and (4) the concentration of the diluents. Factors (1), (2), and (4) vary considerably in water-dispersible insecticide powder formulations and none of these formulations is, therefore, suitable as a standard abrasion agent. Lonergan & Hall (1958) and Kolta, El Refai & Saad [5] recognized these variables, but for the lack of better materials used DDT and other water-dispersible powders in the tests they conducted. There have also been attempts to use single component materials such as emery powder, but their abrasiveness is far above that of the usual insecticide diluents and their particle size is difficult to control carefully.

For the testing of tip abrasion the equipment specifications of the World Health Organization (1964) and the US Agency for International Development [6] require the use of a 5% water-dispersible DDT formulation made from 75% DDT water-dispersible powder that complies with World Health Organization (1967) and USAID [7] specifications for this material. This requirement is justified on the basis that these powders are used almost exclusively in malaria programmes.

Water-dispersible DDT powders, however, vary greatly in their composition and properties and are not suitable for use as a standard abrasive agent. The principal diluent in the powders is Hi-Sil, a synthetic material with a high silica content, and the formulators frequently substitute cheaper clays and thereby alter the abrasive power; furthermore

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[4] The term abrasion rather than erosion is used because the latter includes wear by chemical and mechanical action. The wear discussed here is of the mechanical type only.

Kolta, S., El Refai, A. & Saad, A. M. (1964) The effect of different qualities of DDT water-dispersible powders on nozzle erosion and factors responsible for this effect (unpublished document WHO/Vector Control/66). A limited number of copies of this document is available to persons officially or professionally interested on request to Distribution and Sales, World Health Organization, 1211 Geneva, Switzerland.

[6] USAID Specification No. 7705-4, dated 1 July 1964.

[7] PHS/NCDC-1-102, dated 8 June 1967.

TABLE 1 [a]

PHYSICAL AND CHEMICAL PROPERTIES OF HI-SIL 233

Bulk density	10 lb/ft³ (160 kg/m³)
Specific gravity	1.95
Average particle size	0.022 μ
Colour	White
Refractive Index	135-165 G/S [b]
Surface area	140-160 m²/g
pH (5 % water suspension)	7.3
Loss at 105°C	5 %
Loss at 1200°C	10 %
SiO_2	87 %
CaO	0.5 %
Fe_2O_3	0.2 %
Al_2O_3	0.6 %
NaCl	1.0 %

[a] By courtesy of the Pittsburgh Plate Glass Co., Pittsburgh, Pa., USA.
[b] G/S = Gardner-Sward procedure.

TABLE 2

COMPARISON OF ABRASION PROPERTIES OF 75 % w/w DDT AND HI-SIL 233

Group initial range of flow rate (ml/min)	Discharge (gal)	Flow rate increase (%)		Ratio DDT/HI-SIL
		DDT	HI-SIL	
<740	50	4.0	4.0	1.00
	100	6.9	7.0	0.98
	150	7.2	8.7	0.83
	200	8.6	10.5	0.82
	250	9.9	12.0	0.82
			Average	0.890
740-769	50	3.0	5.1	0.59
	100	4.5	7.5	0.60
	150	5.3	9.2	0.58
	200	6.4	10.6	0.60
	250	7.0	11.6	0.60
			Average	0.594
770-779	50	3.1	4.8	0.64
	100	4.1	6.9	0.59
	150	5.2	8.5	0.61
	200	6.2	10.0	0.62
	250	7.1	11.4	0.62
			Average	0.616
>779	50	2.8	4.9	0.57
	100	4.4	6.8	0.65
	150	5.3	8.2	0.65
	200	6.1	9.6	0.64
	250	6.8	10.8	0.63
			Average	0.628

a number of other high-silica synthetic diluents are coming into use.

The diluent Hi-Sil 233 [1] is a uniform material with constant chemical and physical properties (Table 1) and is used extensively as an insecticide diluent, and would appear to be an ideal agent to use in a standardized procedure for measuring nozzle-tip abrasion. This paper describes the development of such a standard method.

The study had the following objectives: (1) to develop a testing procedure in which the nozzle tip under test is the only variable; (2) to establish a factor for the conversion of data obtained in past years with a 5% DDT suspension to values comparable with data obtained by the new method; and (3) to develop an accelerated abrasion procedure for the rapid measurement of nozzle-tip wear.

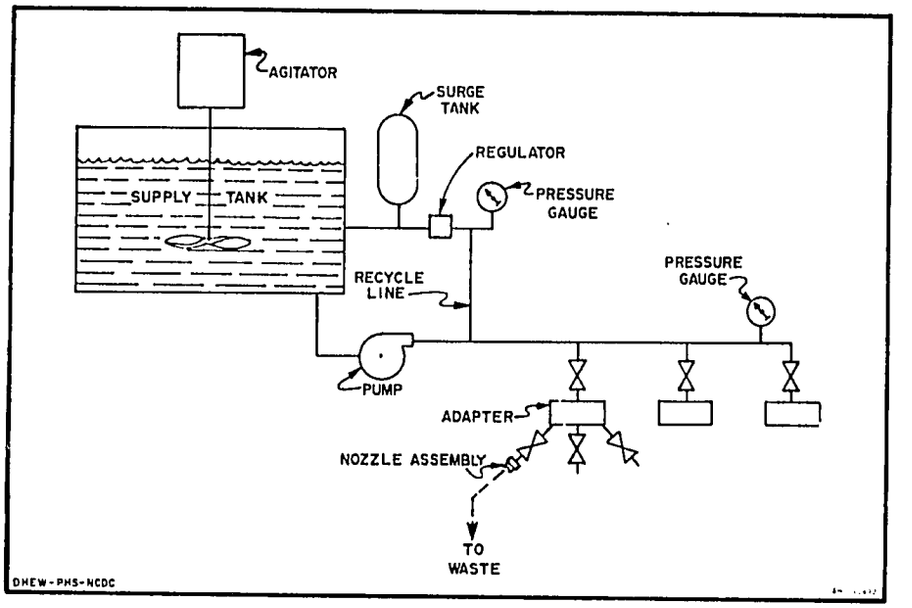
EXPERIMENTAL

The testing equipment is shown diagrammatically in Fig. 1 and consists essentially of a 300-US gal (1135-litre) supply tank with a stirrer; a screw-type pump with bypass provision; a short pipeline terminating in 3 clusters of nozzle-tip bodies, each cluster accommodating 8 tips; pressure gauges; and spray-receiving tanks with provisions for the settling of the Hi-Sil and decanting of the water.

A batch of 104 tips, purchased from the trade

[1] Pittsburgh Plate Glass Co., Pittsburgh, Pa., USA. Use of trade names is for identification only and does not constitute endorsement by the Public Health Service or by the US Department of Health, Education, and Welfare.

FIG. 1
EQUIPMENT FOR TESTING NOZZLE-TIP ABRASION



and identified as HSS8002B,[1] was randomly divided into 2 groups: one for use with Hi-Sil 233 suspension, containing 2 lb (907 g) in 50 US gal (189 litres) of water, and the other for use with the 5% DDT water-dispersible powder suspension prepared from a 75% water-wettable-powder formulation containing 4 lb (1814 g) of Hi-Sil 233 in 50 US gal (189 litres) of spray. The tips were examined for initial flow rates and divided into subgroups each made up of tips with similar rates.

RESULTS

Data in Table 2 show the abrasion rates of the 2 experimental suspensions. These suspensions were passed through the orifices only once, and at a pressure at the tip of 40 lbf/in² (2.81 kgf/cm²). The third major column shows the percentage increases in flow caused by the 2 suspensions, and the last column shows the ratios of these increases. These ratios are fairly constant with an average value close to 0.6, except for the first subgroup of tips with low initial flow rates. The high ratio here is probably caused by faulty finishing in which a clamshell-like metallic residue was formed in the orifice. This thin residue is readily abraded by the DDT suspension.

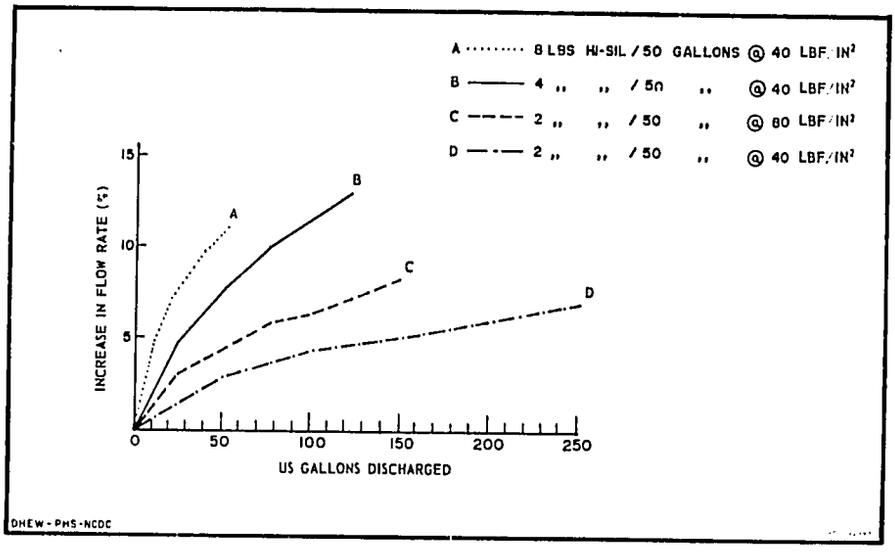
In summary, the data show that the Hi-Sil 233 suspension is 1.6 times as abrasive as the 5% DDT suspension, and this value may be used for data conversion purposes. One may also conclude from the data that the DDT protects the orifice from the abrasion of the diluent—in this case Hi-Sil 233.

A second study was made to determine a suitable concentration of Hi-Sil 233 in water that would increase the abrasion so that the passage of 10 US gal (37.8 litres) of suspension would abrade a nozzle-tip orifice to a point where the flow rate would be increased above the 6% allowed in the WHO and USAID equipment specifications. Further, the study was intended to show the increase in abrasion with an increase in the velocity of the suspension through the orifice. This velocity increase was obtained by doubling the pressure at the tip.

Fig. 2 shows the effect of 3 different concentrations of Hi-Sil 233 in water, namely 2 lb, 4 lb, and 8 lb per 50 US gal (907 g, 1814 g and 3628 g per 189 litres). Also shown in Fig. 2 (curve C) is the effect of doubling the pressure, thereby increasing the flow rate by a factor of about 1.4, while using 2 lb

[1] Spraying Systems, Inc., Bellwood, Ill., USA.

FIG. 2
RELATION BETWEEN HI-SIL CONCENTRATION, NOZZLE PRESSURE AND ABRASION



of Hi-Sil 233 in 50 US gal (compare curves C and D). Moreover, curve A shows that the passage of 10 US gal (37.8 litres) of a Hi-Sil 233 suspension containing 8 lb (3628 g) of Hi-Sil 233, at 40 lbf/in² (2.81 kgf/cm²), will abrade a standard HSS8002B nozzle tip beyond the amount allowed in the WHO and USAID equipment specifications. Thus tips of this type may be evaluated for abrasion resistance in 1 hour with the Hi-Sil suspension instead of 20 hours when a 5% DDT suspension is used.

RÉSUMÉ

MÉTHODE STANDARD PERMETTANT DE MESURER RAPIDEMENT LE DEGRÉ D'ABRASION DES BECS DE BUSE

Dans la méthode mise au point par les auteurs, le milieu abrasif est représenté par une suspension de 3628 g de Hi-Sil 233 (produit utilisé très largement pour la dilution des insecticides) dans 189 litres d'eau. Cette suspension est pulvérisée en une seule fois sous une pression de 2,81 kgf/cm² à l'orifice du bec et on mesure ensuite le degré d'érosion en termes d'augmentation de débit de la buse. Grâce à cette méthode, il est possible de vérifier en une heure si le bec répond ou non aux normes de fonctionnement, alors que la méthode adoptée par l'OMS, qui utilise comme milieu d'épreuve une suspension aqueuse à 5% de poudre à 75% de DDT dispersable dans l'eau, exige 20 heures. Des essais comparatifs effectués sur un matériel identique par les deux méthodes ont montré que le pouvoir d'abrasion de la suspension d'Hi-Sil 233 est 1,6 fois plus élevé que celui de la suspension à 5% de DDT. On dispose ainsi d'un facteur de conversion applicable aux données recueillies par la méthode OMS.

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PRINTED IN SWITZERLAND