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Handpump Testing and Evaluation

To support Selection and Development of Handpumps for Rural Water Supply Programmes

Report on an International Working Meeting held at Harpenden, Hertfordshire, England 29 May - 1 June 1979

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Report on an International Working Meeting
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PREFACE

The International Working Meeting on Handpump Testing and Evaluation was held at Harpenden, Hertfordshire (England) from 29 May - 1 June 1979. The Meeting was organized by the WHO International Reference Centre for Community Water Supply (IRC) in association with the Harpenden Rise Testing and Research Laboratory of the Consumers' Association (U.K.).

The Meeting was attended by 33 delegates from government departments and institutes involved in water supply and public health, international organizations and bilateral development agencies, and research, testing and consulting organizations. The list of participants is given in Annex A.

The Meeting programme provided for plenary discussions, working group sessions, and a visit to the Harpenden Rise Laboratory to inspect the handpump testing work being conducted there for the Overseas Development Administration (U.K.). The Agenda is given in Annex B.

Dr. R.C. Ballance (WHO, Geneva) was Chairman of the Meeting; Professor S. Subba Rao (India) and Mr. L.H. Robertson (Malawi) acted as Rapporteurs.

In his introduction, Mr. E.H.A. Hofkes (IRC, The Hague) emphasized that it is worthwhile investing in testing and evaluation of handpumps, to assist government authorities and development agencies in making a judicious selection of pumps, or to help develop suitable designs. At present there are no uniform procedures for handpump testing and evaluation, and the primary object of the Meeting, was to work out a widely acceptable methodology and guidelines for this type of work.

Mr. C.K. Stapleton presented his introductory paper "Considerations in the Selection and Development of Handpumps for Rural Water Supply Programmes", which was welcomed as a valuable contribution to help the Meeting in assessing the role of handpump testing and evaluation in support of selection and development of pumps.

After the Agenda had been approved, the Chairman invited the participants to introduce themselves and give a brief account of the interest their respective countries or organizations have in handpump testing and evaluation.

The objectives of the Meeting were considered and approved as follows:

1. To clarify the way in which handpump testing and evaluation can assist in the selection, or contribute to the development of handpumps for rural water supply programmes;
2. To develop guidelines for handpump testing;
3. To develop guidelines for evaluation of handpumps;
4. To design a mechanism for international cooperation and a full exchange of results obtained in handpump testing and evaluation work;
5. To consider a proposal for a programme of handpump field testing projects in selected countries.

The consensus of opinion was that the Meeting should primarily concentrate on the items 2, 3 and 4.

It was agreed that the Meeting should base its discussions on the two draft guidelines documents prepared for the Meeting by Mr F. Eugene McJunkin, and Mr J. Kingham respectively.

The main issues were summarized and the direction was indicated for further work to improve the reviewed documents. It was concluded that the draft reports of Mr McJunkin and Mr Kingham should be integrated, together with other relevant material, into one consolidated guidance document. In addition, some recommendations for further research, studies and activities in the subject area were made.

REPORT

The India Mark II Handpump. *Inalsa*

1. INTRODUCTION

BACKGROUND

There is a growing awareness of the important role which protected wells and boreholes equipped with a handpump* will realistically play in providing an adequate supply of safe water to the rural population of many developing countries. A review of data from a global survey[1] on the situation shows that in 1975 some 1250 to 1350 million people, excluding China, lacked adequate water supply facitilities. The vast majority of these people live in the rural areas.

Handpumps fitted on protected wells or boreholes are often a suitable means of water supply, and where applicable in many cases the cheapest. Depending on the cost of the well or borehole and the density of the population served, a handpump water supply may be provided for an initial capital cost of as little as US$ 0.50 to $ 3.00 per capita[2].

A well or borehole with a handpump is of no use if the pump is out of order; the functioning of the whole unit is dependent on the pump. Each time it breaks down, the community is exposed to the hazards of using unsafe water from other sources until the

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* The term 'handpump' as used herein refers to any simple water lifting device, powered by human energy, and used in rural drinking water supplies.

1) World Health Statistics Report, 29, No. 10 (1976).

2) F.E. McJunkin. Hand Pumps. Technical Paper No. 10, IRC, The Hague (Netherlands). July 1977 (also translated into Spanish and French).

pump is put back into operation. When handpumps are not kept operational this inevitably means that the benefits of protected wells cannot be realized, so that open, large diameter wells equipped with nothing more than a rope and bucket may have to be used with concomitant contamination of the water.

The technical and economic feasibility of handpump water supplies is not in doubt. However, experience shows that the communal use of handpumps presents serious problems with regard to engineering design, quality of manufacture, installation and maintenance. There is certainly much scope for improvement in the design and manufacture of pumps, the modification of existing models, development work, and testing of innovative types of pumps.

Testing handpumps in the field and in the laboratory, and field performance monitoring are valuable tools for the selection and development of suitable pumps for rural water supplies. Such tests and monitoring can be used to identify weaknesses in designs or materials. They may also provide direction to research and development work aimed at effective modification of designs, cost savings, increased durability and simplification of installation and maintenance.

The subject of handpump testing and evaluation has gained extra attention because of the obligations arising from targets set for the International Drinking Water and Sanitation Decade. The national governments, international organizations and bilateral development agencies which are seeking to improve the water supply situation of the rural population in developing countries, share the concern that handpumps shall fully meet the requirements. This will be a decisive factor in the success of any handpump water supply programme.

HANDPUMP TECHNOLOGY

The growing interest in handpumps is reflected, among other things, in the great acceleration during the past decade of research and development work on handpumps, new materials and manufacturing methods.

Considerable scope for further improvements exists. Innovative designs and new materials are available, and careful development work is needed to bring out their full potential.

Recognizing the importance of this work, and the need for improved handpump technology, the IRC organized an International Workshop on Handpumps in July 1976. That Meeting reviewed the state of handpump technology, research and development. It gave guidelines for the use of handpumps in rural water supply programmes. In 1977 the IRC published a handbook on handpumps, under the joint sponsorship of UNEP and WHO. In November 1978, a Workshop on Handpump Evaluation and Testing was held in Voorburg (The Hague). Current handpump testing activities were reviewed.

TESTING AND EVALUATION OF HANDPUMPS

Testing and evaluation for selection and development of handpumps is of relevance to water supply authorities of developing countries, international organizations and bilateral aid agencies, and their engineering and economic advisers.

Many decisions concerning the types and models of handpumps to be used in national water supply programmes, are being made or will be made in the near future. The development of a sound and widely-accepted methodology for handpump testing and evaluation, therefore, has considerable urgency.

Field and laboratory testing of handpumps, and surveys for monitoring their field performance require careful design if the results are to be reliable and significant. Problems encountered in designing a suitable test and evaluation programme include:

- the extreme variation in conditions under which handpumps are used; they may serve on shallow or deep wells, with many or few users; operation may range from almost continuous to infrequent, and maintenance from adequate to none at all;
- the wide variation in design, cost, reliability and durability of handpumps;
- the great differences in geographical, social and cultural environment in which handpumps serve;
- the interchangeability of components in some handpump models makes it difficult to decide which combination to test.

INTERNATIONAL COOPERATION AND COORDINATION

Several projects for field testing and evaluation of handpumps, or testing of pumps in the laboratory, are currently underway or being prepared. Some are undertaken under the sponsorship of international organizations, others with active support from bilateral development agencies. Each of these projects develops test procedures and methods which are tried out and so yield valuable experience and results.

Comparison and evaluation of handpumps on an international basis would require common criteria, definitions, methods, checklists and reporting format. It is desirable that a standard methodology be used in handpump performance monitoring, field and laboratory tests, to provide for coordination between countries and regions. In this way results may be 'pooled', thereby giving the

possibility to treat the different projects as one experiment. It would provide valuable information about the effects of the different geographical, social and cultural environments in which handpumps have to function. Coordination and the use of a common methodology is not easy; detailed techniques may be needed, such as the use of uniform pro-forma records, and a free exchange of original data rather than of conclusions alone.

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2. SURVEY OF HANDPUMP TESTING AND EVALUATION PROJECTS

GENERAL

Very few handpump programmes have incorporated formal testing and evaluation of handpumps, although evaluation is obviously an integral part of any rural water supply programme.

Whilst recognizing that much valuable work in field testing and laboratory testing of handpumps, and field performance surveys have been carried out over the past few years, it should be pointed out that valid comparison of test or survey results between different handpump programmes, countries and regions is usually impossible in the absence of uniform procedures and methods.

In this section, a survey of handpump testing and evaluation projects in various countries is given providing a worldwide picture*.

ODA/CA PUMP TESTING PROJECT (U.K.)

A laboratory testing project on hand/foot pumps is being undertaken by the Harpenden Rise Testing and Research Laboratory of the Consumers' Association (U.K.), funded by the Overseas Development Administration (U.K.). The contract was signed in July 1977, the actual testing of the pumps began in early 1978. A full set of comparative tests is carried out.

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* For comprehensive information on methodology and test procedures used in the various projects, reference is made to the companion document "Survey of Handpump Testing and Evaluation Projects".

Only deepwell pumps are tested, 12 brands in total, in two batches of 6 each. Of each pump model two samples are being (first batch), or will be tested (second batch).

The pump models tested in the first test series are listed in the following table. Preliminary results have been reported in December 1978.

BRAND	MODEL	MANUFACTURER	TYPE
Petro Pump	Type 95	Petropump Sweden	Diaphragmatic hose
Vergnet	Type AC2	Ets Pierre Mengin France	Hydraulic operation diaphragmatic
Dempster	23F (OS)	Dempster Ind.Ing U.S.A.	Lift pump
Mono	EC 30	Mono Pumps (Engg) Ltd., U.K.	Rotary helical screw-type operation
Climax	N.A.	Barnaby Climax U.K.	Fly wheel Lift pump
Godwin	W1H 51	H.J. Godwin Ltd U.K.	Greased Lift pump

Pumps included in the second batch for testing are: Monarch (Canada); Beatty (Canada); India Mark II (India); ABI (Ivory Coast); AID/ Battelle (Costa Rica and Nicaragua); Kangaroo (Tanzania). The PVC pump developed by the Waterloo Research Institute, under sponsorship of the International Development Research Centre (Canada) is tested under a separate arrangement and the first results have been reported in January 1979.

The reports of the ODA/CA Testing Project are recommended sources of information for any organization with an interest in the 13 pump models tested. They should also provide much useful information to research and development institutes doing work on handpumps. The project is due to be completed by March 1980.

IDRC/WATERLOO RESEARCH INSTITUTE PUMP DEVELOPMENT AND TESTING PROJECT (CANADA)

The objective of this project was to develop an inexpensive handpump with optimal use of modern materials and production methods. The recommended final design is for a plastic (PVC) pump, with a simple operating mode, inexpensive, easy to install and to maintain. With a few exceptions, all components are made of plastic materials. These have been selected for their easy manufacture and low cost, as well as for the suitability in a water pump application. Many of the parts are standard size, extruded items which are provided by plastic suppliers. Special tooling is thus not needed. The relatively few special shapes, which are required, can all be injection moulded. All the recommended plastic parts are based on rigid PVC or polyethylene.

Details of the various components of the recommended pump are described in the project report. Also provided are description of alternative parts and components, which may be equally satisfactory or which have been considered and rejected as deficient compared to the final selected configuration.

Laboratory tests were done on prototypes of the pump, a 2-inch and 3-inch model, for various pumping rates and well depths. The test results were used to determine the mechanical and hydraulic efficiency of the pump under various conditions. Most of the pump components were also tested for tensile strength and wear characteristics.

In a related study the application of plastic pipe for use as the well casing in hand operated water pumps was investigated. The use of the well casing as the pump cylinder and drop pipe can be attractive for reasons of economy.

WORLD BANK/UNIVERSITY OF MARYLAND PROJECT FOR TESTING OF WOODEN BEARINGS FOR HANDPUMPS (U.S.A.)

The purpose of the testing project carried out by the University of Maryland (Rural Water Resources Development Laboratory) for the World Bank was to evaluate other types of bearings than those used in conventional pivot points (mild steel pin with cast iron bearings). Because metal/metal interfaces show considerable wear, a search was carried out for bearing materials having better wear characteristics. The materials selected should be readily available in developing countries, correspond to the user's level of technology, and show minimal wear under heavy use. For these reasons, various types of wood were investigated and tested.

Data on wood properties were collected, and their fatigue resistance and structural strength were investigated. Structural analysis of the loads associated with the pumping operation was performed to determine the size and location of the journals.

A fatigue testing machine was developed capable of testing a number of wood handles simultaneously. Following a short pre-test, an expanded wear test was performed to investigate the behaviour of bubinga wood and common pipe bearings (both oil-impregnated and dry) with shafts of mixed steel pin and galvanized steel pipe.

In the pre-test, a specimen of bubinga wood was tested for 100 000 cycles, and a endurance test was done on another specimen for 250 000 cycles under a heavier load.

Based on the test results, a method was developed to determine the fatigue resistance level and the dimensions of wooden handpump handles. It was concluded that an expansion of the investigation to include other wood specimens, more accurate simulation of pump operations, and field tests would be required for verification of the preliminary results of the study.

AID/BATTELLE PUMP DEVELOPMENT AND TESTING PROJECT (U.S.A.)

This project comprised the development of a handpump suitable for use and manufacture in developing countries. In 1966 the project started based on an agreement between the US Agency for International Development (AID) and the Battelle Columbus Laboratories (U.S.A).

The project was organized in three stages. The first stage was a study to determine the requirements imposed upon handpumps by various environments; to determine typical usage patters prevailing in less-developed countries; to identify the shortcomings of existing pumps; and to develop detailed criteria for the design of a suitable pump. In this phase, extensive laboratory tests were conducted to generate additional information for the final evolvement of a new pump design. The second stage included the design, construction and evaluation of a prototype pump, and a suggested set-up for a typical small-scale workshop for the manufacture of the new pump. This phase was later modified to include some additional tests of the developed pump model to determine its characteristics in comparison with existing models. Further work in the project mainly concerned additional laboratory testing, and improvement of component parts of the developed pump model.

In the third stage of the project, a field evaluation programme was conducted which included collaboration with several manufacturers in the production of pumps, the preparation of an instruction manual for installation, operation and maintenance; also reporting of the pump's performance, field tests and evaluation. Under a separate contract with AID, the field evaluation programme was conducted in three countries; Bangladesh (in cooperation with UNICEF), Nigeria (under direction of CARE), and Thailand (under direction of AID).

More recently, the AID/Battelle pump model was field tested in many other countries (e.g. Upper Volta, Cameroun, Costa Rica, Nicaragua, India, Indonesia). The pump design has served as a basis for numerous local pump development activities.

AID/GEORGIA INSTITUTE OF TECHNOLOGY FIELD TESTING PROJECT (COSTA RICA AND NICARAGUA)

The final design of the AID/Battelle pump was developed in late 1976 and AID then contracted the Georgia Institute of Technology (Engineering Experiment Station) to evaluate the field performance and the acceptability of the AID/Battelle pump in comparison with other pumps used in developing countries, and also to evaluate the feasibility of local manufacture of the pump in selected developing countries.

The project comprised the manufacture of AID/Battelle pumps in Nicaragua and Costa Rica, the purchase of locally available comparative pumps, installation of the pumps in rural villages, and evaluation of the field performance of each pump over a one-year period. In each country one manufacture was selected to produce the AID/Battelle pump. A minimum of 30 pumps of various makes were installed in each country, and detailed frequent monitoring was arranged.

In Costa Rica, two pumps were chosen for comparative testing with the locally manufactured AID/Battelle pump: a Dempster and a Japanese Kawamoto Daiichi "Lucky" pump. In Nicaragua, a Dempster, the Brazilian "Marumby" and a pump developed by the IDRC (Canada) were used for comparative analysis. In total 60 field test sites and 30 comparative pumps. Field test sites were chosen primarily because of their relative high usage and their accessibility. During a 12-month period, the pumps were carefully monitored on their overall performance reliability, maintenance requirements and acceptance. In addition, a cost analysis of the local manufacture as well as further design modifications were made.

The field testing project was carried out under agreements involving the national governments, the Central American Research Institute for Industry (ICAITI) and the Georgia Institute of Technology (U.S.A).

DEVELOPMENT AND TESTING OF THE BANGALORE PUMP (INDIA)

This project was aimed at developing an improved deepwell handpump, suitable for community use in rural villages of Karnataka and other States of India, and to identify possibilities for reducing the cost of the pump. The Government of Karnataka, WHO and UNICEF collaborated in the project. The project began in March 1973 and ended in December 1974.

The pump was developed after an extensive survey of indigenous and imported pumps in order to identify strong and weak points of design and construction. Field surveys were performed to study existing problems and patterns of usage. The development of design criteria was based on full analysis of the collected data.

Based on the adopted design criteria and with full consideration of hydraulic, mechanical and materials requirements, the cylinder and pump head were further developed, prototypes were made and laboratory tested.

After the laboratory tests it was considered that the pump development had reached the point where the pump should be manufactured in sufficient numbers to enable field tests to be conducted in a number of States of India under different conditions and over a long enough period for defects to become manifest. Further design improvements could then be made.

The cast iron pump head of the Bangalore pump has served as a point of departure for the development of the India Mark II pump head. This is a newly designed pump head using fabricated steel construction.

DEVELOPMENT AND TESTING OF MARK II DEEPWELL HANDPUMP (INDIA)

In 1974, when surveys and many reports indicated that both the locally produced and imported handpumps were unsuitable for the intensive use in rural villages, the Government of India and UNICEF became directly involved in the improvement of the village handpumps.

The following design criteria were developed:

- trouble-free operation for at least one year after installation, serving a maximum of 2000 persons and drawing water from a static water level of maximum of 150 ft. deep;
- cost of pump head, complete with 100 ft. rising main, connecting rod and cylinder must be less than $ 200,-;

- the design must be suitable for local manufacture and not require any imported items or materials;
- the pump must be very easy to operate;
- maintenance must be executed by persons with a minimum of technical skill;
- any pollution of the well must be prevented.

In the first stage of the pump development, the main concern was the handle mechanism, as field reports indicated that 70% of the pumps broke down because of failure of the handle. The orginial guided cast iron handle of the basic pump model (the Sholapur) was replaced by a single pivot handle. This modified model was known as the Sholapur Conversion Head.

Many further improvements were made leading to the final design of the India Mark II Pump Head. Prototype pumps were manufactured, and, as from October 1976, the India Mark II pump head is undergoing field testing in UNICEF-assisted projects in the States of Tamil Nadu and Madya Pradesh. The test areas were selected because of their deep groundwater table and high population density, providing severe operating conditions.

The India Mark II pump is now regarded as standard in the Government of Inida/UNICEF-assisted village water programme and the pump is now under mass production. Quality control of manufacture, and the development of suitable maintenance schemes are particularly noteworthy.

The major concern at this moment is the development of an equally suitable pump cylinder. Various configurations are being tested in the field.

DEVELOPMENT AND TESTING OF MODIFIED HANDPUMP (SINGUR) (INDIA)

During the years 1971-1972, the All India Institute of Hygiene and Public Health, Calcutta, under the joint sponsorship of WHO and UNICEF, carried out an investigation into the performance of existing handpumps in India.

It was found that these handpumps were very inexpensive but the quality of manufacture was often poor. Various locally manufactured brands were examined on their deficiences in design and construction with the object to identify possible improvements, while keeping the cost as low as possible. A study was undertaken to develop a suitable handpump and produce specifications for different component parts.

The first phase of the study was mainly concerned with data collection on many types of existing locally-manufactured handpumps. Pumps were selected, repaired and re-installed and their field performance was monitored. At a later stage the pumps were upgraded in workshop and re-installed for further testing. It was found that most breakdowns occurred because of the brittleness caused by a high phosphorous content of the iron, and poor quality of finish resulting in rapid wear of the cup seals.

In the second phase a new design and drawings for an improved pump were prepared. A prototype pump was made and put to rigorous laboratory tests to check its performance. Reducing the phosphorous content in the castings proved impractical and plastic cylinder liners were used to obtain a smooth cylinder bore, and so reduce the wear of the cup seals. A field trial with these liners was conducted followed by endurance tests.

A further extension of the project is envisaged, as it is necessary to subject the new pump design to comprehensive field tests in order to fully evaluate its performance, and if necessary, to further improve and modify the pump before a final design is chosen. A comprehensive protocol for this project extension has been written.

UNICEF/DPHE SHALLOW WELL HANDPUMP DEVELOPMENT (BANGLADESH)

Since 1971, UNICEF has assisted the Department of Public Health Engineering (DPHE) in Bangladesh in a very large shallow well handpump programme. In a relatively short time, over 400 000 new handpumps were manufactured and installed. The programme has stimulated considerable experimentation, prototype testing and many design modifications in shallow well handpumps.

The newly developed model, the "New No. 6 Pump" has been installed in large numbers, over 300 000 by 1979. This new pump represents a cross between the AID/Battelle pump and the existing Maya No. 6 pump. The name "New No. 6" is part of the effort to ensure local acceptance. The design of the pump was strongly influenced by the severe shortage of pig iron and the limited casting capabilities available in Bangladesh.

With so many handpumps installed, maintenance has become the most important factor to be considered. A maintenance system has been set up with local pump caretakers receiving their spare parts from decentralized stores at subsidized cost. The handpump development work in Bangladesh has demonstrated the benefits of having an operation base at the field level with experienced personnel in constant attendance. The UNICEF/DPHE programme has tested prototypes under field conditions, obtained, analyzed and responded to

feedback information from field tests as well as regular operation. An expensive handpump (less than $ 20,- per unit) which is locally manufactured, and suitable for the local conditions has resulted from this pump development work.

UNICEF/ARD HANDPUMP TESTING AND EVALUATION PROJECT (THAILAND)

The main objective of this project was the critical evaluation and improvement of existing handpump models in Thailand, particularly reciprocating deepwell pumps. The project was carried out by the Office of Accelerated Rural Development (ARD) (Ministry of Interior) with UNICEF assistance.

The project involved: the study of actual usage patterns; the study of performance, failures and maintenance problems of various indigenous types of handpumps under actual field conditions; the appraisal of each type of handpump; the evaluation of types of materials used and their costs; and the establishment of guidelines for handpump maintenance.

To arrive at guidelines for handpump design and maintenance organization, the project followed a schedule divided over 9 major stages, of which stage 5 and 8 can be regarded as field testing stages (see schedule). The pumps selected for improvement and field testing were: a handpump model of the Mineral Resources Department; a handpump model of the Public Works Department, the "Korat" handpump; a handpump model of the Accelerated Rural Development Office, and a commercially available shallow well handpump.

TASK NO.	DESCRIPTION	TIME PERIOD																							
		1977							1978														1979		
			J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J		
a.	Selection of sample deep wells																								
b.	Deep wells classification																								
c.	Preparation of data recording forms																								
d.	Installation of hand pumps																								
e.	Data collection																								
f.	Data analysis																								
g.	Improvement of hand pump																								
h.	Installation of improved hand pumps																								
i.	Monitoring of operation of new hand p.																								
j.	Evaluation and report preparation																								

SHALLOW WELL PUMP IMPROVEMENT AND TESTING PROJECT (MALAWI)

The Shallow Well Pump Improvement and Testing Project in Malawi started in December 1977 with a survey of some 68 shallow wells in the Dowa District of the Central Region of the country. This survey was Stage I of the project, which is funded by the IDRC, Ottawa, Canada. The project was a joint venture of the Ministry of Community Development and the Malawi Polytechnic.

Several field surveys of handpumps were carried out to monitor the general condition of each pump, its ease of operation, and discharge capacity. The pumps were dismantled for inspection of component parts, and measurements were taken. Comments of pump users (villagers) were noted regarding the maintennace requirements, availability of the water supply, frequency of failures, etc.

The shallow well pump was developed through several stages, with each modified pump model having a different designation (Mark I, II, III and IV). Each model was field tested, and further design modifications were based on critical evaluation of field survey findings.

Laboratory tests on several pump components and arrangements were included in the development and testing work, particularly on a modified version of the IDRC/Waterloo PVC pump model.

The objective of the project is to perfect a few handpump models so that they can be standardized for use throughout the Malawi rural water supply programme, and possibly also in other countries.

GHANA UPPER REGION (CIDA) WATER SUPPLY PROJECT FIELD TESTING AND EVALUATION PROGRAMME (GHANA)

In November 1973 the Upper Region Water Supply Project in Ghana was initiated as a bilateral programme assisted by the Canadian International Development Agenct (CIDA), in collaboration with the Ghana Water and Sewerage Corporation. The programme was managed by a Canadian consulting engineers firm.

In view of the unsatisfactory field performance of the handpumps previously used in the Upper Region Water Supply Project, it was decided that only a comprehensive comparative field testing programme could provide the necessary basis to select a suitable pump model. The pump selection and development programme was started by evaluating the most promising pumps available throughout the world. A total of 27 pump models (79 units in total) from 16 different manufacturers of 10 countries were eventually placed on test.

		Country	Number of Pumps on Test
1.	ABI Type M (ball bearings at fulcrum)	Ivory Coast	2
2.	African (Pleuger) (ball bearings and cable)	Ghana	1
3.	African (Pleuger) (wood frame)	Ghana	1
4.	Beatty "Brute" (ball bearings, heavy steel)	Canada	1
5.	Beatty Model 1205 (first order)	Canada	1
6.	Beatty Model 1205 (mod.) (second order)	Canada	4
7.	Beatty Model 1205 (mod.) (oilite bushings)	Canada	6
8.	Beatty Model 1205 (mod.) (nylon-teflon bushings)	Canada	2
9.	Beatty Model 1205 (mod.) (nyletron bushings)	Canada	2
10.	Byer (steel pin in cast iron)	Germany	2
11.	Consallen LD-4 (ball bearings)	U.K.	2
12.	Dempster 23F (EK) (steel pin in nylon bushings)	U.S.A.	3
13.	Godwin HLD (lever type)	U.K.	1
14.	Godwin W1H (wheel type)	U.K.	7
15.	Monarch P-2	Canada	1
16.	Monarch P3-A (steel pin in cast iron)	Canada	1
17.	Monarch P3-B (oilite bushings)	Canada	1
18.	Monarch P3-C (ball bearings)	Canada	10
19.	Mono (rotary)	U.K.	2
20.	Moyno 1V4 (rotary)	Canada	2
21.	Moyno 2V2.6-1 (rotary)	Canada	10
22.	Nigerian Battelle (mild steel in cast iron)	Nigeria	2
23.	Sholapur No. 002	India	4
24.	Uganada (East Africa) (wood frame)	Kenya	2
25.	"UST" Ghana	Ghana	3
26.	Hydro-Pompe Vergnet	France	4
27.	Vogel (mild steel in cast iron)	Germany	2

LIST OF TESTED HANDPUMPS

GHANA UPPER REGION TESTING AND EVALUATION PROGRAMME

The preliminary results of the first 12-18 months of testing were reported in a progress report issued in July 1977. Of the entire group, 6 pump models emerged as having the greatest promise of meeting the long term service requirements of the Ghana Upper Region. Full analysis of the test results was supplemented by a detailed evaluation of the long term total cost of the alternative pumps (including capital, spare parts and maintenance costs), to provide a basis for the final selection.

In November 1978, another progress report was issued. Four of the first group of 6 selected pumps continued to hold the greatest potential of being a suitable pump. Further design modifications and other improvements were incorporated for the final order of 1000 pumps, which was virtually split between the two most promising designs. The experience in this extensive field testing and evaluation project in Ghana should be of particular interest to neighbouring West African Countries.

HANDPUMP TESTING AND EVALUATION PROJECT (INDONESIA)

In Indonesia, the government authorities involved in rural water supply projects are increasingly concerned about the large number of different types of handpump used in the country, and the resulting difficulties in installation, maintenance and the provision of spare parts. The need is widely recognized to standardize the handpumps for rural water supplies to a limited number of suitable pumps. This would result in considerable cost savings, stimulate local manufacture of pumps, facilitate maintenance and ensure adequate provision of spare parts.

The Directorate of Hygiene and Sanitation, in the Ministry of Health, assumed responsibility for the testing of several prototype pumps, with WHO and UNICEF assistance.

One project concerned the testing and evaluation of the Moyno (Model 2V2.6) handpump. The test was successfully completed and recommendations for some improvements were given.

In another project 2 samples of each of 3 prototype pumps were provided by UNICEF for testing; the pumps were: "Sholapur" (India), "Korat" (Thailand), and "New No, 6" (Bangladesh). The pumps were tested during a period of 6-12 months. Pump characteristics tested for, were: durability, mechanical efficiency, cost, and maintenance requirements. However, the comparative testing was partly suspended, due to drought conditions and some technical failures.

In May-July 1979, endurance tests have been carried out by the Bandung Institute of Technology on prototypes of the "Bandung" pump developed by the West Java Rural Water Supply project (Dutch bilateral assistance project). The test results confirmed the promising performance of the pumps under field conditions sofar.

Student sanitarians check and repair a well near the Kolladuba Health Centre.

WHO Photograph

3. REVIEW OF DRAFT GUIDELINES ON HANDPUMP TESTING AND EVALUATION

SCOPE

The following paraphraphs are intended to highlight selected issues on which consensus of opinion was expressed during the Meeting. However, the observations and views stated in this report are not necessarily shared in their entirety by all who participated.

Many specific comments and suggestions were directed to the improvement of certain sections, paragraphs or statements contained in the draft Guidelines documents. They will be processed and incorporated in the guidance document (manual) which is to consolidate the available information and the review results.

GENERAL POINTS

Water and Health

Water supply alone, whether by handpump or otherwise, cannot be expected to bring the desired health benefits unless accompanied by personal hygiene training, health education, and sanitary excreta and waste disposal. The need was considered to give attention to these elements in order to optimize the chances of achieving the goal of better health through improved water supply. It was suggested that all handpump programmes should budget for activities in these areas.

Influence of Social Environment

In practice, the reliability and durability of a handpump interacts with the social environment in which the pump operates. In this respect, a "bottom-up" approach should be followed involving the local people, to the maximum extent possible, in the design and installation of the handpump water supply. The social factors influencing the acceptance of the pump by its users, should be recognized so as to avoid frustration, sabotage and pilferage. A realistic frame of reference for field testing and evaluation of handpumps takes these social factors into account, as well as influences of culture and water use generally.

Community Involvement in Handpump Maintenance

When selecting or developing a handpump for use in rural water supply programmes, it should be carefully considered whether the expected involvement of the communities in the maintenance of their pump is realistic. The envisaged division of responsibility for maintenance tasks should be clearly stated.

Without adequate information, villagers cannot be expected to be cooperative in ensuring the proper use and maintenance of the handpumps. Without support, i.e. supply of spare parts, it will be impossible for them to contribute their part to the servicing of the pump. Certain requirements are simply beyond the local capacity, at least under present conditions.

Local Manufacture of Handpumps

Where handpumps are not manufactured locally, it may be advisable to carry out feasibility studies to identify the alternatives to importing handpumps. Quality control (preferably by an independent agent) and the supply of spare parts will be vital considerations.

Handpumps designed and manufactured in industrial countries are not necessarily better than indigenous pumps of developing countries. Many of the handpumps imported from industrial countries, were originally designed for single family use; they simply do not stand up to the conditions of intensive communal use in villages*.

The practical problems of local manufacture of handpumps should not be neglected, and one has to be careful not to over-emphasize its desirability.

METHODOLOGY

Field performance monitoring of handpumps, and field and laboratory testing can serve multiple purposes, i.e.:

- improvement of one or more pump designs or models;
- selection of one or more pumps from a number of available types and models;
- development of performance criteria and specifications;
- upgrading of quality control of manufacture.

Of course, several of these purposes may be combined. Laboratory testing can be useful to help identify pumps which have design faults, and are not worth field testing or performance surveys. Laboratory testing is no substitute for field testing and evaluation, it should be linked to them.

It is desirable that field testing and performance monitoring should be designed to give as much information as possible about all characteristics of the pumps. This will enable their results

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* *Failure of half or more of the handpumps within six months after installation, is not an uncommon experience in many of the handpump programmes.*

to be compared with any laboratory test data as directly as possible. Of course, there are parameters which are more easily measured under laboratory conditions than in the field, but every effort should be made to obtain at least some measurements in the field. If resources permit, field tests and laboratory testing on the same pump models would be desirable.

Field performance findings combined with field testing results and laboratory test data, may provide full assessment of the handpump characteristics:

- engineering design
- pumping capacity
- maintenance requirements
- reliability; durability
- convenience and ease of use
- acceptance by users.

It can be very useful to involve handpump manufacturers in the field testing and evaluation of their products, or at least to inform them about the results, to enable them to make effective improvements. In situations where this is not feasible, it would be helpful to associate with an institution that could carry out the handpump development work on behalf of the client organization responsible for the water supply programme. Such handpump improvement work could combine ideas originating from the field testing with the technical expertise of the research and development group.

CHARACTERISTICS OF HANDPUMPS

Costs

Results of handpump testing and evaluation given in financial terms would provide a basis for ready comparison of pumps and their cost-effectiveness. The different costing systems developed in several handpump evaluation projects should be synthesized and further developed for wide application.

Reliability

The reliability of a handpump was recognized as a vital characteristic. Reliability was defined as: the probability of the pump giving satisfactory performance without failure, under given conditions for a specified period of time.

This definition provides the elements to be used in determining a (numerical) measure for the reliability of a handpump.

Performance

To provide a measure of pump performance the data required include:

- total pumped volume of water (for a specified period of time);
- discharge per (standardized) stroke;
- wear of critical points;
- parts replaced (if any).

Users' Acceptance

To arrive at an assessment of the users' acceptance of a handpump, and social factors influencing its functioning, sociological survey techniques and interview procedures may prove useful.

EXPERIMENTAL DESIGN

Framework

The following framework was developed for use in the design of handpump testing and evaluation projects.

Method of obtaining data / Parameter	Measure	Ask	Monitor
Engineering design	X		
Physical environment	X		X
Maintenance regime and economics	X	X	X
Users' acceptance; social factors		X	X

A discussion of how such measurements, questions and observations are to be effected in a systematic way, should be included in the guidance document (manual).

Worked examples should be given to show the procedures for monitoring and recording field data; also guidelines for analysis and presentation of results, and methods for single or multi-characteristic ranking of pumps.

4. CONCLUSIONS AND RECOMMENDATIONS

Whilst recognizing that much valuable work in field and laboratory testing of handpumps and field performance survey, has been carried out over the past few years, it should be pointed out that valid comparisons of test or survey results between different handpump programmes, countries and regions is usually impossible in the absence of uniform procedures and methods.

For this reason it is believed that a guidance document (manual) would be a valuable contribution to future work. Such a manual should provide guidelines on monitoring of field performance, field and laboratory tests of handpumps so that those agencies and institutions interested in the testing, selection and development of pumps can follow the same procedures and methods.

The material contained in the draft documents ("Guidelines on Evaluation of Handpumps", and "Guidelines on Testing of Handpumps") reviewed by the Meeting, provides a good basis for the preparation of a single guidance document (manual) on the subject of handpump testing and evaluation for the selection and development of pumps. Testing in support of quality control of manufacture should also be considered, as well as economic analysis for comparative evaluation of cost effectiveness of different types and models of pump.

The material should be simplified and summarized to the greatest extent possible. Worked examples should be included to demonstrate the method of recording results and the (comparative) evaluation process.

Diagrams should be used to explain and standardize handpump component nomenclature. The guidance docuemnt should indicate what to measure/record/monitor, how to do it, and the way of reporting the test data and evaluation results.

The guidance document, when completed in an improved draft version, should itself be tested on a meaningful scale and revised as necessary in the light of the experience so gained, prior to being finalized and offered for widespread use.

There was general agreement that (comparative) testing of handpumps under controlled laboratory conditions can give very valuable support to the selection and development of pumps. Laboratory tests can be especially useful in identifying weaknesses of design or materials. However, to give the full picture emphasis must be placed on field performance monitoring, field tests and evaluation.

Particular attention was paid to a proposal document submitted by the World Bank to the United Nations Development Programme, describing a global project for field and laboratory testing of handpumps, and development of selection guidelines.

The Meeting unanimously adopted a resolution recommending:

(1) Support to the global project for field and laboratory testing of handpumps, and development of selection guidelines;

(2) Cooperative action and continuing exchange of information on handpumps among the participants in the Meeting, and other interested agencies and persons;

(3) Coordination function of the IRC/CWS in respect of the cooperative action and continuing information exchange.

The full text of the resolution in given in Annex C.

ANNEXES

Annex A

LIST OF PARTICIPANTS

NATIONAL AGENCIES/ORGANIZATIONS

Bangladesh

Tewari, K.D.	Assistant Project Officer, Water Supply and Environmental Sanitation, UNICEF, Dacca, Bangladesh.

Ethiopia

Alebachew Beyene	Regional Manager (Southern Region), Ethiopian Water Resources Authority, Addis Ababa, Ethiopia.

Ghana

Acquah, T.B.F.	Chief, Planning and Research, Ghana Water and Sewerage Corporation, Accra, Ghana.
Bannerman, R.R.	Project Manager, Ghana Upper Region (CIDA) Water Supply Project, Bolgatanga, Ghana.

India

Subba Rao, S. (Rapporteur)	Professor and Head of Department of Sanitary Engineering, All India Institute of Hygiene and Public Health, Calcutta, India.

Indonesia

Soebeno Hadiwidjojo	Chief of Rural Water Supply Project, Directorate of Hygiene and Sanitation, Ministry of Health, Jakarta, Indonesia.

Malawi

Robertson, L.H. (Rapporteur)	Senior Water Engineer, Ministry of Community Development, Lilongwe, Malawi.

Philippines

Borromeo, C.M.	National Resource Expert in Water, Ministry of Human Settlements, Makati Main, Metro Manila, Philippines.

Thailand

Verasak Kraivichien	Chief of Equipment Control Division, Office of Accelerated Rural Development, Ministry of Interior, Bangkok, Thailand.

BILATERAL DEVELOPMENT AGENCIES

Bennell, B.M.U.	Principal Engineering Adviser, Overseas Development Administration, London, England.
Wilson, D.R.	Consultant, CIDA, Hull, Quebec, Canada.
Surla, L.T.	Consultant, US AID, Washington, D.C., U.S.A.
Ahman, I.	Head of Section for Water and Sanitation, SIDA, Stockholm, Sweden.
Schippers, Ing. C.	Consultant, DTH Netherlands, IWACO, Rotterdam, Netherlands.
Köppler, J.E.	Senior Water Engineer, German Agency for Technical Cooperation, (GTZ), Eschborn, West Germany.

INTERNATIONAL ORGANIZATIONS

Ballance, Dr. R.C. (Chairman)	Sanitary Engineer, Division of Environmental Health, World Health Organization, Geneva, Switzerland.
Villa-Real, R.M.	Assistant Procurement Officer, UNICEF, New York, U.S.A.
Bayer, P.P.	Procurement Officer, UNICEF, Geneva, Switzerland.
McLeod, K.R.	Project Officer (Water Section), UNICEF, New Delhi, India.
Kalbermatten, J.M.	Water and Wastes Adviser, World Bank, Washington, D.C., U.S.A.
Tsutsui, H.	Senior Officer, Land and Water Development Division, FAO, Rome, Italy.

RESEARCH, TESTING AND CONSULTING ORGANIZATIONS

Cuthbert, Dr. J.	Head of Testing, Consumers' Association, Harpenden Rise Laboratory, Harpenden, England.
Potts, P.W.	Senior Research Scientist, Office of International Programs, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia, U.S.A.
Collett, J.R.	Water Project Officer, Intermediate Technology Development Group, London, England.
Kennedy, Dr. W.K.	Lecturer in Engineering Mechanics, The Open University, Faculty of Technology, Milton Keynes England
Sternberg, Dr. Y.M.	Director, International Rural Water Resources, Development Laboratory, University of Maryland, College Park, Maryland, U.S.A.

Knight, L.	Scientist, International Rural Water Resources, Development Laboratory, University of Maryland, College Park, Maryland, U.S.A.
Paulsen, J.S.	Manager International Operations, W.L. Wardrop & Associates Ltd., Winnipeg, Manitoba, Canada.
Dillon, L.S. (Observer)	Resident Manager, Associated Engineering Services Ltd., Ethiopian Water Resources Authority, (Southern Region), Addis Ababa, Ethiopia.

CONSULTANTS

McJunkin, Dr. F.E.	Consulting Engineer, Chapel Hill, N.C., U.S.A.
Stapleton, C.K.	Consultant, Buxton, Derbyshire, England.

SECRETARIATE

Hofkes, E.H.A.	Programme Officer, WHO International Reference Centre for Community Water Supply, Voorburg (The Hague), The Netherlands.
Kingham, J.A.	Project Controller, Consumers' Association, Harpenden Rise Laboratory, Harpenden, England.
Bianco, M.M. (Conference Secretary)	Programme Assistant, WHO International Reference Centre for Community Water Supply, Voorburg (The Hague), The Netherlands.

Annex B

AGENDA

1. Opening of the Meeting

2. Introduction of Chairman and Rapporteurs

3. Scope and Objectives of the Meeting, Mr. E.H.A. Hofkes, IRC

4. Presentation by Participants

5. Introduction of Background Documents

6. Introductory Paper, by Mr. C.K. Stapleton,
   - Handpump Requirements of Rural Water Supply Programmes -

7. Presentation of Guidelines for Handpump Testing (Working Document No. 1), by Mr. J. Kingham

8. Presentation of Guidelines for Evaluation of Handpumps (Working Document No. 2), by Dr. F.E. McJunkin

9. General Comments by Participants

10. Working Group Sessions
    - Handpump Testing (Field and Laboratory)
    - Handpump Evaluation (Technical, Economic, Socio-cultural)

11. Visit to Harpenden Rise Testing Laboratory

12. Working Group Sessions
    - Handpump Testing Guidelines
    - Handpump Evaluation Guidelines

13. Final Review Session
    - Handpump Testing Guidelines
    - Working Group Report
    - Final Review and Discussion
    - Recommendations

14. Final Review Session
    - Handpump Evaluation Guidelines
    - Working Group Report
    - Final Review and Discussion
    - Recommendations

15. Projects
    - Country Projects for Field Testing and Evaluation of Handpumps
    - Multi-country Cooperation

16. Cooperative Action
    - Mechanism for Exchange of Results
    - Coordination

17. Adoption of Recommendations

18. Closing Session

Annex C

RESOLUTION

Whereas, this Conference recognizes the urgency of attaining the goals of the International Drinking Water and Sanitation Decade;

Whereas, a significant proportion of country level programmes during the Water Decade will centre on the wide application of handpumps in developing countries;

Whereas, a serious problem exists in the area of handpump technology, design and application;

Whereas, the development of handpump technology will require a set of standard guidelines establishing the protocol and methodology for handpump testing, evaluation and development;

Whereas, international cooperation and correspondence in the area of handpump technology will be of universal benefit to all countries of the world;

Whereas, a coordinating mechanism will be required to administer international efforts in handpump technology;

It is resolved, as this Conference does hereby resolve to:

1. notify the United Nations Development Program by way of a copy of this Resolution, of this Conference's strong recommendation to approve the Global Project Proposal entitled:

   Rural Water Supply: Hand Pumps
   - Laboratory and Field Testing -
   - Development and Selection Guidelines -

   as submitted in June 1979.

2. undertake cooperative action in the field of handpump technology through a continuing exchange of information among the participants (as listed in Annex A) and other interested agencies and persons;

3. request the International Reference Centre for Community Water Supply to undertake the administration and coordination functions required by the resolved undertakings as described in the preceeding paragraphs above;

4. authorize the Chairman to inform the United Nations Development Programme of the passage of this Resolution.

Executed on this 1st day of June, Nineteen Hundred and Seventy-Nine, in Harpenden, Hertfordshire, United Kingdom.