May 1977

International Workshop on hand pumps for Water Supply

A report on the International Workshop held in Veenstarg, The Netherlands, 12-16 July 1976

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Bulletin Series

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WHO INTERNATIONAL REFERENCE CENTRE
FOR
COMMUNITY WATER SUPPLY

INTERNATIONAL WORKSHOP ON HAND PUMPS FOR WATER SUPPLY

Voorburg (The Hague), The Netherlands
12-16 July 1976

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REPORT

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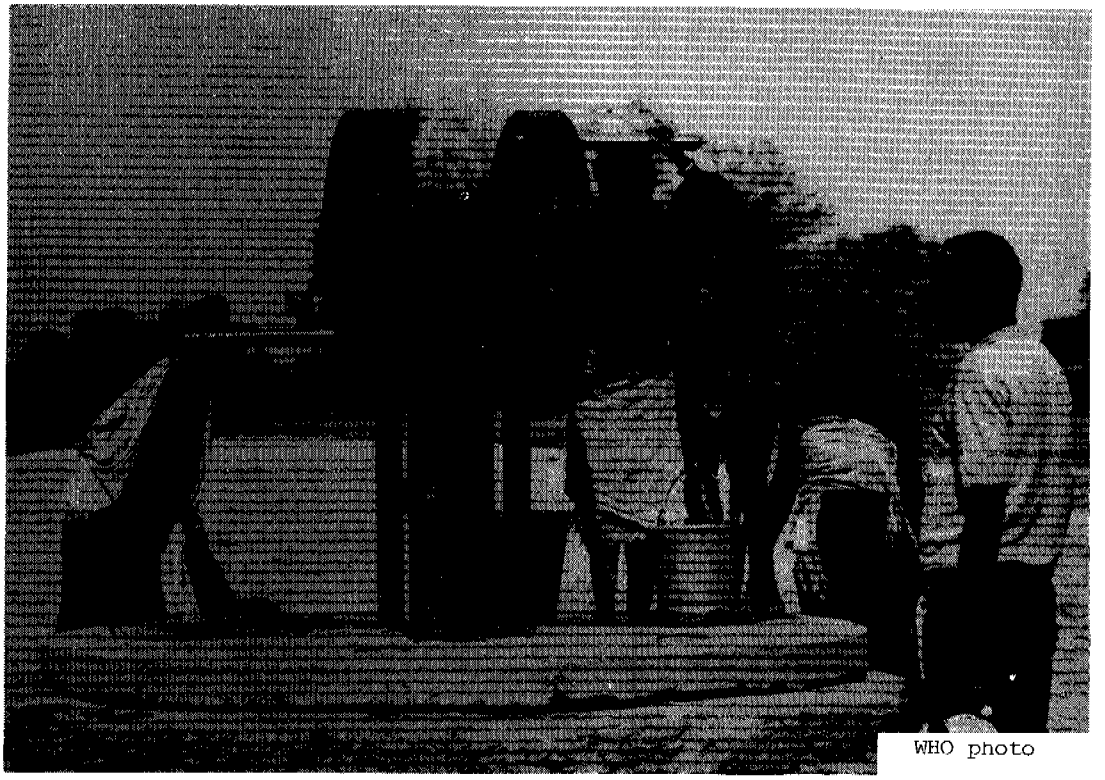

WHO photo

Hand pump performance must be reliable even under almost continuous use

1. INTRODUCTION

1.1 Background

Groundwater is a source of water supply widely used all over the world. When tapped at suitable depths, the water is free of suspended solids and has most of the desirable physical, chemical and bacteriological characteristics. Often, the water can be supplied to the community without any treatment. Thus, groundwater has been a proper choice of water source particularly for small communities where treatment of surface water is difficult or impossible to administer. In developing countries, where the majority of the population lives in rural villages, groundwater, if available, almost always constitutes the best possible source of potable water.

A small diameter tube well or a protected dug well equipped with a hand pump* is well suited for the provision of safe water to rural communities. Hand pumps are important elements in the supply of drinking water in villages. Consequently the safety and health of the rural community will depend considerably on the performance of these simple water lifting devices. Although representing basically simple technology, hand pumps are often not built and installed to proper specifications. Since components of a hand pump are subject to wear, maintenance services and organization of supervision are required.

Millions of people already depend on hand pumps for their drinking water. Major hand pump programmes are underway or planned in many countries. There is a growing awareness of the important role hand pumps will realistically play, for a long time to come, in providing an acceptable water supply to many millions. However, experience shows that many existing hand pumps are deficient or have been abandoned altogether, because of inadequacies in design, manufacture, installation, operation and maintenance. Each time a pump fails, the community is exposed to the hazard of using unsafe water from the locality until the pump is put back into operation. Quick attendance to hand pumps that break down is often difficult to arrange because of inadequate community involvement and motivation, poor communication, inadequately trained repair staff and non-availability of spare parts. A pump's failure renders a well useless. Appropriate design criteria are needed that can be used, particularly by developing countries in meeting prevailing operating

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

conditions as well as health requirements. There is a search for pumps which are more durable, trouble-free, sanitary, and inexpensive; which require maintenance within the limitations of local capabilities; which are easy to operate and acceptable to users, including women and children; and which, in principle, are suitable for local manufacture using such materials, equipment and manpower, as are available.

There appears to be a new interest in rural water supplies of developing countries. Amongst other things, this is mirrored in research and development on hand pumps, new manufacturing and appropriate technology approaches. Within the past ten years, several studies of different types of hand pumps have been sponsored by international organizations, national agencies and pump manufacturers, under varying conditions. Several organizations have worked on a simple technology that can be appropriately used in the design and manufacture of hand pumps at the village level.

1.2 Preparation of Handbook on Hand Pumps

Information on hand pumps presently seems to be more in demand than ever. Governments of developing countries as well as international organizations and bilateral development agencies are involved in rural water supply programmes. Many governments are developing programmes to supply water to rural communities by constructing tubewells and boreholes, and fitting them with hand pumps.

The proposal for the preparation of a handbook on hand pumps, was submitted by WHO to the Fund of UNEP in February 1973. Simultaneously, collection of information on hand pumps was started and much documentation was gathered from various sources. WHO also supported a number of investigations on hand pumps, but the findings tended to be inconclusive.

In April 1975, UNEP agreed to partially finance the preparation of the manual on hand pumps*. WHO then contacted the IRC to explore the possibilities of making the project a collaborative effort. This resulted in the IRC taking on the project on the basis of mutually agreed inputs and contributions.

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* UNEP Project No. (462) 0101-74-002.

The handbook is intended to serve engineers and administrators who are planning and administering hand pump programmes, mainly in the technical sense. It is meant to be a contribution to the challenging task of improving the water supply situation in the developing countries, particularly in the rural areas.

Numerous reports, correspondence, memoranda from field staff, drawings, specifications and other information were made available to the IRC by national water supply authorities, international organizations, universities, research institutes and hand pump manufacturers.

Mr. F.E. McJunkin, acting as consultant, reviewed and evaluated the available documentation and collected much information that was found lacking. He prepared a comprehensive draft, which was first circulated for review to some 60 agencies and individuals known to have active hand pump programmes or interests.

Major points raised in this review stage were:

- much further work would be required to develop the draft handbook into a final document
- it would be better to issue an interim version of the handbook as soon as possible with a finalized report following later
- the necessity of community involvement in respect of hand pump maintenance should be clearly mentioned
- pumps for shallow wells should be differentiated from deep well pumps
- open top cylinders should be dealt with in comparison with closed top cylinders
- it would be appropriate to mention the possible use of multiple pump leathers
- some information on small diameter pump cylinders should be given
- a brief review of the use of PVC-pipe for well casing and pump cylinder would be useful

Following the review by mail, the draft of the handbook was revised and presented for formal review.

2. DESCRIPTION OF THE WORKSHOP

2.1 General

The International Workshop on Hand Pumps was held in Voorburg (The Hague), the Netherlands, from 12th to 16th July, 1976. The conference was organized by the IRC.

The purposes of the meeting were:

- to review, evaluate and supplement the draft report on hand pumps, as prepared by the consultant, Mr. McJunkin
- to commence the preparation of integrated guidelines for water supply projects using hand pumps
- to recommend further studies and activities in planning, technology, and management aspects of hand pumps, and formulate international collaborative programmes with a view to initiate their implementation

The workshop operated informally. There was a general agenda to guide the presentations and discussions and to provide a basis for time control. Questions and comments were permitted freely.

Mr. G.W. Putto, Deputy Director of the National Institute for Water Supply, Voorburg, welcomed the participants to the Workshop. He informed the meeting that Mr. G. Biryukov, who was to officially represent UNEP at the opening session, was unable to attend because of illness. Dr. Ballance of WHO, Geneva, was especially thanked for the continuous support he had given to the preparations of the meeting and the work on the draft hand pump manual.

Professor O. Kranendonk, of the Royal Tropical Institute, Amsterdam, opened the meeting, speaking from his experience as an international health worker. He stressed that for many people, especially in rural areas of developing countries, the availability of an ample, acceptable and safe water supply would mean a new quality of life. To improve the living conditions of communities in under-privileged parts of the world, water supply engineers and health professionals should join forces, even more so than in the past.

Mr. B.M.U. Bennell, of the Ministry of Overseas Development, United Kingdom, acted as Chairman and deserves everyone's thanks for guiding the discussions and enabling the agenda to be covered within the available time.

Many participants observed that the work of compiling information on hand pumps for subsequent development into guidelines has stirred up considerable interest. Apparently, there is a real information need to be served.

Considerable discussion was stimulated by the question as to which users the handbook should, at this stage, primarily address itself to. Should emphasis be directed to making available comprehensive technical information on hand pumps? It was agreed that, in using the handbook's information to best advantage, each country should decide for itself which approach would promise to be most productive in the particular set of conditions in that country. In doing so, the social and institutional factors associated with hand pump programmes would be better taken into account.

The desirability of a uniform hand pump nomenclature or terminology was mentioned several times. The point was made that a uniform methodology for the development and field testing of hand pumps should be developed, in order to enable information to be compiled and disseminated on a systematic basis.

Technology combining simplicity and low cost with good reliability is much needed and should be developed, preferably within the developing countries themselves. Translating research from the laboratory to field practice is of major importance. Several methods were proposed to facilitate this transfer, such as the exchange of personnel between operating and research agencies, consultancy assignments for research workers and collaborative programmes designed to translate research findings into field operations.

It was strongly advocated that the handbook should deal with the various subjects in a very practical way, if it was to be useful to the planners and executive engineers involved in hand pump programmes. The handbook should cover hand pump technology and related subjects as completely as possible but its scope should not be extended beyond the well development; the design and construction of wells themselves were no subjects for a manual on hand pumps.

On behalf of the Secretariate, it was explained that Mr. McJunkin, with the help of the IRC, would prepare an improved version of the handbook. All comments, suggestions, recommendations and points made in the discussion would be taken into account. The document would then be made available for distribution, primarily to the participants of the workshop and other directly involved experts and organizations; following formal clearance the manual would be published for wide circulation.

It was also expected that the participants would ensure active participation of their organizations in the follow-up activities and studies recommended by the workshop. The IRC would support the collaborative projects by providing clearing-house assistance and coordination.

In summarizing the discussion, the Chairman observed that it is necessary to develop basic options which can be applied to varying sets of situations. The ultimate goal should be to develop a document which analyzes the financial, technical and social aspects of hand pump programmes.

The workshop participants expressed their unanimous appreciation to the organizations which had sponsored and organized the meeting: the United Nations Environment Programme, the World Health Organization and the International Reference Centre for Community Water Supply. The conviction was cited that the workshop would provide a valuable contribution in furthering the development of the rural water supplies with hand pumps.

The present report consolidates the proceedings of the workshop relating to subjects discussed in general.

Many comments and suggestions of the participants in the meeting were contributed to the detailed review of the draft of the *Handbook on Handpumps*, as prepared by the consultant. They will be incorporated in the revised edition of the handbook which will be published by the IRC, under the joint sponsorship of UNEP and WHO, in summer 1977.

Although representing the general opinion expressed in the workshop, the observations and views given in this report are not necessarily shared in their entirety by all who participated.

3. CONTRIBUTARY PRESENTATIONS

Mr. W.K. Journey briefly set out the conditions that actually pertain to rural areas. The hand pump must perform reliably under almost continuous use. Experience suggests that rural residents should as far as practical, maintain their water supply themselves. To meet the conditions of endurance and reliability under heavy use, a design for hand pumps should:

- employ local materials as much as possible
- be mechanically very simple and
- lend itself to local, untrained maintenance

Mr. Journey described a design recently proposed which simplifies the pump mechanism, and substitutes plastic pipe for the traditional steel and cast iron. This simplification and substitution may reduce the cost of manufacturing hand pumps in many areas.

Principal features of the design are*:

- plastic pipe is used to perform a dual function: as well casing and as pump cylinder
- submerged, interchangeable piston and check valve reduce complexity
- pump rod employs local materials
- pump rod guides may not be necessary
- local materials can be used to make pivot points
- cup seals are made of leather

Mr. Journey mentioned that the concept was already being used in limited numbers in Ghana and Thailand, where it has been developed independently. It was generally considered that the use of plastics and simplified designs has potential.

Mr. V.J. Emmanuel described the development of the Bangalore pump**. This work was carried out, from 1973-1975, as part of the national project "Village Water Supply" of the Government of India. The project has received and continues to receive financial and technical assistance from UNICEF and WHO.

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* Report prepared by W.K. Journey for internal use, World Bank, June 16th, 1976.

** Report prepared for the Government of India, WHO South East Regional Office SEA/Env. San/168, New Delhi, March 1976 (given general clearance by Government of India: July 1976).

To support the pump development work, considerable time was spent on the study and evaluation of the different existing deep-well hand pumps available. It was evident that the good features of several types would need to be combined in an improved version. As it turned out, the design of a cylinder produced by the project depended very little on existing models. For the improved cylinder, the use of epoxy resin components was adopted and all parts of brass or machined metals were eliminated. For the pump head, the single pivot chain-link arrangement, first devised in India by the Jalna pump manufacturers and subsequently modified in the Sholapur pump, was adopted, some modifications being made to the bearings and the roller chain.

Dr. A. Chakravarty completed the presentation on the hand pump development work in India by describing the role of the Mechanical Engineering Research and Development Organization (MERADO), Madras. MERADO collaborated from the beginning in the WHO assisted project, and prepared certain working drawings, produced the prototype cylinder assemblies and executed the construction of the accelerated testing device. The cast iron pump head of the earlier design (Bangalore Pump) was discarded in favour of a newly designed pump head of fabricated steel construction. The cylinder valve assembly, however, remained basically unchanged. The later model of the pumps, for which the development work was carried out entirely by the MERADO, from July 1975 onwards, may more accurately be referred to as the "Deep Well Hand Pump - Mark II" as distinct from the Bangalore Pump. MERADO will be supervising extensive field trials of the Mark II pump.

Mr. R.D. Fannon described the history of the evolution of the Battelle* pump. This programme was initiated by US AID to define the requirements and specifications of hand pumps suitable for water supply use in developing countries.

The basic specifications used in developing the pump were:

- low production cost
- long life under severe conditions
- easy maintainable with simple tools and unskilled labour
- suitable for shallow or deep-well installations, with only minor changes (cylinder location)

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* Field research and testing of a water hand pump for use in developing countries, Battelle Laboratories, Columbus, Ohio, U.S.A. January 1975 and several other Battelle reports.

- capable of being manufactured by established firms within the developing countries with a minimum of capital investment
- easily operatable by small people, including women and children
- so designed that pilfering and vandalism will be discouraged

A simple piston pump design was identified as being the most suitable for the needs of developing countries. For the selected design, a manufacturing specification and drawings were prepared. Arrangements have been made for the fabrication and supply of shallow well-type pumps for field evaluation. This is being done in Bangladesh in conjunction with the UNICEF Water Supply Programme. Some further development work is being carried out with regard to the deep-well version.

Mr. Fannon emphasized that cost and maintenance factors are becoming more important. Local manufacture should be recommended in order to assure spare part availability for maintenance, as well as acceptability of the pump design.

Mr. J.F. Shawcross, UNICEF, Dacca, gave a presentation on the Bangladesh drinking water programme. The presentation covered data gathered so far, on the status of the water programme. Major points made were as follows:

- 1.200 deep wells were completed by mid 1975
- 160.000 shallow wells were completed by mid 1975
- 155.000 shallow wells have been started and will be completed by mid 1979
- 5.000 deep wells will be completed by mid 1979
- the overall rural drinking water situation shows 30 percent of the population being served in 1970, 60 percent in 1976 and there will be an estimated 80 percent being served in 1979
- polyvinyl chloride pipe, instead of galvanized iron (G.I.) pipe, is used, decreasing cost of wells considerably
- the hand pump used has been modified to where it is fairly reliable
- prototypes of new types of hand pumps have been completed (for family use inside of the house)
- manual irrigation pumps appear to have potential
- the rationale for choosing a pump that will be suitable for widespread distribution depends on such things as tradition, existing pumps, cost of wells, cost of pump alternatives, intensity of use, stresses on pump, types of maintenance organizations, social attitudes of population served and local production ability
- with regular maintenance a reasonable pump design can be kept in operation

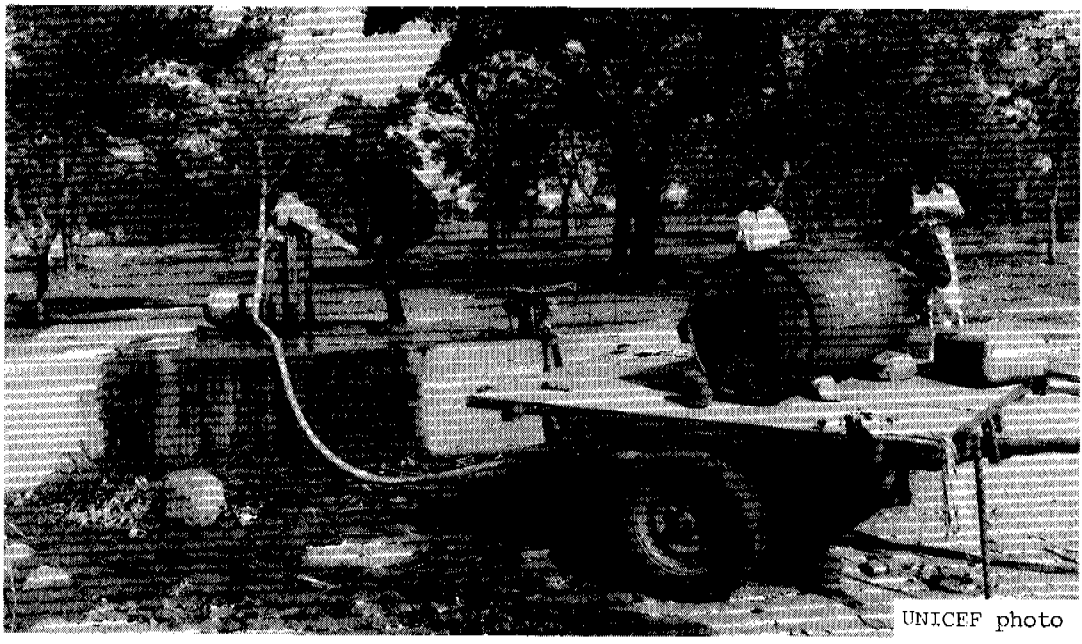
Mr. C.J. Bonnier, Netherlands Agency for Development Cooperation, gave a presentation on the Shinyanga Shallow Wells Project in Tanzania. The general discussion concentrated on costs of the pump and well (pump costs about Shs. 2.000)*, environmental aspects and alternatives available to the use of the Shinyanga pump. Practices of maintenance were questioned and how maintenance could be improved. The techniques adopted for the construction of the wells received keen interest.

Mr. S. Atallah made a special contribution on rural water supply services in Tunesia, illustrated with photographic slides. He explained that, in view of the wide dispersement of the rural population, groundwater sources were used where possible, i.e. protected springs or dug wells equipped with a hand pump. An indigenous hand pump had been developed and will be used in preference to currently available import models.

Dr. A. Abrobah-Cudjoe outlined activities undertaken on the UST hand pumps which feature a plastic drop pipe and cylinder and roller bearings. He emphasized the use of steel welding as a possible alternative manufacturing method for the pump body. He also briefly introduced comparative field testing of hand pumps in Ghana.

* About U.S. $ 240.

WHO photo



UNICEF photo

Pumping water for transport to the users

4. INSTALLATION, OPERATION AND MAINTENANCE

4.1 General

Installation of hand pumps on tubewells and dug wells may best be carried out with government assistance, but normal maintenance should be paid for by the local authorities and communities themselves. Attention by supervising agencies to record the performance and condition of hand pumps has been irregular.

4.2 Installation

Hand pump installation programmes should use the rough guideline of at least one pump for every two hundred people; the pumps should preferably be situated at less than 1 kilometer walking distance from the village centre. Of course, hand pump supplies must never be installed near open sewerage, nor primed with dirty water.

4.3 Operation

Health education may be expected to promote the proper use and operation of a hand pump. If the information should be presented in a booklet, the caretakers of the pumps should be given some pre-orientation prior to receiving it. Some operational instructions may be cased into the hand pump body itself.

4.4 Maintenance

Maintenance and repair of hand pumps presents a great problem. Premature pump wear, shortage of mechanics and lack of authoritive maintenance programmes, all add to the poor performance record.

Often administrators tend to confuse maintenance with repairs. The importance of maintenance as a means of preventing breakdowns should be brought out more clearly. Many rural water supply programmes will need an improved system of maintaining the installed pumps, if the impact of the programme is to continue. Assistance which stops at providing a village with a hand pump water supply, does not ensure that the villages will continue to be served. It is necessary to develop community participation and involvement with particular emphasis on preventive maintenance. Often good maintenance is secured, when a cooperative or a prominent person in the community or a school committee, takes responsibility for the hand pump water supply.

Common problems encountered in hand pump servicing, are:

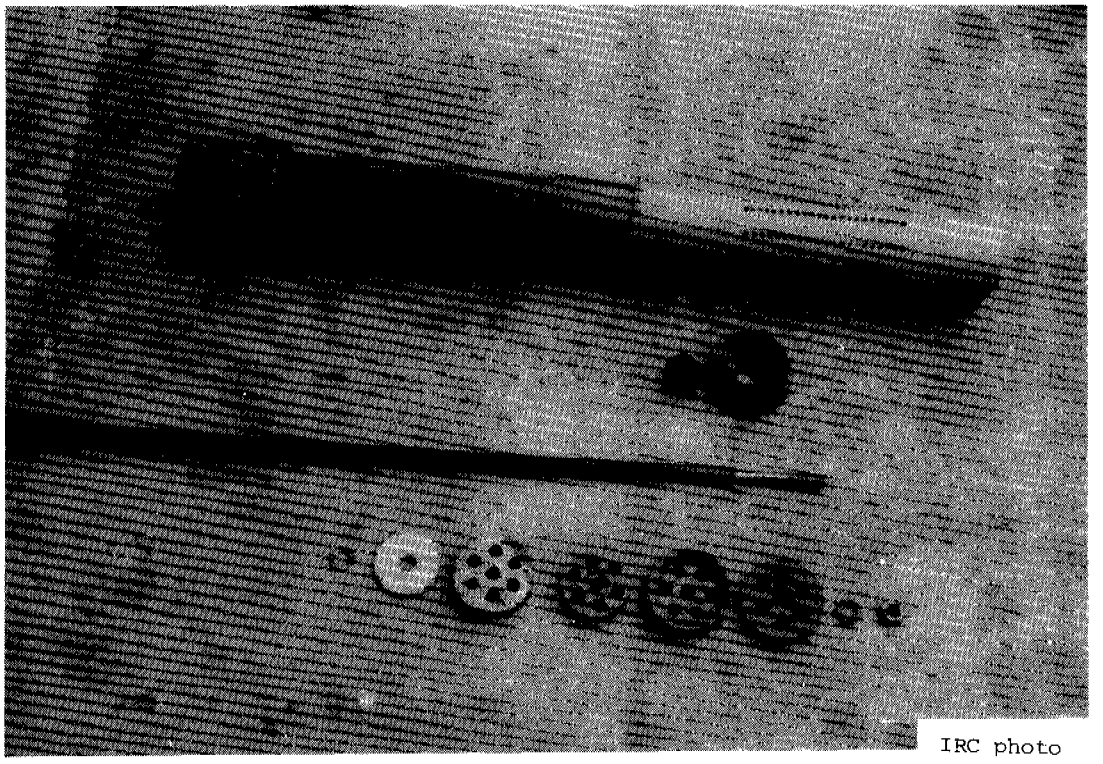
- difficulties in replacing plunger cup seals
- failure to lubricate pins and connectors
- rod coupling failure (in case of deep well pumps)
- pilfering of parts
- inferior tools
- poor store house facilities resulting in weathering or corrosion of spare parts

Centrally organized maintenance is likely to be expensive because of long distance use of vehicles and inefficient use of mechanics. It also requires an administrative organization which is often not fully capable of taking prompt action upon receipt of a notification for repair.

It is noted that in many countries there is apparently no lack of technical skills in the villages because people use and maintain bicycles, motorcycles and small gasoline and diesel engines for pumping irrigation water of grinding grain. These devices are often much more complicated than a hand pump and if the villagers are successful in keeping them in order, the proper maintenance of their hand pump should not present major problems.

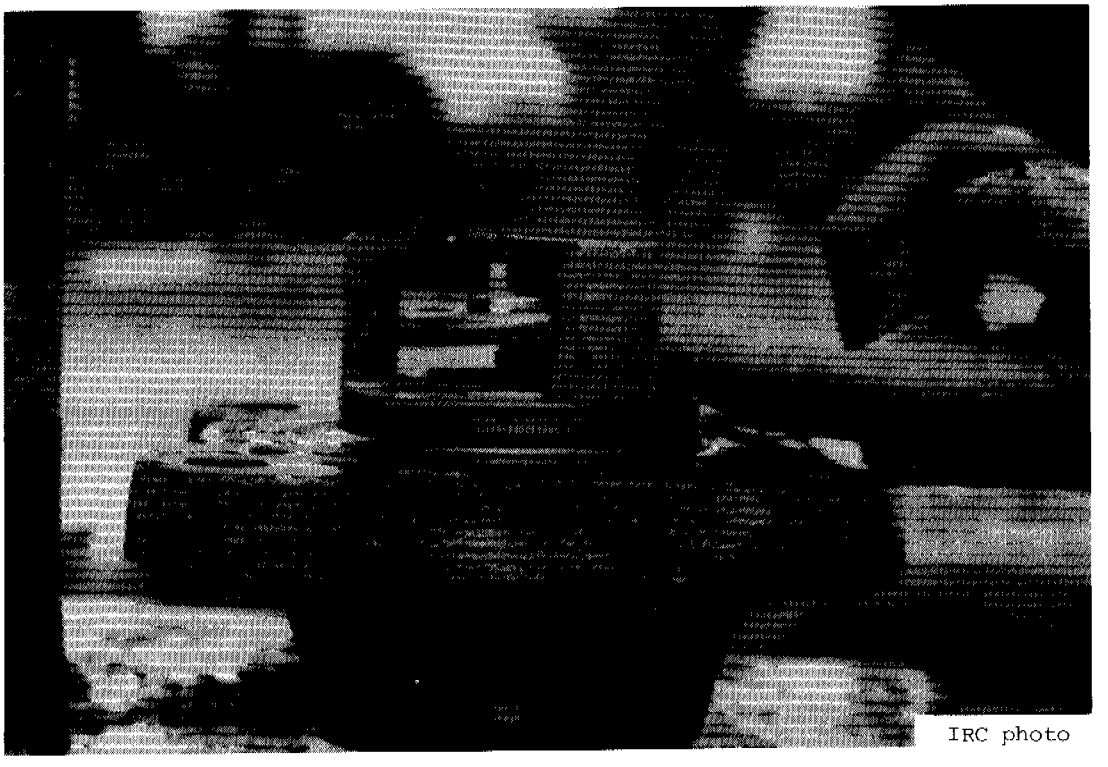
Spare parts must be made readily available to the village mechanic or hand pump caretaker. He should know the name and address of the nearest place where they can be obtained. In addition, a repair manual for the pump should be available as well as the address of the provincial or district agency to be notified in case a problem develops that is beyond the village capability.

There are no fixed rules to determine which balance of government and village community involvement is right for each country. Organizations which seem to hold good chances of success are those where a governmental service takes responsibility and imposes charges for regular maintenance work. Exceptional expenditure such as replacements may be shared between the government and the village community.



IRC photo

Pump cylinder with pump rod and valve elements



IRC photo

Worn valve

5. TECHNOLOGY, RESEARCH AND DEVELOPMENT

5.1 Hand Pump Technology

Many water lifting devices developed in historical times or more recently are mainly for irrigation applications and have little potential for water supply. In rural areas, their application is largely restricted to lifting groundwater from open wells of large diameter, or water from irrigation courses.

While it is true that the reciprocating piston pump known since ancient times and made, over the centuries, from all kinds of materials, is by far the most extensively used, one should not be solely concerned with this type of pump. Other types may be considered and merit attention although they are not used so widely for water supply purposes; e.g. the chain type pumps, the diaphragm pumps, and the helical rotor pumps.

Hand pump nomenclature

Hand pump nomenclature varies considerably with each source of information using its own set of terms to indicate the different parts. A uniform terminology, if widely accepted, would be very useful.

Users' characteristics

Data on users' characteristics are important to determine basic criteria for hand pump design and installation; however, as yet there have been very few efforts to collect these data on a systematic basis.

Bearings

Proper understanding of mechanical and structural loading of a hand pump and the resulting stresses is essential. Bearing pressures should be calculated carefully, in view of the fact that failures and unsatisfactory performance are common experience.

Projected pin area should be adequate for the calculated forces with bearing pressures within the allowable range. It would be interesting to know allowable bearing pressures for different materials depending on lubrication, smoothness, tolerance etc. Roller bearings might well be considered a cost-effective feature for deep well pumps.

Pump cylinder

It is difficult to obtain cast iron cylinders sufficiently smooth to prevent rapid wear of leathers and buckets. The wear may be assumed directly proportional to the roughness of the cylinder wall.

Brass cylinders or thin brass liners have been used to advantage, but PVC pipe may also be used to obtain a smooth cylinder. PVC is available in most countries and, in sizes below 100 mm in diameter, is usually lower in cost than any other material.

Cast iron cylinders may pit and rust very quickly in acid waters, particularly in that portion of the cylinder not contacted by the stroking plunger. Epoxy coatings can possibly be used to provide a smooth cylinder bore at acceptable costs.

Open-top cylinders may be more readily adaptable to local manufacture than conventional ones. The easy removal of plunger and check valve together with the pump rod is an advantageous feature, enabling good maintenance of open-top cylinders.

Valves

There is little published information on what type of valves will best perform the various functions in a hand pump, in terms of cost, reliability, resistance to wear etc. In most instances the flapper valve possibly fitted with new type materials instead of leather, can be used.

Both flapper and poppet valves are capable of satisfactory performance, but for deep well service the poppet valve may be preferred because it can give longer service without maintenance. Poppet-type check valves should have some feature preventing wear due to the impact of the valves on the seats. For deep well use the valves should be fitted with gaskets.

Pump Body and Handle

The pump stand ordinarily supports the handle, but it is often simpler to have the handle supported on a separate post. Local materials may be used to advantage for this. The handle can be made of wood and replaced locally when worn or broken. It is necessary to have a stop on the support pier otherwise the handle will strike the top of the pump stand.

The position of the separate post supporting the handle can be so chosen as to obtain the best leverage depending on the depth of the water to be pumped. Pump stands not bearing the load and stress caused by the handle operation need not be as strong as conventionally loaded ones.

5.2 Research and Development

In programming research and development work on hand pumps, the possible direct usefulness of the findings for the planners and executive engineers responsible for hand pump programmes, should be emphasized.

Descriptions of research and development work would gain in value if some indication of cost, in terms of manpower and time requirements is included. This would be most useful in the planning of other research projects.

Experiences with the planning of a research programme as part of a hand pump installation project show, that due to the urgent nature and time constraints of such projects the actual pump development work is very often limited to modifications of existing local pumps rather than the development of a new design.

There is a need to develop a methodology for research in rural water supply including hand pumps. Such methodology, if widely accepted, would materially assist in the exchange of information on a systematic basis.

6. MANUFACTURE; USE OF LOCAL MATERIALS; COSTS

6.1 Manufacture; Use of Local Materials

The quality of hand pumps manufactured in local foundries and machine shops is often not satisfactory, but the potential of local manufacture should not be overlooked because of the inherent advantages as well as the beneficial indirect effects of such production.

Guidelines indicating at what level of hand pump usage local production should be considered instead of the use of imported pumps, would be most useful. Costs related to size of production runs, local manufacturing capabilities, quality control etc. should be taken into account.

The problems of setting up production facilities are not to be taken lightly. Assembling hand pumps from off-the-shelf components and the use of local materials may constitute the appropriate intermediate step, because it requires less expertise. Quality aspects of casting and machining pump parts should be given full attention. It will not be possible to consistently maintain the machining tolerances required unless machine tools are better kept than in current practice.

Before beginning a local manufacturing activity it is wise to determine the most feasible alternative, as a means of arriving at the best decision. Questions to be considered are: whether the parts should be purchased from national firms, or locally produced or imported in bulk; also, whether the parts should be made from castings which require foundry facilities, or fabricated using welding techniques or assembled from various other materials such as wood, plastic etc.

Except for some low lift pumps which can successfully be made in the village, hand pump manufacture must be thought of in terms of adequately equipped workshops capable of building pumps from durable materials, usually metals. They rank as small industries and often serve districts, provinces or even countries.

6.2 Costs

Technical feasibility is not identical to economic feasibility. Revenue derived from the sale of the finished hand pump, or its estimated market value, should be compared with the cost of production.

Cost budgeting requires estimating labour involved, raw material requirements and overhead, preferably for each separate part. Historical data where available can be helpful, otherwise educated guesses are necessary. A rational cost analysis should be aimed at. Comparing the costs of complete pump assemblies is less useful than cost comparison of various components.

6.3 Reference Material on Existing Hand Pumps

It would be useful to have reference information on existing hand pumps, possibly in loose-leaf form. This would comprise a tabulation (kept up-to-date) giving:

- drawing showing principal features
- estimated number in use; length of time pumps have been used
- head and discharge capacities
- maintenance and cost data
- weight; quantities and types of materials used
- percentage of imported components
- level of production capabilities required

Such information will materially assist in the selection of a hand pump best suited to a particular set of conditions and also prove useful in determining the best procurement procedures.

The Handbook on Hand Pumps will comprise a Directory of Hand Pump Manufacturers.

7. RURAL WATER SUPPLY PROGRAMMES INVOLVING HAND PUMPS

7.1 Integration with other Programmes

The rural water supply programme is to be dovetailed into the national development plan. It is necessary to seek the active participation of the rural communities in all stages of the programme implementation. Employment of local labour and use of indigenous materials should be favoured. In allocating water resources for drinking water supply, future requirements of the rural communities must be taken into account. The national procurement policy should include encouragement of local industry and stimulate the improvement of the quality of indigenous products.

7.2 Financing, Investment Justification and Charging for Water

The size, scope and success of the rural water supply programme will depend on adequate financing to develop a strong organization, having the staff to plan, design, construct, supervise the programme and ensure its continuance. This will require adequate funds becoming available.

The funds for the overall administration and management of the programme will primarily need to come from the national government. The major portion of the funds for the construction of the facilities will also have to be provided by the government from its own resources but may partly come from international and bilateral grants and loans. A contribution to the works in the form of labour, materials and funds (if at all possible) should be made by the communities to promote that they place a proper value on the facilities and help maintain them after completion.

To obtain funds from the national government it is essential that the policy makers understand the programme and its needs and make adequate financial commitments. Emphasis should be placed on the relationship of the water supply programmes with the overall development strategy. This will facilitate proper justification of investment in water supply facilities. Funds should be estimated and arranged for several years to ensure that the programme can continue without interruption.

For accelerating the water supply programme, the government should consider whether to obtain loan funds from international agencies. In such a case, the national government will have to assume the debt service since the rural population cannot be expected, at least during the initial stage, to pay the full costs and are likely to pay not more than operation and maintenance costs. A commitment on the part of the government to provide the funds to meet this obligation, has to be made.

Commitment to meeting the maintenance cost should, in principle, be required from the village leaders before installation of a hand pump supply or inclusion of a particular village in the water supply programme. To assist the village community in carrying out proper maintenance, expert guidance should be given for the first six months after the installation of the hand pump and the cost should be considered part of the government programme. This period is also meant to train and equip the local persons responsible for maintenance.

Spare parts for minor repairs should be sold at a basic fee covering the replacement cost of these materials. Major repairs would be done with the assistance of the national organization. Decentralized storage facilities for spare parts should be established where necessary to expedite maintenance and repair work. Suitable budgeting arrangements must be made for the maintenance work and support function that will be carried out by the national organization. This budget should provide for personnel, travel, materials and equipment, tools and training.

At the village level, a suitable organizational entity, e.g. a committee or users' group, should be formed to assume responsibility for the operation and maintenance of the water supply facility, and for the collection of charges from the users.

7.3 Personnel Management, Manpower Training and Follow-up

Management of personnel irrespective of numbers is the key to the success of any rural water supply programme. Personnel, whether technical or non-technical, need specific training for specific types of jobs and, also follow-up training to keep abreast of new ideas and methods. Training programmes are to be developed for engineers, technicians and mechanics. Instruction material explaining maintenance work on hand pumps and wells should be made available.

8. RECOMMENDED ACTIVITIES AND PROJECTS ON HAND PUMPS

PRIORITY A

1. Comparative Field Evaluation of Hand Pumps

Comparative study of different types of pumps evaluating actual performance, reliability and costs (both capital and maintenance costs). This should include field testing of pumps in similar situations.

2. Comparative Laboratory Testing of Hand Pumps

Laboratory testing of selected hand pumps, under controlled conditions, for performance comparison and evaluation. The laboratory arrangement should enable the testing of pumps under various conditions, so that test results will be comparable. Failure frequency investigation of complete pumps as well as different parts.

3. Value and Reliability Engineering Approach to the Design and Testing of Basic Piston Pump Components

This study will use a value engineering approach in the improvement of designs of piston pump components, including:

- bearing interfaces (pivots)
- valves
- cup seals/cylinder interface
- fasteners
- support structure for pump lever system

This will require:

- information gathering
- analysis and design
- field and laboratory testing
- evaluation of test results
- redesign and retesting

4. Advisory Maintenance Group

Formation of a group of professionals with experience in rural water supply, to carry out a study on maintenance organizations, obtain funds, advise the participating countries as to the establishment and structure of hand pump maintenance organizations. To evaluate results. The group will need to:

- make a survey
- identify possible types of maintenance organizations
- obtain commitments of the participating countries to try out different systems
- coordinate and evaluate progress
- select the types of organizations that warrant promotion and
- (especially) give administrative and technical advice

5. Directory of Manufacturers of Hand Pumps and Hand Pump Components

The directory should comprise:

- name of firm, address, country
- types of pumps produced, size range
- special features, if any
- cross-reference product/component
- countries/regions where the products have been/are used

6. Glossary of Technical Terms relating to Hand Pumps

This study will produce a basis to facilitate the exchange of information and data on hand pumps; at a later stage, it may enable the development of a data bank.

7. Study of Community Involvement relating to Hand Pump Maintenance

To develop guidelines on the best way to inform and instruct the rural communities to adequately maintain their hand pump water supplies. This should include study of customs and traditional belief. Also impact of health education, formation of supervisory village committee, assignment of local responsibilities and technical training.

8. Policy Level Motivation for Rural Water Supply Programme

Hand pumps are important elements in rural water supply programmes to provide villages with an acceptable supply of water, but much more is involved. Officials responsible for policy making need to be informed of the importance of water supply, and the links of water supply programmes with general development regarding housing and sanitation.

This study may result in a guideline giving the general approach and basic factual information, for use in the formulation of the national policy concerning water supply programmes. This should also include a documentary basis for the allocation of priorities within national water programmes.

9. Active File of Information on Existing Hand Pumps

To prepare a catalogue of existing pumps suitable for the different kinds of situations where hand pumps are needed. Pumps for shallow wells should be differentiated from deep well pumps. The catalogue should comprise a series of loose-leaf (e.g. three page) descriptions giving:

- name of pump, drawing, design features
- place(s) of manufacture
- countries and regions where used; estimated number in use
- head, discharge capacity, efficiency
- cost
- maintenance requirements etc.
- addresses for further information

PRIORITY B

10. Preparation of Grass-root Instruction Materials

Preparation of instruction materials from the available information on hand pumps, for those responsible for and involved in the actual installation and maintenance of hand pumps in the field. Also, where appropriate, for the hand pump users. Pamphlets, demonstration models, concise handbooks and other instruction aids (e.g. audio-visual means, radio lectures) for grass-root use. Preparation of the materials in the recipient country, based on or assisted by documents available from international agencies and other sources.

11. Bibliography on Hand Pumps

Comprehensive list of available literature and documentation, with full details including:

- name of author
- publisher
- year when published

Note: to be included in Handbook on Hand Pumps (1977)

12. Study of Drilling Procedures and Techniques as Applicable in different Sets of Conditions

To make available information which may be necessary in the planning of rural water supply projects. This should include guidelines on the most suitable drilling procedure for various types of ground conditions. Information regarding equipment, accessories, required supplies and operational costs will be useful.

13. Study of Impact of District and Village Level Organizational Structure on Water Supply Programmes

To compile information on the present types of organizations at district and village level that are participating in rural water supply programmes. To prepare an analytical report from which orientation for future programmes can be taken. Types of organizations at district and village level; functions, responsibilities and legal framework; systems of rates and charges; use and application of rates and charges; degree of success in collecting rates and charges.

14. Programme Analysis Procedure for Priority Allocation

To assist the countries to work on a survey of rural water supply programmes involving the installation of hand pumps, in order to evaluate the key parameters and constraints. To arrive at a procedure to determine the priority of village communities to be served. This involves:

- the selection of parameters pertinent in each country
- modification of a basic procedure to suit the particular country
- assistance in the application

PRIORITY C

15. Training Programme for Caretakers of Hand Pumps

To develop a workable training programme for the caretakers of hand pumps, including actual practice in carrying out preventive maintenance and minor repairs.

16. Study of Hand Pump Manufacturing Capacity at Country Level

To assess the national production potential for manufacturing hand pumps. To provide information supporting the establishment of local manufacturing facilities. To identify the constraints and problems encountered when hand pump manufacturing activities are included in rural water supply programmes.

17. Study of Possible Standardization of Materials, Specifications and Testing Methods

To provide better access to existing standards for the equipment, materials and civil works used in rural water supply systems. Also to give recommended specifications for materials and dimensions. To select from the several standards and procedures the ones that may most readily lend themselves to adaptation to different conditions, on the basis of the field engineer's design. Compilation of available information on equipment, materials and civil works will serve to

facilitate the preparation of tender documents, both national and international. To select most common technology and component sizes. Development of standard methods for testing pumping equipment on durability, mechanical efficiency and maintenance requirements.

18. Study of Applicability of Solar and Wind Energy in Water Pumping

To prepare a state-of-the-art paper describing possible applications of solar and wind energy to water pumping in rural areas. Short description of cases where solar energy has actually been applied and experience obtained.