PROCEEDINGS OF THE NATIONAL WORKSHOP ON POTENTIAL IMPROVEMENTS IN INDIA MARK II DEEPWELL HANDPUMP DESIGN

MAY 24 & 25, 1990

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Introduction

Background

At the end of the International Drinking Water Supply and Sanitation Decade (IDWSSD), in spite of the considerable advances made, the provision of safe drinking water on a sustainable basis to the approximately 600, 000 villages as well as the underserved populations of peri-urban India continues to represent a major challenge. The response to this challenge is seen in terms of both research and development to develop appropriate technologies as well as successful implementation in the field.

India has the largest national rural water supply program in the world using extensively the India Mark II deepwell handpump for the supply of safe potable groundwater. At present over 1.5 million India Mark II handpumps are in operation in India alone, serving an approximate population of over 260 million. Several thousand India Mark II deepwell handpumps are serving rural communities in many part of Africa, Latin America and Asia.

Extensive field and laboratory tests have proved that the India Mark II deepwell handpump is a very durable and reliable handpump. However, it is not easy to maintain at the village level, as it needs heavy tools and considerable skills for carrying out below-ground repairs.

As part of the global effort to improve handpump designs and to field test handpumps, the UNDP/World Bank Water and Sanitation Program, and UNICEF in collaboration with the National Drinking Water Mission, Tamil Nadu Water Supply and Drainage Board and Richardson & Cruddas (1972) Limited (a Government of India undertaking) established a Handpump Field Testing Project near Coimbatore with the objective of carrying out potential improvements to the India Mark II so as to increase the Mean Time Before Failure (MTBF) and to make maintenance procedures simpler.

During this project (1983-1988) potential improvements were made in the India Mark II design. Field tests confirmed the advantages that the improvements offered in terms of frequency and ease of repairs, reliability and maintainability. At the end of the Coimbatore Handpump Field Testing Project, two optional designs emerged:

a) the India Mark II (modified) Deepwell Handpump, and
b) the India Mark III (VLOM) Deepwell Handpump

These improvements when implemented will have a significant impact on the national Rural Water Supply Program.

The National Workshop on "Potential Improvements in India Mark II Deepwell Handpump Design"

The workshop on " Potential Improvements in India Mark II Deepwell Handpump Design" sponsored by the National Drinking Water Mission, Department of Rural Development, Government of India and cosponsored by UNICEF and the UNDP/World Bank Water and Sanitation Program through its Regional Water and Sanitation Group-South Asia, (RWSG-SA), was held in New Delhi over May 24-25, 1990.

It was attended by 24 representatives from 12 State water supply departments, 8 representatives from the National Drinking Water Mission, 16 representatives from bilateral and multilateral aid agencies and 13 representatives from research institutes, inspection agencies, the Bureau of Indian Standards and non governmental organizations.*

Objectives

The overall objective of the workshop was to take a policy decision and to finalize the strategy for the adoption of the proposed modifications to the existing India Mark II deepwell handpumps and for the introduction of the India Mark III deepwell handpumps on a large scale to facilitate most of the repairs at the village level.

The Workshop assumes greater significance when it is viewed in terms of the Government of India's emphasis on devolution of power to the village level, with special regard to facilitating the control of technology by the villagers themselves. The emphasis on the development of a Village Level Operation and Maintenance (VLOM) model is a significant one in that it holds out possibilities for disadvantaged groups in village society, particularly women, to participate more positively in the development process through their involvement in and responsibility for the maintenance of the handpump.

* A complete list of participants is appended to this report.

Proceedings of the National Workshop on Potential Improvements in India Mark II Deepwell Handpump Design

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INAUGURAL SESSION (May 24, 1990)

The workshop was inaugurated by Mr S.R Sankaran, Secretary, Department of Rural Development, Government of India. In his inaugural address, Mr. Sankaran said that the provision of safe drinking water has been a challenge to administrators and agencies in India keeping in mind the extreme variability of the terrain in the country. While noting that substantial progress had been made, he emphasized the need for control of the community over local resources especially in the approximately 600,000 villages of India.

After a brief welcome speech by Mr. Inamul Haq, Adviser, Department of Rural Development, the floor was given to Mr. G. Ghosh, Mission Director, National Drinking Water Mission, Department of Rural Development, Government of India. In his presidential address to the participants, he emphasized the importance and relevance of the India Mark III Village Level Operation and Maintenance (VLOM) handpump to the villages. Mr Ghosh said that research to develop a "true" village handpump had been ongoing since the mid-1960s. He also said that the coverage of 85% of India by handpumps was a truly impressive achievement and underlined the valuable contributions made in this regard by institutions such as UNICEF, UNDP, and the World Bank. In this regard, Mr. Ghosh said that currently, efforts were under way to develop facilities for testing handpumps as well as backup research support in the country. While noting that the rate of failure of handpumps was less than 25% even in drought-prone areas, he stressed the need for further innovation, with specific regard to industrial designing from the user's point of view.

Ms. E. Watanabe, Representative, UNICEF, India Country Office, said that the achievements in India regarding the provision of safe drinking water demonstrated that given the necessary political will and sufficient resources, targets would be met. She saw the design modifications to the India Mark II handpump and the evolution of the VLOM handpump as representing an opportunity for empowering people at the village level, more especially the village women.

Mr. Tauno Skytta, Manager, UNDP/World Bank Water and Sanitation Program, RWSG-SA, underscored the felt need for the development of a VLOM handpump, with all the resultant advantages in terms of operation and maintenance at the village level. He also mentioned that it was the Coimbatore Handpump Field Testing Project that had facilitated the development of the Modified India Mark II and the India Mark III(VLOM) handpump. In closing, Mr Skytta noted that the development in handpump technology was directly related to the positive interaction between the Department of Rural Development, Government of India, UNICEF and the UNDP/World Bank Water and Sanitation Program.

A vote of thanks was offered by Mr.Arun Kumar Mudgal, Project Officer, RWSG-SA.

SESSION I (May 24, 1990)

Chairperson: Mr Inamul Haq, Adviser, Department of Rural Development, Government of India.

The session commenced with an overview of the Coimbatore Handpump Field Testing Project by Mr. Inamul Haq, Adviser, Department of Rural Development, Government of India. He noted that the commitment of the Government of India to the provision of safe drinking water to the rural/peri-urban communities was well known. In this context, he observed that the National Drinking Water Mission was providing support for technological inputs for the concerned research and development aspects. In his presentation, Mr Haq stressed the need for people's participation in the operation and maintenance of the handpump and said that the design of the India Mark II Deepwell handpump did not allow for this kind of participation, involving as it does a relatively high degree of skills and fairly sophisticated maintenance equipment. The need, he felt, was for committed persons and systematic field evaluation in order to ensure a safe and sustainable supply of drinking water. In this regard, he noted that the Coimbatore Handpump Field Testing Project had followed a schedule of regular visits to selected pumps. Mr. Haq also felt that there need not be an immediate conversion of India Mark II to India Mark III handpumps - the viable option would be to work with a modified India Mark II handpump, with its replacement by an India Mark III only when major overhaul of the pump was needed. He referred the participants to the Draft Report on Field Testing in Coimbatore of the Standard India Mark II and Open Top Cylinder India Mark III Pumps for the role played in the Project by agencies such as the UNDP, World Bank, UNICEF, the Tamil Nadu Government, Richardson and Cruddas (1972) Limited and the National Drinking Water Mission, Department of Rural Development, Government of India.

Mr. M. Akhter, Senior program Officer, Water and Environmental Sanitation, UNICEF, referred to a study on the functioning and utilization of handpumps conducted by the Operations Research Group (ORG) in 1985 and 1987 and a subsequent one conducted in 1989. He stressed the fact that the sample size had been relatively small and that more detailed studies were needed. The draft report could be made available by UNICEF, consisting as it did of 5 chapters relating to overall methodology; use of pumps; environment around the pump site; performance of the pumps; preventive maintenance and repair. Mr. Akhter said that the experience had been that of the 3 crucial factors, namely quality of pump, installation and preventive maintenance, it was the last that caused relatively more concern. Going into slightly more detail, he felt that the main areas of concern indicated by the study related to inadequate platforms, ineffective drainage around the pump, related waterlogging and lack of adequate preventive maintenance both in terms of skills and allocated responsibilities. Further, a Knowledge, Attitudes and Practice (KAP) survey conducted in 1989 had established that on an average, some 360 people used one handpump, which was considerably more than the targeted 7th Plan figure of 250 people per handpump

Presenting his paper* on "Production/Quality Control of Handpumps,", Mr. Mansoor M. Ali, Project Officer, Handpumps and Piped Systems, UNICEF stressed the need for the close monitoring of the production and quality of pumps/components in order to ensure the success of the rural water supply programme. He emphasized the area of materials quality control in which UNICEF, since 1976, in tandem with the Bureau of Indian Standards had been assisting the Government of India. This assistance had been through helping GOI monitor production capacity and quality standards for pumps and spares to match the national requirement of handpumps under the Rural Water Supply Program of the Government. Mr Ali also felt there was a need for Water Boards or Public Health Engineering Departments (PHEDs) at the state and at the panchayat level as well as the implementation level to check the quality of handpumps and spares received.

Mr. Arun Kumar Mudgal, Project Officer, RWSG-SA presented two papers namely, "Modifications to the India Mark II Handpump Design" and "India Mark III Deepwell Handpump Design and its Benefits". In the first paper, he noted that the modification efforts were concentrated on improvements in design and the material of construction of components that would increase the Mean Time Before Failure (MTBF) of the pump and improve its serviceability. The paper also discussed the details of these improvements along with the present status, benefits expected, cost of modification of the existing India Mark II Deepwell handpump and the suggested methodology for carrying out modifications to the handpump. In the second paper, Mr. Mudgal emphasized the fact that the development of the India Mark III handpump made possible the establishment/implementation of a village-based and community-managed handpump maintenance system, which could be operated by a village mechanic with fewer tools and minimal skills if the spare parts and tools are available at the village itself.

DISCUSSION

The chairperson threw the floor open at this point of time for a discussion. The discussions basically dealt with matters such as: the possibility of using more appropriate materials for cylinder jackets for the modified India Mark II and India Mark III pumps in view of the corrosion prone nature of the cast iron cylinder jackets presently in use; the need to consider alternate materials for connecting rods and GI pipes; the problem of incorporating additional riser pipes as the water tables fall; and the need for the Bureau of Indian Standards (BIS) to approve separate standards for each assembly rather than the whole pump, which could facilitate the quick revision of standards: and the desirability of modifying the present norms of 100mm dia of borewells to 125mm so as to accommodate the 2-1/2" ID riser pipe assembly of the India Mark III handpump.

* This paper, and all other papers referred to in the proceedings, are appended to this document.

SESSION II (May 24, 1990)

Chairperson: Mr. Inamul Haq, Adviser, Department of Rural Development, Government of India.

The second session began with the presentation of a paper "Handpumps Demonstration Projects' Findings" by Mr M. Sampath Kumar, National Country Officer, RWSG-SA. In this paper Mr. Sampath concluded that the field performance of both the modified India Mark II and the India Mark III handpumps had demonstrated the improved reliability of these pumps as compared to the Standard India Mark II pump. An important indicator of this was the high Mean Time Before Failure (MTBF) of both the pumps. Observations from the 4 demonstration projects also suggested that the users find it easier to operate and repair the India Mark III. The paper also noted that stagnation of water was considerably less due to the improved platform design. However, the paper points out that it would be necessary to monitor the pumps over at least a 4-year period to obtain a realistic average of the number of visits/pump/year, spare parts requirement, maintenance costs and the life period of wearing pump components. Present observations have been restricted to 13.7 and 16.5 months respectively for the modified India Mark II and India Mark III pumps.

Mr. D.K Agrawal, Director, Bureau of Indian Standards (BIS) noted in his paper "National Standards for Deepwell Handpumps - a Review" that an Indian standard on deepwell handpumps, IS:9301 was first published in 1979 and subsequently revised in 1984. In keeping with the advances in design and technology, another revised version is currently under print. Mr. Agrawal also pointed out that draft Indian Standards were being considered presently for the VLOM and the Extra Deepwell Pumps. Further, a code of practice for the installation and maintenance of the deepwell pumps had been laid down in two parts of Indian Standards:11004. Also under printing was a separate Indian Standard in which every nomenclature and part classification has been fixed.

A paper entitled "Betul Handpump Demonstration Project - Experiences on Pump Performance" was presented by Mr R K Dubey, Executive Engineer, Betul Division, Betul, Madhya Pradesh. Observing that a modified India Mark II and the India Mark III pump can play an important role in optimizing pump operations and thereby making better use of the limited water resources for rural populations, Mr. Dubey said that the overall performance of the modified India Mark II and the India Mark III handpumps had been excellent. He also felt the need for special training programmes, particularly for tribal women, in the installation and maintenance procedures of the pump. The paper concluded that the installation of the India Mark III handpumps in Betul Division will help to provide uninterrupted potable water, especially to villages cut off by heavy rains and floods. The easy maintainability of the pump is an important factor in this regard.

DISCUSSION

The Chairperson invited comments from the floor. The main points of discussion at this juncture were: the need for using-left hand thread bolts in the pump assembly so as to reduce loss by theft; and a reminder that the present results pertaining to the modifications to the India Mark II handpump had been obtained from demonstration projects and the consequent need to be cautious about propagating these results too actively.

Mr. S.V. Sakare, Senior Drilling Engineer, Directorate of Groundwater Surveys and Development Agency (GSDA), Government of Maharashtra, in his paper, "Maharashtra Handpump Demonstration Project: Experiences of Maintenance", coauthored with Mr. V.B. Maldhure, Senior Drilling Engineer, GSDA, Pune Region, underlined the need to investigate what he categorized as an abnormal failure in the functioning of handles and riser mains in both the India Mark II and India Mark III handpumps. He concluded however, that, overall, the India Mark III (VLOM) pump was more convenient for cost-effective, timely, individual maintenance at the village level. Further, he felt that community participation had been considerably enhanced through the prospect of village level operation and maintenance and that the prospects of round-the-year water supply was a great source of satisfaction to the community.

Mr Raj Kumar Daw of the DANIDA Project Directorate, Bhubaneshwar presented a paper entitled "Maintenance of India Mark III Handpump - Experience from the DANIDA-assisted Orissa Drinking Water Supply Project". The chief thrust of the paper was that, on the basis of field observations over the period 1986-89, the India Mark III pumps had substantial performance and maintenance advantages as compared to the India Mark II Deepwell handpump, especially in terms of the pumps' users being involved in its operation and maintenance.

In his paper "Experience in the Handpump Demonstration Project in Rangareddy District of Andhra Pradesh for the period of February 1988 to April 1990", Mr T K Kanagarajan, Project Officer, UNICEF, South-east India Office, Hyderabad, stressed the fact that the India Mark III (VLOM) pump would help to demystify handpump technology. Of the 64 VLOM mechanics trained under the project, 12 are women, who will hopefully continue as nodal maintenance persons. A simple VLOM Mechanic Tool Set has also been developed, which is left with the concerned Sarpanch from whom the VLOM mechanic will take the tool as and when required. Summarizing the Rangareddy experience, the paper observes that the India Mark III (VLOM) handpump has infused confidence in the village that safe drinking water can be expected throughout the year.

SESSION III (May 25, 1990)

Chairperson: Mr Inamul Haq, Adviser, Department of Rural Development, Government of India.

Mr Mansoor M. Ali, Project Officer, Handpumps and Piped Systems, UNICEF, presented a paper entitled "Community Based Handpump Maintenance Approach" in which he observed that handpump maintenance stood at the crossroads with meagre funds and vacillating commitments to back it. He noted that the low priority accorded to maintenance has resulted in a serious shortfall regarding planning and co-ordination which in turn has affected the mobilization of financial, material and human resources. Keeping in mind the new developments in the design of the India Mark II handpump and the emergence of the India Mark III handpump the thrust of the paper was to underline the need for gradually decentralizing handpump maintenance with careful planning when resources are scarce and to assign a higher priority to handpump maintenance at all levels of government in order not to let the massive efforts under way falter.

Speaking on "Communications for community-managed handpumps", Mr Ashoke Chatterjee, Adviser, National Institute of Design, Ahmedabad, pointed out that while engineers can deliver water to the pump/tap, they have no effective control over the use of water by the people. Stressing the need for educating both the technician and the so-called beneficiaries, Mr Chatterjee emphasized two aspects of communication: communication for training and communication for motivation.

DISCUSSION

The floor was thrown open by the Chairperson for discussions. The issues raised related to the following: the question of how beneficiaries would view the idea of paying a nominal sum for their water supply; the need for planned maintenance in order to address mechanical problems as soon as they become perceptible; the question of the number of pumps a village mechanic should be responsible for; and the wide variations regarding modes of transport for the mechanics considering that the distances between pumps differ considerably and the terrain is substantially different in various parts of India.

A paper was prepared and tabled by Professor S. Balaram, National Institute of Design, Ahmedabad, on "Handpump Design ; A checklist of considerations", but was not presented at the workshop. Basically, the paper is an example of the social marketing approach designed to optimize the benefits of the pump to its user and the environment.

SESSION IV (May 25, 1990)

Chairperson: Mr Inamul Haq, Adviser, Department of Rural Development, Government of India.

At the beginning of this session, the Chairperson divided the participants into 3 groups.

Group I - Chairperson: Mr S.B. Kundu, Chief Engineer, Government of West Bengal.

Topic of discussion: India Mark II modifications.

Group II - Chairperson: Mr Gulam Ahmed, Chief Engineer (Retired), Government of Karnataka.

Topic of discussion: Adoption of India Mark III handpump on a large scale.

Group III- Chairperson: Mr Ashoke Chatterjee, Adviser, National Institute of Design, Ahmedabad.

Topic of discussion: Community management of handpump maintenance.

The three groups presented their recommendations, which were then the subject of considerable discussion. The outcome of these discussions in the form of 'Recommendations' finalized by the National Drinking Water Mission, in consultation with UNICEF and the RWSG-SA is appended to this report as "Recommendations of the National Workshop on Potential Improvements in India in Mark II Deepwell Handpump Design".

CLOSING SESSION (May 25,1990)

Chairperson: Mr Inamul Haq, Adviser, Department of Rural Development, Government of India.

The closing session was prefaced by a valedictory address by Mr M Akhter, Senior Program Officer, Water and Environmental Sanitation, UNICEF, who briefly summed-up the proceedings of the workshop. Mr Akhter noted that some significant recommendations had emerged from the Workshop's deliberations which could have far-reaching implications for India's Rural Water Supply Program. He observed that the developments in handpump technology were oriented towards a maintenance system that could be managed at the village-level especially by the women. Mr Akhter concluded by saying that this approach would facilitate the transfer of responsibility to the village level and consequently allow the rural people to become agents of their own development.

A vote of thanks was proposed by Mr. Inamul Haq, Adviser, Department of Rural Development, Government of India,in which he thanked the organizers, participants, speakers and all others involved in the two-day workshop, who had contributed to the successful conclusion of the "National Workshop on Potential Improvements in India Mark II Deepwell Handpump Design".

RECOMMENDATIONS OF THE NATIONAL WORKSHOP ON POTENTIAL IMPROVEMENTS IN INDIA MARK II DEEPWELL HANDPUMP DESIGN

1. The following modifications are recommended for incorporation in the existing India Mark II handpumps.

   a) Nitrile rubber bucket washer along with modified space.

   b) Two piece upper valve.

   c) The extra flange with a modified head.

2. The following methodology is to be adopted for the modification program. The replacements may be carried out while attending the below ground repairs in the existing India Mark II pumps.

   a) Replace the leather bucket washer by a nitrile rubber bucket washer.

   b) Replace the standard spacer by a modified spacer.

   c) Replace the three piece upper valve by a two piece upper valve.

   d) Replace the cylinder body if the cylinder brass liner is found scored.

   e) The extra flange with a new modified head may be replaced whenever the existing head needs replacement.

3. The following developments may be incorporated in the India Mark II deepwell handpump specifications.

   a) The bracket opening in the head shall be increased such that the stroke length is increased by 25 mm.

   b) The water tank height shall be increased by 25 mm.

   c) The stand assembly height shall be decreased by 75 mm.

4. The new borewells drilled shall be fitted with the India Mark III Deepwell Handpump. The borewell should be drilled to a sufficient depth to ensure a yield of 900 liters of water per hour throughout the year. The internal diameter of the borewell should be a minimum of 110 mm.

5. The conversion of the existing India Mark II into the India Mark III handpump is to be considered only when the existing pumps are due for major overhaul and involves the replacement of riser pipes.

6. The present demonstration exercise shall continue to generate regular feedback from the field to assist research and development activities towards cost reduction. A few more pilot demonstration projects may be established in selected districts in various parts of the country.

7. The program of installation of the India Mark III pump in villages has to be simultaneously matched with a community-based maintenance system.

8. The workshop recommended that in order to operationalize the design improvements the preparation/modification of BIS standards should be within the shortest possible time.

9. The workshop recommends that BIS should take up the certification of deepwell handpump spare parts.

10. A national Standard should be finalized as soon as possible for the India Mark III handpumps.

11. Suitable training programs should be developed for trainers and people involved in implementation of the handpump program.

12. Importance of clear maintenance policies, reflected in administrative structures, financial resources and human resources at each level, PHED, district panchayat, village, have to be spelt out. Only such policies, structures and financial arrangements can provide a guarantee of quality of service which would make community participation strategies credible.

13. Self-government structures (particularly Panchayati Raj) are basic to community management and participation. The experience of states such as Kerala needs to be more widely disseminated.

14. The concept of ownership of a community asset is basic to this issue. Even though the ultimate responsibility for safe water sources may rest with the state, day-to-day responsibility must increasingly be accepted by user communities.

15. Cost recovery policies can assist in encouraging actual community responsibility for safe water sources. However, the social goals of safe water must be predominant.

16. Within the community, the role of women as managers of domestic water must be recognized. Without their participation, and indirect management, there can be no safe water as a reality at the individual level.

17. Communication is the chemistry which can make possible changes in attitude and action at the community level as well as at policy making levels. Communications can support the two major sectors of participation need: training programs on the one hand and motivation towards safe water practices on the other.

EXECUTIVE SUMMARY OF THE DRAFT REPORT ON "FIELD TESTING IN COIMBATORE OF THE STANDARD INDIA MARK II AND OPEN TOP CYLINDER INDIA MARK III PUMPS"

BACKGROUND

India Mark II deepwell handpumps benefit an estimated 300 million people in Asian, African, and Latin American countries. India, with the largest national rural water supply program in the world, has over 1.3 million India Mark II deepwell handpumps installed in rural and peri-urban areas to provide safe water to over 260 million people. Though extensive field and laboratory tests have demonstrated that the India Mark II deepwell handpump is very durable, it is not easy to maintain because of the high skills, special tools and a motorized van needed to service the below ground components of the pump. This report describes how the potential improvements made to the India Mark II in the Coimbatore handpump testing project make the handpump more reliable and easily serviceable, with the consequent impact on downtime, maintenance structure and costs.

THE COIMBATORE HANDPUMP PROJECT

The project was taken up in late 1983 by the Tamil Nadu Water Supply and Drainage Board in collaboration with the UNDP/World Bank Handpump Testing and Development Project, UNICEF and Richardson & Cruddas (1972) Limited, a major manufacturer of handpumps. The National Drinking Water Mission, Department of Rural Development, Government of India, coordinated the intensive development and testing project at the national level.

The dominant issues in the rural water supply being maintenance costs and difficulties in maintenance, the project aimed at:

1. Verification of actual costs of operation of the India Mark II deepwell handpumps and;

2. Identification and testing of potential improvements to the standard India Mark II handpump design to make maintenance easier and less expensive.

METHODOLOGY FOR DATA COLLECTION

Approximately 80 handpumps were tested near Coimbatore over a period of four-and-a-half years under conditions of heavy use and deep static water level.
A sample of roughly 50 standard India Mark II handpumps provided the baseline information with which the performance of the experimental variations were compared. Each pump assigned with an identification number was visited by project staff on a regular basis and repaired whenever necessary. The data collected on performance, maintenance and repair were entered into a database for analysis.

PUMP DEVELOPMENT WORK

Two types of design were tested: first, the design improvement that will increase the Mean Time Before Failure (MTBF); second, the design improvements that would make the pump easier to take apart and reassemble, using fewer tools and less manpower. Radical design changes were avoided to ensure a high degree of compatibility with the existing India Mark II deepwell handpump.

ANALYSIS OF FIELD DATA

Analysis of field data shows the following distinct improvements in the reliability and serviceability of the experimental pumps - India Mark II (modified) deepwell handpump and India Mark III deepwell handpump - over the standard version India Mark II deepwell handpump. In the India Mark III deepwell handpump, the average frequency of service required (from a mobile maintenance team) was reduced by 89% per year and the mean annual active repair time was reduced by 67%. In fact, 90% of the total repairs for the India Mark III deepwell handpump can be carried out by a bicycle-mobile mechanic using few tools and with the assistance of the handpump caretaker/users.

In the India Mark II (modified) deepwell handpump, minor design changes like a nitrile cup seal instead of a leather cup seal, a two-piece upper valve instead of a three-piece upper valve and a modified spacer increase the MTBF by 100%.

SUMMARY AND CONCLUSIONS

The implications of these design improvements are as follows:

1. Minor modifications costing Rs 250 - which will be fully offset in less than two years - to the existing 1.3 million India Mark II deepwell handpumps will, due to increased MTBF, result in a substantial decrease in the maintenance cost and effort. This will increase the quality of service as mobile teams will be required to make fewer visits.

2. Adoption of the India Mark III deepwell handpump will substantially reduce the dependence on a mobile team for most of the repairs. It will be possible for a village-based mechanic to move about on a two wheeler and carry out 90% of the repairs with the help of a handpump caretaker/user. This will substantially reduce the downtime and also the maintenance cost.

3. The additional capital cost of Rs.1320 in the case of the India Mark III deepwell handpump will be fully offset by the lower maintenance cost in less than three years time.

4. There is need for further improvement in the handpump design to make the maintenance of the handpumps simpler and easier so that the handpump caretakers are able to carry out most of the repairs at the village level itself.

RECOMMENDATIONS

1. Design improvements to the India Mark II deepwell handpump be incorporated into the national standard specifications.

2. The existing 1.3 million India Mark II deepwell handpumps be modified to substantially increase the MTBF.

3. The India Mark III deepwell handpump be installed on a large scale in all the states presently using the India Mark II deepwell handpumps and a village-based maintenance system be developed which needs minimal support from a mobile team.

4. A national standard be prepared for the India Mark III deepwell handpump.

5. A study on a national level should be conducted to evaluate the strengths and weaknesses of the various existing maintenance systems and to suggest ways to create village level capacity and capability to repair deepwell handpumps.

6. Further research and development should be undertaken to simplify maintenance requirements which will encourage the users themselves to carry out the maintenance.

PRODUCTION/QUALITY CONTROL OF HANDPUMPS

Mansoor M. Ali
Project Officer
Handpumps and Piped Systems
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The National Drinking Water Mission has emphasized that some of the most important objectives for rural water supply are to improve the reliability of the pumps and to establish a maintenance system which can reduce their downtime.

The UNDP/World Bank report "Community Water Supply: The Handpump Option" has under "Manufacturing needs for the India Mark II handpump", stated that the degree of quality control needed to ensure reliable operation makes the pump unsuitable for manufacture in countries with only low industrial development and no formal quality control. Also, the report has good evidence that inspection procedures and quality testing are essential if premature breakdowns are to be avoided with current pump designs.

In India almost all India Mark II handpumps are produced in the private small-scale sector. The present group of suppliers/manufacturers have individual ancillary units, who fabricate sub-assemblies/components and thus support a recognized and licenced manufacturer.

There are a total of 56 licenses (given by BIS) who are authorized to manufacture handpumps as per IS:9301 specifications. Of these, 45 have undergone a rigorous works inspection and update on their establishments, jigs and fixtures, tools and gauges, skills upgradable and capacity assessment.

The so-called qualified manufacturers (45) during the last decade produced annually 150-200,000 handpumps and approximately 40% of the total number in value terms in spare parts.

BIS and UNICEF have worked closely together right from 1976-86 to standardize the India Mark II handpump and have assisted the Government of India in monitoring production capacity and quality standards for pumps and spares to match the national requirement of handpumps under the Rural Water Supply Program of the Government of India. This close monitoring of production and quality of pumps/components has led to a singularly successful handpump program.

OBJECTIVES

1. To establish manufacturing capacity of handpumps and spares to match needs of the national RWS program.

2. To ensure control on quality of product, its material quality, specifications and performance through internal and external quality checks during manufacture and at the consignee end.

3. To continuously monitor the manufacturers' range of production, production capacity, level of approval/rejection and compliance with delivery schedules.

METHODOLOGY OF QUALITY CONTROL

The quality control exercise is carried out at two levels:

1. At the manufacturing level; and
2. At the consignee level.

At the manufacturing level again there are 3 stages of checks/inspection undergone by the product:

(i) Internal quality control of the manufacturer when the raw material is imported on receipt, checks in dimensions of sub-assemblies during fabrication, and final check while assembling/fitment of the complete pump with the use of gauges/equipment.

(ii) Quality control inspection by the Bureau of Indian Standards for lots of 200 handpumps to check conformation to IS:9301, packaging standards, etc.

(iii) Third party inspection by UNICEF-designated inspection agencies to carry out checks on finished pumps and spares.

3. Quality control checks are carried out through trained personnel (PHE) while receiving material to check standards/specifications as well as packaging. UNICEF is presently involved in the training of field personnel on consignee inspection, packaging standards and storage/distribution.

The quality control inspection process is explained in the flow charts annexed at the factory and consignee end.

Present System

The quality control of handpumps at the manufacturer's end is implemented in the following stages:

1. Prequalification of manufacturers to ensure that they have the necessary infrastructure, technical expertise, jigs, fixtures, measuring instrument and gauges, etc.

2. Selection of the suppliers from among the pre-qualified manufacturers and grading them in order of merit and capacity.

3. Insistence on registration of units under BIS.

4. Insistence on pre-delivery inspection of pumps and spares at the manufacturers works by an independent inspection agency prior to despatch.

Government departments are provided with ISI and UNICEF-approved manufacturers. Based on tender evaluation, orders are placed with the manufacturers and material is procured. UNICEF presently arranges for pre-delivery inspection of pumps and spares and contributes towards the payment of inspection fees for all government purchases.

A continuous monitoring of the quality of production and the performance of the manufacturers is also undertaken. This helps in the review of manufacturers' quality and quantity capabilities.

Methods for proper identification and marking of inspected goods, elaborate packing standards, stamping and markings, etc., have been developed and implemented.

Quality control of products is further extended to consignee ends where the objectives of the inspection are:

1. To ensure that only inspected and accepted goods are received at consignee stores.

2. To ensure that correct materials are received as per order.

3. To collect full data regarding damages, discrepancies, etc., and to give feedback to headquarters for taking up with the suppliers.

As an executing authority of handpump installation and maintenance and as an important link between the pump manufacturer and villagers, proper care taken by the PHED at all stages will go a long way in the trouble free working of each handpump in the remote corners of the country.

Recommendations for a Quality Control System

In order to implement a well-defined quality control system for the handpump water supply scheme the following methodology is suggested.

1. An apex body responsible for ensuring quality control should be formed at the centre with representations of Department of Rural Development, Technology Mission, central government representatives, BIS representatives and other experts as members to formulate and guide the programme.

2. Six regional committees consisting of state level members who will be responsible for implementation of the quality control measures.

3. State level quality control cells to act as a task force for carrying out actual inspection and collect data for review by regional committees and in turn by the apex body for the periodic overall monitoring and review of the system.

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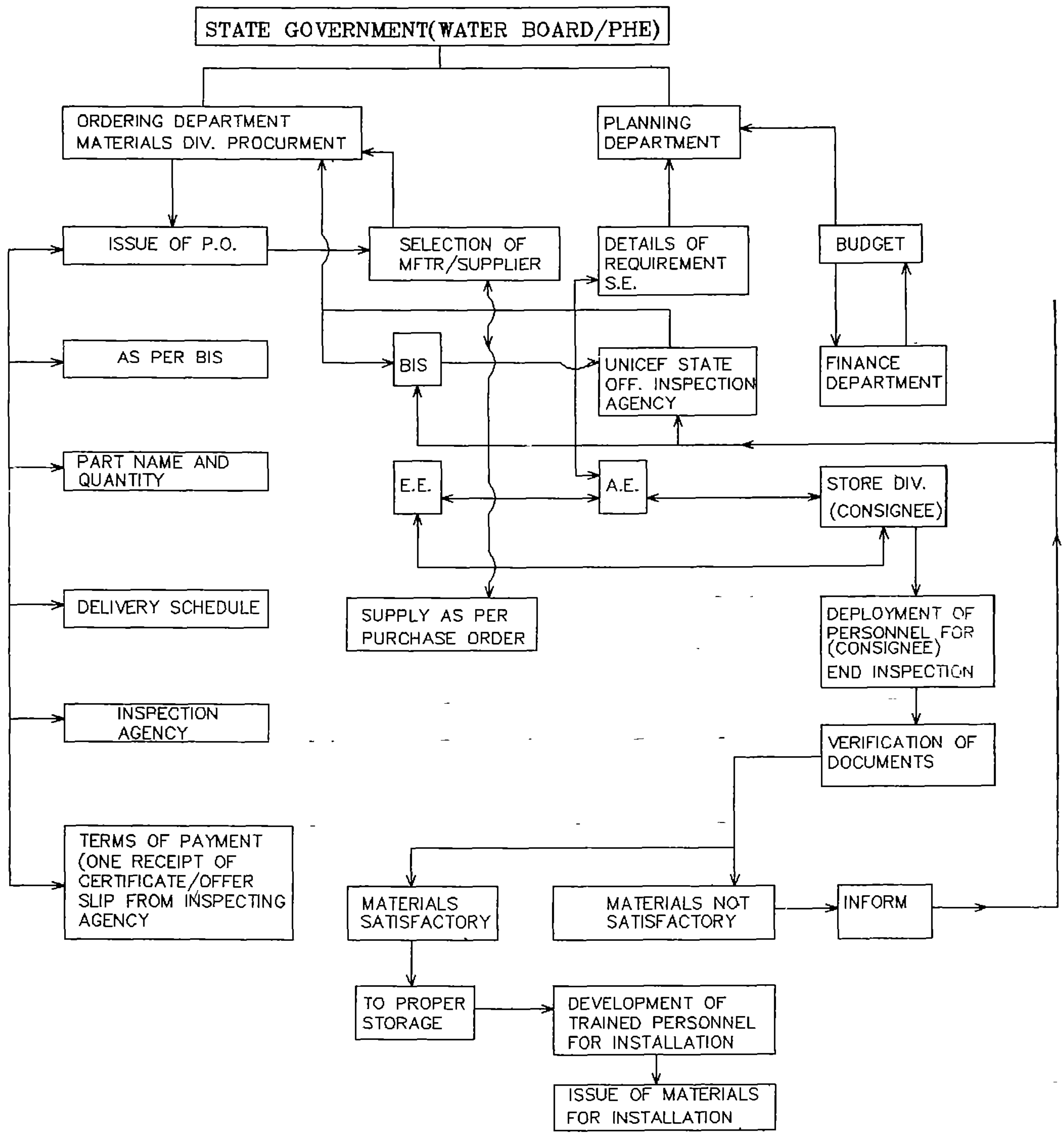
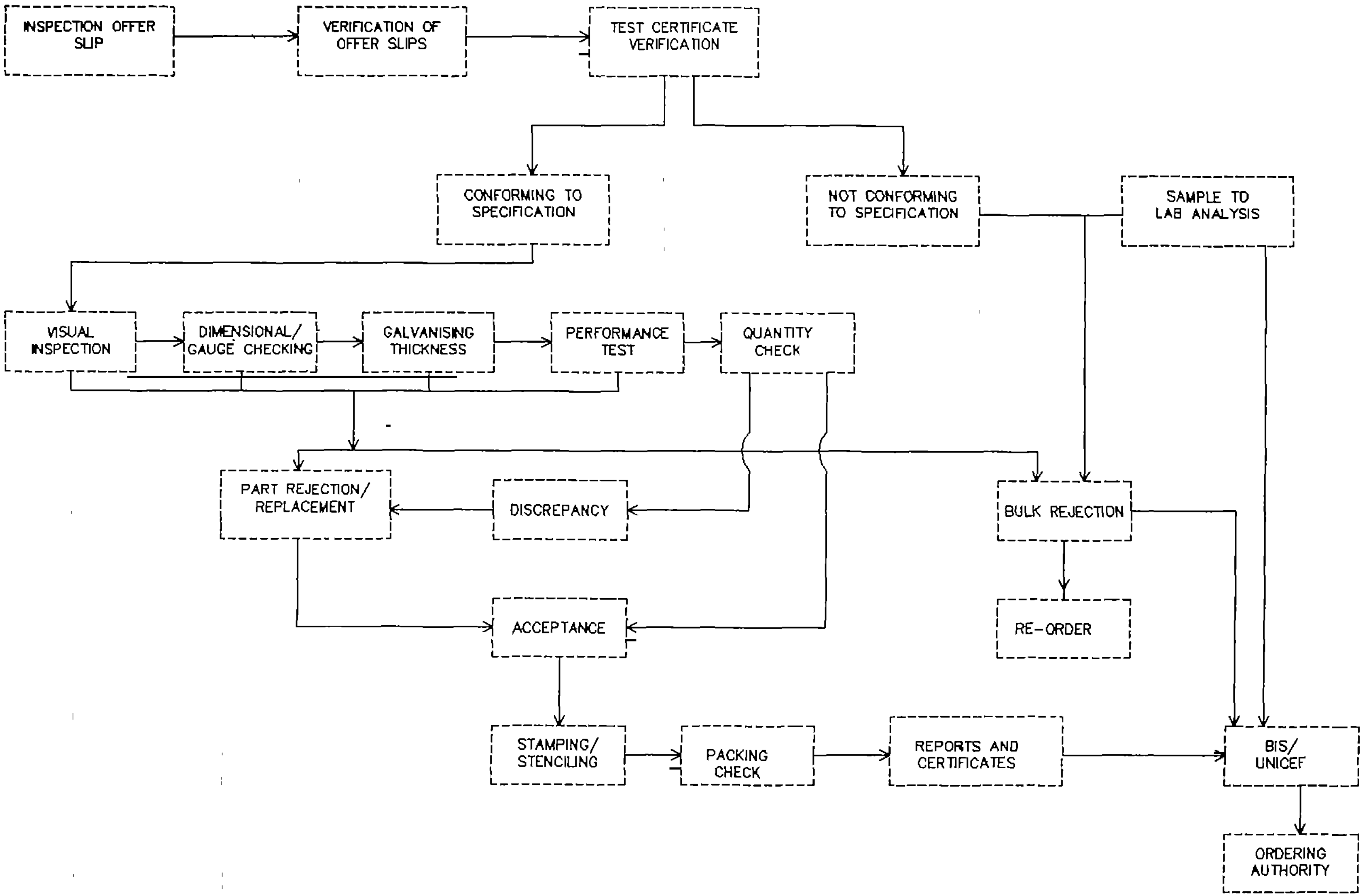
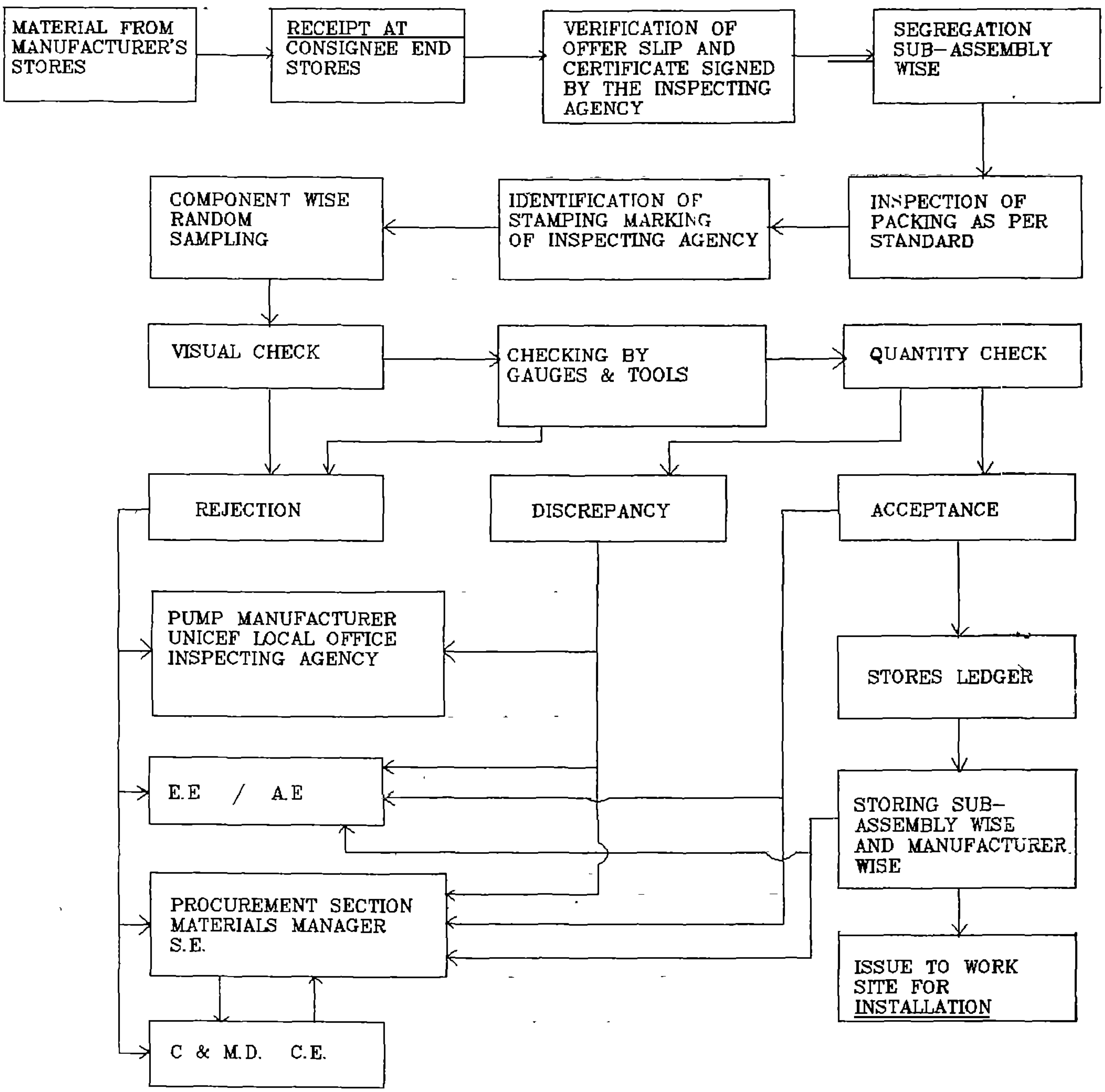
PROCUREMENT & QUALITY CONTROL SYSTEM FOR PUMPS & SPARES



INSPECTION PROCEDURE



METHODOLOGY FOR CONSIGNEE END INSPECTION AND FEED BACK EVALUATION SYSTEM



MODIFICATIONS TO THE INDIA MARK II HANDPUMP DESIGN*

Arun Kumar Mudgal
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Water & Sanitation Program
Regional Water & Sanitation Group-
South Asia

BACKGROUND

As part of the global efforts to develop low-cost water supply options the UNDP/World Bank Water and Sanitation Program in association with multilateral and bilateral agencies, initiated in the early 1980s a global/interregional project for laboratory and field testing and technological development of community water supply handpumps. The laboratory tests were carried out by the Consumer Association in the United Kingdom and field trials were carried out in 17 countries involving some 2700 handpumps of 70 different models, to assess their individual performance. The Coimbatore Handpump Field Testing Project in India which was implemented in cooperation with the National Drinking Water Mission, Department of Rural Development, Government of India, Tamil Nadu Water Supply and Drainage Board, Government of Tamil Nadu, UNICEF and Richardson & Cruddas (1972) Limited, formed part of the Global Handpump Testing Project where efforts were largely concentrated on the further development of the India Mark II deepwell handpump.

The development efforts were concentrated on improvements in the design and material of construction of components that would increase the Meantime Before Failure (MTBF) of the pump and improve its serviceability. The below-ground components identified for further development were the cup washer and piston valve. The above-ground components identified for improvement were the pump head, handle assembly and the water chamber.

The details of potential improvements carried out and field tested in the Coimbatore project during 1983-1988 together with the present status, benefits expected, cost of modification of the existing India Mark II deepwell handpumps and suggested methodology for carrying out modifications in the existing 1.3 million India Mark II deepwell handpumps are discussed here.

POTENTIAL IMPROVEMENTS TO THE INDIA MARK II DEEPWELL HANDPUMP

During the project the following potential improvements were carried out and were proved very useful in field trials.

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* The views expressed in this paper are that of the author and should not be attributed in any manner to the UNDP/World Bank Water & Sanitation Program.

1. <u>Nitrile Cup Washer</u>

(i) The replacement of the leather cup washer accounts for nearly 70% of the repairs in the India Mark II deepwell handpumps. The average life of the chrome tanned leather cup seal varies from 6-12 months depending on the usage, water quality and static water level.

(ii) During the project, cup washers made from acrylo-nitrobutediene (NBR) popularly known as nitrile rubber were developed (see Annex I for details) and field tested. The advantages of the nitrile cup washer are as follows.

(a) <u>Average working life is more than double when compared with chrome tanned leather cup washers:</u> Annex II gives details of the average cup washer life by type. It may be noted that the nitrile cup washer was found to have an average working life of <u>715 days as against 188 days</u> for the chrome tanned leather cup washer in the test pumps working on an average for seven hours a day in borewells with an average static water level (SWL) of 25 meters.

(b) <u>Reduced frequency of below-ground repairs</u>: Due to the much higher average service life of the nitrile rubber cup washers, the frequency of breakdown will be reduced by at least 50 per cent resulting in reduced maintenance costs.

(c) <u>Reduction in operational effort</u>: Unlike the chrome tanned leather cup washer, the nitrile cup washer does not swell when immersed in water. This reduces friction between the cup washer and the cylinder liner and consequently less effort is required for operation of the handpump.

(d) <u>Higher cylinder brass liner life</u>: Unlike the leather cup washer where sand gets embedded resulting in scoring of the brass liner, sand does not get embedded in the nitrile cup washer and therefore the brass liner does not wear out as fast as in the case of the leather cup washer.

(e) <u>Consistent quality:</u> Leather is a natural product and its quality depends on various factors that are difficult to control in the mass production of cup washers. In the case of the nitrile cup washer the quality can be controlled at the factory by using the proper mix of chemicals and appropriate production methods.

(iii) The replacement of the chrome tanned leather cup washers by nitrile cup washers in the existing India Mark II handpump, necessitates replacement of the following components in the cylinder.

(a) Replacement of the existing spacer: It is necessary to replace the existing spacer by a modified spacer to prevent excessive tightening and deformation of the nitrile cup washer. See Annex III for details.

(b) Replacement of cylinder liner: If the brass liner in the cylinder is rough, the life of a nitrile cup washer will be much less, as it is very sensitive to a rough surface. It is therefore necessary to either replace the existing cylinder body with a brass liner or to replace the existing brass liner. If the brass liner is in good condition there is no need to replace it.

2. Two-piece piston valve

The existing three piece piston valve can be replaced by a two-piece piston valve. This design does not have threaded connection and therefore failures due to the uncoupling of the rubber seat retainer are eliminated. See Annex IV for details.

3. Additional flange

At present the process of removing the pump head in the India Mark II is rather cumbersome. The maintenance process can be simplified considerably by inserting an additional flange (see Annex V for details) and providing a hole of 75mm diameter in the head flange. This modification offers the following advantages.

(i) Simplified maintenance procedure.

(ii) Sufficient space is available to disconnect the chain from the connecting rod.

(iii) Guide bush position can be adjusted to avoid rubbing of the connecting rod.

4. Handle assembly

The average life of bearings has been recorded as 2.8 years during the field testing of India Mark II handpumps in Coimbatore.It was noticed that the fit between the bearing housing and the bearing outer race was loose, hence the life of the bearings was less and also that instead of changing the bearings alone, the handle assemblies themselves were replaced. The average life of bearings has considerably improved after incorporating the following improvements.

(i) Use of 60mm square instead of 60mm dia. section for bearing housing to improve rigidity of the housing.

(ii) Adoption of revised tolerance 47mm -0.017-0.042 instead of 47mm +0 -0.025 in the bearing housing seats.

(iii) Electrogalvanizing of the handle assembly instead of hot dip galvanizing.

(iv) Elimination of reaming of bearing housing after welding and galvanizing. The present practice of reaming of bearing housing seats introduces ovality to the extent of 0.1mm.

5. Head assembly

The banging of the handle at the bottom and top of the bracket stops reduces the life of the bearings. To reduce the banging, the handle bracket opening in the head assembly was increased such that the stroke length increased from 100mm to 125mm. In addition, the foot rest of the platform was raised by 80mm and the total height of the water tank assembly and stand assembly was decreased by 50mm. These improvements helped in reducing significantly the banging of the handle on the bracket stops.

6. Water tank assembly and stand assembly

During the pumping operation it was noticed that the water splashes into the head and also leaks from in between the head flange and water tank flange - this results in rusting of the chain assembly. To overcome this problem the height of the water tank assembly was increased from 135mm to 160mm. This has virtually eliminated the splashing of water.

The height of the stand assembly was reduced by 75mm which makes repairs more convenient. It also helps in reducing the banging of handle on the bracket bottom stop.

STATUS OF THE ABOVE MODIFICATIONS

The above-mentioned modifications 1-4 have already been adopted by the Bureau of Indian Standards Sub-Committee on Handpumps and will be incorporated shortly in the IS:9301, which is currently under revision.

COST OF MODIFICATIONS

The estimated cost of modifications in the existing India Mark II deepwell handpumps is as follows:

(a)	Nitrile cup washer	1 set.	Rs. 20
(b)	Cylinder body	1 No.	Rs.130
(c)	Piston valve	1 No.	Rs. 17
(d)	Modified spacer	1 No.	Rs. 25
(e)	Additional flange	1 No.	Rs. 30
(f)	Machining of 75mm dia hole in the pump head	1 No.	Rs. 28
	Total cost of modifications per India Mark II deepwell handpump		Rs.250

The cost indicated here includes only the cost of material. It is assumed that the modifications will be carried out to the existing India Mark II deepwell handpumps in the normal course of below-ground repairs.

SUGGESTED METHODOLOGY TO MAKE CHANGES

The following methodology is suggested for carrying out the modifications to the existing India Mark II deepwell handpumps:

(i) Items (a) to (e) are procured in sufficient quantities from the approved handpump manufacturers. The materials must be inspected and accepted by an independent inspection agency at the manufacturer's works before despatch.

(ii) The items referred to are made available to all the repair teams so that whenever a repair team carries out the below-ground repairs in an existing India Mark II deepwell handpump, the modifications are incorporated in the existing cylinder assembly. The old cylinder bodies can be reworked at a central workshop by replacing the brass sleeve and kept as spares for reuse.

(iii) For making modifications in the head flange, either of the following options may be adopted.

OPTION 1

Fifty pumpheads with a 75mm dia hole are procured per block and used for replacing the pumpheads in the existing 50 handpumps. The old pumpheads can be brought to a block level or district level store for providing a 75mm dia hole in the pump head either by using a lathe or gas-cutting equipment. A coat of red oxide primer and two coats of enamel paint may be provided on the bare metal surface of the flange. These pumpheads can then be used to replace another fifty pumpheads and the process can continue till all the pumpheads are modified.

OPTION 2

Equipment for gas-cutting is mounted on a mobile van which can visit each pump installation in the block/district. The 75mm dia hole can be made in the pumphead by gas-cutting at the site itself. A coat of red oxide primer and two coats of enamel paint may be provided on the bare metal surface of the flange. This pumphead can then be mounted along with a new additional flange. For the purpose of gas-cutting of a 75mm dia hole, the guide bush can be used as the center.

BENEFITS DUE TO MODIFICATIONS

These modifications will result in the following benefits:

(i) Saving in annual recurring maintenance cost: An annual saving of at least Rs.150 is expected as a result of reduction in the frequency of breakdowns. The investment of Rs.250 required for carrying out modifications will be recovered in less than two years. On a national level, the savings in annual recurring maintenance costs alone will be at least Rs.185 million.

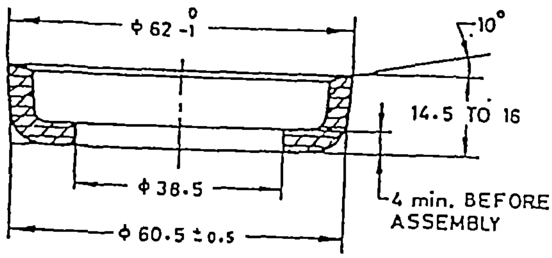
(ii) The mobile maintenance teams will be able to respond quickly to the service calls as they will be required to attend fewer complaints (virtually half the present number).

(iii) Due to the reduction in the frequency of breakdown and reduced response time of the mobile maintenance teams the downtime of the India Mark II handpump will be reduced substantially.

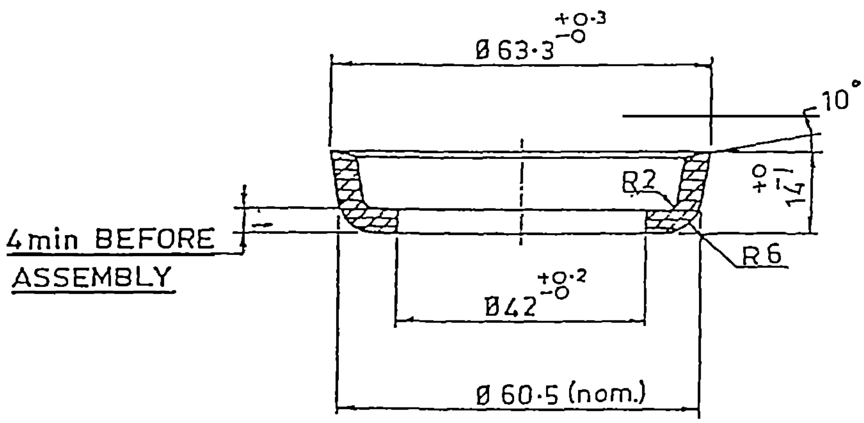
The modifications to the existing India Mark II deepwell handpumps offer advantages that will more than justify the modest investment.

CONCLUSION

The modification of the existing 1.3 million India Mark II deepwell handpumps into the modified India Mark II deepwell handpumps on a national scale will need an additional investment of approximately Rs.325 million. These modifications will reduce the frequency of breakdown by at least 50 per cent and result in an annual saving of at least Rs.185 million. Apart from this, an indirect financial saving of approximately Rs.338 million can be expected due to reduced downtime. This will further enhance the operational reliability of the India Mark II handpump and will reduce pressure on mobile teams and will improve the response time.



MATERIAL:- CHROME TANNED LEATHER



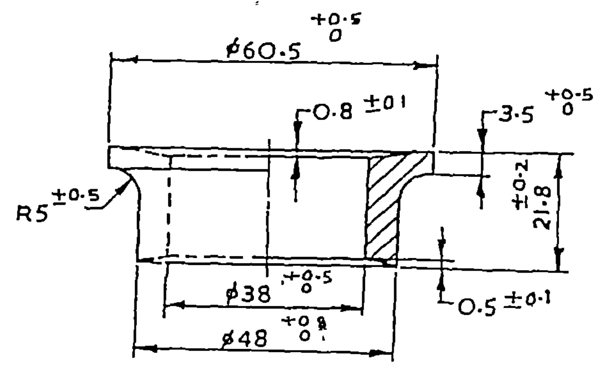
MATERIAL:- NITRILE RUBBER (NBR)
SHORE HARDNESS: $80^{\pm 5}$ SCALE 'A'

HAND PUMP PROJECT INT / 087 / 013	
CUP SEAL	SCALE :- 1:1
	DRG. No.:-

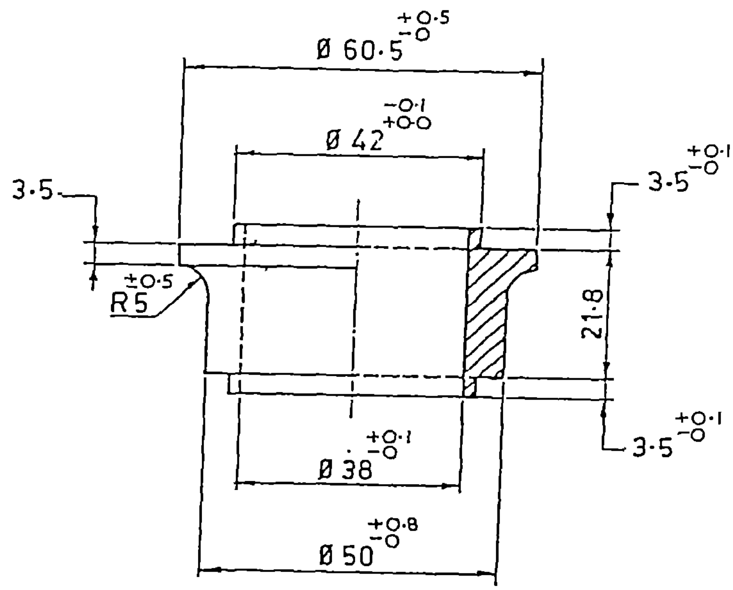
AVERAGE PISTON SEAL LIFE BY TYPE

Type of piston seal	Seal life						Quantity
	Average		Minimum		Maximum		Sets
	M4 x100	days	M4 x100	days	M4 x100	days	
Chrome tanned leather	256	188	26	19	1082	793	122
Vegetable tanned leather	734	538	60	44	2515	1843	35
Vegetable tanned leather (in operation)	509	373	148	109	1641	1203	6
Nitrile rubber	861	631	210	154	1898	1391	36
Nitrile rubber (in operation)	975	715	259	190	2539	1861	46

Note: Piston seal life in days is based on an average usage of 7 hrs per day and an average static water level of 25 meters.



STD. INDIA MARK II

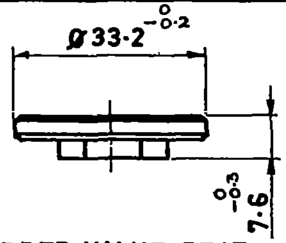


MODIFIED INDIA MARK II

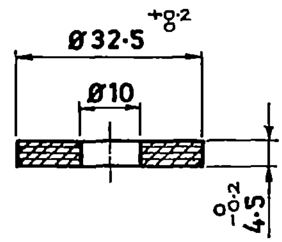
MATERIAL :- Gr. LTB 2 OF IS.318 - 1981 (GUN METAL)

HAND PUMP PROJECT INT/087/013	
SPACER	DRG. No.
	SCALE 1:1

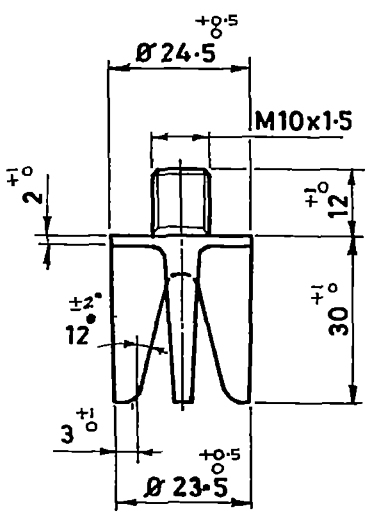
THREE PIECE UPPER VALVE



UPPER VALVE SEAT

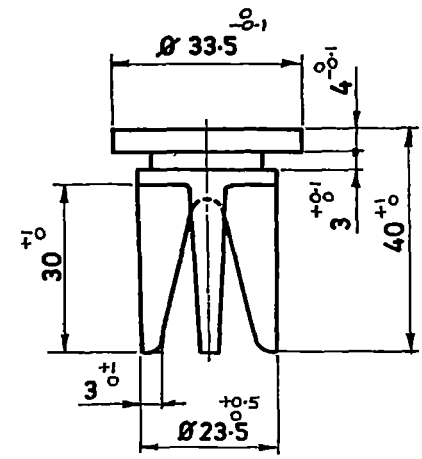


RUBBER SEATING

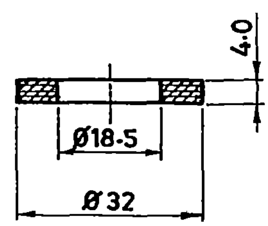


UPPER VALVE GUIDE

TWO PIECE UPPER VALVE

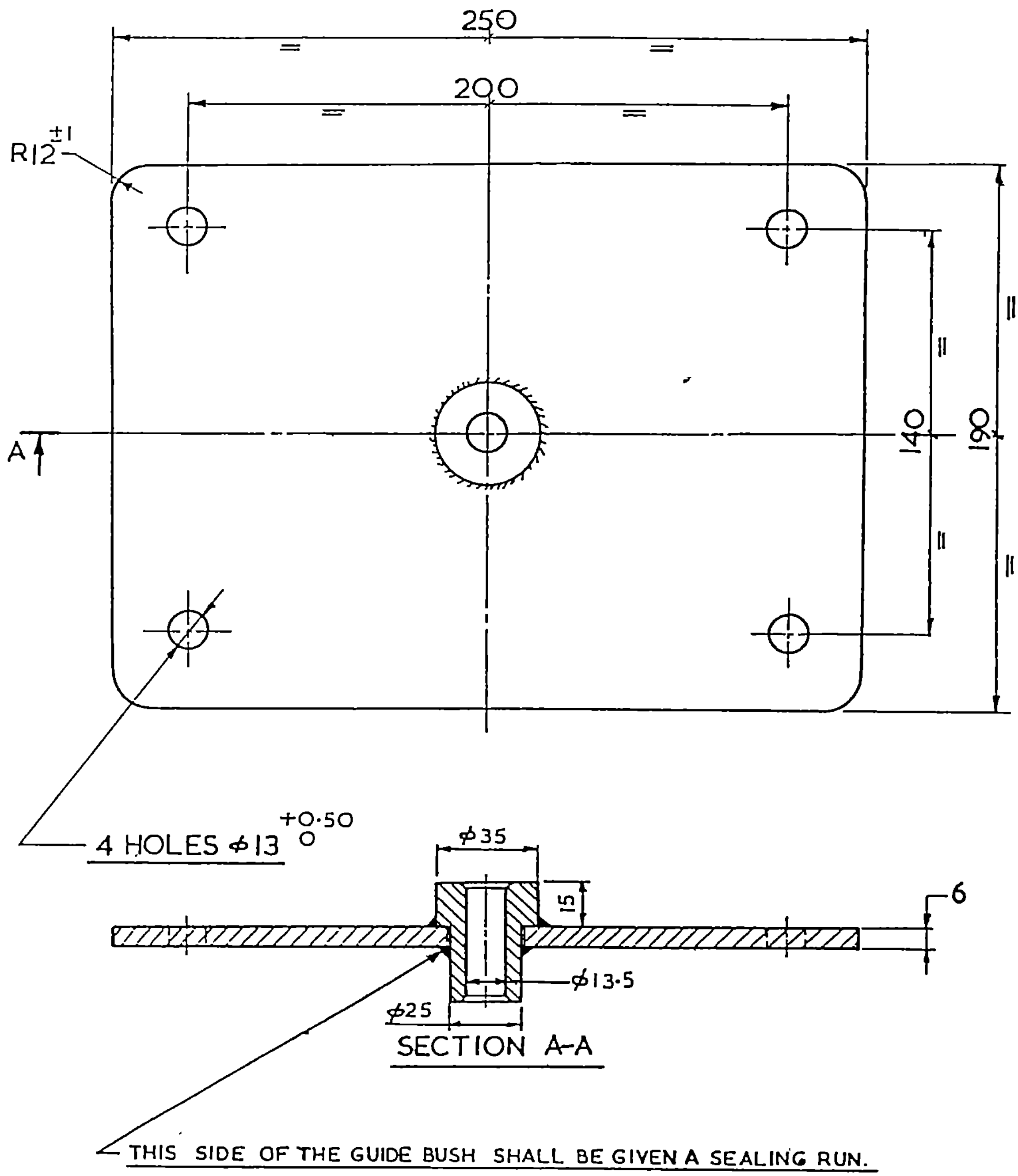


UPPER VALVE GUIDE



RUBBER SEATING

HAND PUMP PROJECT INT / 087 / 013	
UPPER VALVE	SCALE :– 1:1 DRG. No. :–



HAND PUMP PROJECT INT / 087/ 013	
ADDITIONAL FLANGE	DRG. No.
	SCALE 1:1

INDIA MARK III DEEPWELL HANDPUMP DESIGN AND ITS BENEFITS*

Arun Kumar Mudgal
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Water & Sanitation Program
Regional Water & Sanitation Group-South Asia

BACKGROUND

An estimated 300 million people in Asian, African and Latin American countries benefit from India Mark II deepwell handpumps. In India alone more than 260 million people in rural and peri-urban areas are served by over 1.3 million India Mark II deepwell handpumps (India Mark II). This handpump is regarded as one of the most reliable and sturdy deepwell handpump in the world. However, it relies heavily for most of the below-ground repairs on a centralized mobile maintenance team, consisting of a motorized van with special tools, heavy spares like pipes and connecting rods and a team of 3-4 semi-skilled workers. This requirement virtually eliminates the possibility of developing a village-based handpump maintenance system which has high replicability and makes most of the repairs (including below-ground repairs) possible by a village level mechanic with fewer tools.

For the long-term sustainability of a deepwell handpump program it is necessary that most of the handpump repairs are carried out at the village level itself with minimal outside support. In the Indian context this is the essence of the VLOM concept, as enough local manufacturing capacity exists in the country. To achieve this it is necessary that :

(i) The handpump design in use is such that it facilitates most of the repairs at the village level with fewer tools and minimal skills; and

(ii) The spare parts and tools are available at the village.

As part of the global efforts to develop low-cost water supply options the UNDP/World Bank Water & Sanitation Program, in association with multilateral and bilateral agencies, initiated in the early 1980s a global interregional project for laboratory and field testing and the technological development of community water supply handpumps. The laboratory tests were carried out by the Consumer Association in the United Kingdom and field tests were carried out in 17 countries involving some 2700 handpumps of 70 different models to assess their individual performance. The Coimbatore Handpump Field Testing Project

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(Coimbatore Project) in India which was implemented in cooperation with the National Drinking Water Mission, Department of Rural Development, Government of India, Tamil Nadu Water Supply & Drainage Board, Government of Tamil Nadu, Richardson & Cruddas (1972) Ltd., and UNICEF formed part of the Global Handpump Field Testing Project where efforts were largely concentrated on the further development of the India Mark II. One of the important outputs of the Coimbatore Project is the development of a VLOM version of the India Mark II deepwell handpump known as the India Mark III deepwell handpump (India Mark III).

This paper discusses the details of the India Mark III design, its present status, and expected benefits when used in a rural water supply program.

DEVELOPMENT OF THE INDIA MARK III

As more than 0.8 million India Mark II handpumps were already in the field by 1983 when work on further improvements to the India Mark II design was begun, it was considered necessary that the future VLOM deepwell handpump design should use the India Mark II components and subassemblies to the maximum extent, so as to ensure a high degree of interchangeability of components. This restriction prevented the development of an entirely new deepwell handpump design.

The research and development efforts spread over four and half years in the Coimbatore Project resulted in the development of a VLOM derivative of the India Mark II now known as the India Mark III deepwell handpump. This pump has design features which have simplified the below-ground repairs substantially.

Design features of the India Mark III

This pump design enables the extraction of the piston and foot valve without having to remove the rising main pipes and facilitates below-ground repairs (excepting the repairs in the rising main and cylinder body) by one mechanic with the help of a pump user. Annexes I and II give details of India Mark III specifications and its cylinder assembly. The following are the important design features of the India Mark III.

(i) The piston and foot valve can be extracted without lifting the rising main.

(ii) When the piston assembly is screwed on to the foot valve body, the push rod lifts the upper valve guide. This helps in dumping the column of water soon after the foot valve is lifted up by a few millimeters. This makes the lifting of the foot valve, piston assembly and pump rods much easier.

(iii) The foot valve is placed in a conical receiver and sealing is provided by an O-ring.

(iv) Nitrile rubber piston seals have been used which have much higher life than leather seals and the cylinder brass liner does not get scored as easily.

(v) The two-piece upper valve eliminates failures due to disconnection of the threaded joint.

(vi) An additional flange known as the intermediate plate is placed between the head flange and the water tank top flange. This facilitates removal of the head assembly without the removal of the handle assembly. This improves access to the chain assembly and simplifies the maintenance of the above-ground mechanism.

(vii) A square bearing housing instead of a round bearing housing ensures higher rigidity and less distortion of the housing due to welding. This improves the quality of the bearing housing and will enhance the life of the bearings and handle assembly.

(viii) The increased window opening reduces the hitting (banging) of the handle on the bracket bottom stop.

(ix) The height of the water tank assembly was increased to eliminate the splash of water during fast pumping operations. The overall height of that stand assembly was reduced by 75mm to bring the operating end of the handle close to the platform foot rest. This reduces the banging of the handle on bracket bottom stop and makes repairs more convenient.

National Standard

A national standard on the India Mark III is under preparation by the Bureau of Indian Standards, and is likely to be finalized during the year 1990.

Capital cost

The capital cost of a complete India Mark III installation with cylinder setting at 24 mts is approximately Rs.1350 higher than for the India Mark II. The increase in cost is mainly due to the use of a bigger size rising main which is necessary to facilitate extraction of the plunger assembly and foot valve assembly without lifting the raising main.

BENEFITS

The India Mark III offers substantial benefits that are discussed in the following paragraphs.

Improved SERVICEABILITY and its effect on MAINTAINABILITY

The India Mark III is easier to service than the India Mark II with regard to the below-ground components except for the riser main pipes and the cylinder body. For the routine maintenance of India Mark III pumps, a set of fewer and lighter tools and less labour is needed to replace the parts most frequently needing replacement, such as: piston seals, valves, valve seats and above-ground parts and occasionally, pump rods. The comparison of active repair time for the two-pieces of equipment is a good indicator of the relative ease or difficulty in repairing the equipment. The following table gives the mean values of active repair time spent per pump per year to replace various parts.

TABLE 1

COMPARISON OF MEAN ANNUAL ACTIVE REPAIR TIME BY COMPONENT
INDIA MARK II VERSUS INDIA MARK III

Component	Repair time (minutes/pump/year)			
	Mark II	Serviced by	Mark III	Serviced by
Above-ground				
Handle assembly	3.1	BM	2.7	BM
Bearings	1.5	BM	1.5	BM
Chain	2.4	BM	1.3	BM
Lubrication	6.4	C	5.2	C
Sub-total	13.4	--	10.7	--
Below-ground				
Pump rods	7.7	MV	0.7	C & BM
Piston seals	154.7	MV	45.2	C & BM
Foot valve	11.7	MV	3.9	C & BM
Rising main	71.4	MV	15.7	MV
Cylinder	4.8	MV	9.6	MV
Others	1.0	MV	0.7	MV
Sub-total	250.8	--	75.8	--
Total	264.2			86.5

Note: The average depth of cylinder setting for both types of handpumps is 36M.

It may be noted from the table that 67% less time was spent on the India Mark III when similar repairs were carried out on both pumps. Another noticeable feature is that while a mobile team was needed for all below-ground repairs to the India Mark II, the situation is quite different in the case of the India Mark III, where most of the below-ground repairs were carried out by a mechanic with the help of a handpump caretaker. The dependence on a mobile team will be 0.16 times per pump per year in the case of the India Mark III as against 1.44 times in the case of the India Mark II.

Frequency and cost of replacements of parts

The frequency of replacement of parts is 9.15 parts per pump per year in the case of the India Mark II as compared to 4.79 for the India Mark III. The cost of parts replaced was 46% less in the case of the India Mark III, i.e. Rs.228 per India Mark III per year as against Rs.423 per India Mark II per year.

Maintenance Costs

Maintenance costs (see following table) for the India Mark II and India Mark III have been worked out based on the assumptions made on the density of pumps and travel distance and the data collected during the Coimbatore project on consumption of spare parts, active repair time and manpower needed for various types of repairs.

TABLE 2

COMPARISON OF MAINTENANCE COST PER PUMP PER YEAR

Item		Mark II Rs.	Mark III Rs.
1.	Maintenance Cost		
	(a) Caretaker	40.00	40.00
	(b) Block mechanic	18.61	42.25
	(c) Mobile team	392.10	70.66
	(d) Spare parts	423.50	228.20
	Total	874.21	381.11
2.	Saving/annum in maintenance	--	493.10

The maintenance costs given here should be treated only as indicative of the sensitivity of maintenance costs to the change of technology. The maintenance costs will vary from region to region due to many variable factors such as pump usage, pump density, quality of tube well and quality of water.

However it is evident that there are substantial savings in the maintenance cost in the case of the India Mark III. These savings can be further increased if village-level mechanics are trained to carry out most of the repairs at the village level itself and an efficient spare parts distribution system established.

Breakeven point on cash basis

It is estimated that the extra expenditure of Rs.1350 (approx.) on the capital costs in the case of the India Mark III will be offset in 3 to 5 years time due to lower maintenance costs.

Lower downtime

In the case of the India Mark III, over 90% of the repairs can be carried out by a mechanic (using a two-wheeler) with the help of a pump user. This mechanic will be easily accessible and will therefore cut down communication delays and reduce the response time. This will reduce the downtime. The financial and economical benefits accruing due to lower downtime will be far in excess of the savings in the maintenance cost.

CONCLUSION

The India Mark III deepwell handpump is substantially easier to maintain and it is possible to train village based mechanic/handpump caretakers to carry out most of the repairs including the replacement of cup washer, plunger and foot valve components, connecting rods, bearings, chain assembly etc. which account for more than 90% of the repairs to the pump.

The shifting of most of the repairs to the village level will result in substantial financial savings and reduction in downtime which in turn will result in considerable financial and economic benefits.

The design has been field tested for a sufficiently long period, and is recommended for adoption on a large scale.

ANNEX I

SPECIFICATIONS FOR INDIA MARK III HANDPUMP

The handpump shall conform to IS-9301-1984 in all respects excepting the following:

(A) Head assembly

1. Handpump head base to have 75mm dia hole instead of guide bush.

2. Bracket opening is increased to enable a minimum stroke length of 127mm.

3. Additional flange similar to head flange (St.Mark II) with the guide bush welded at the center. The guide bush ID to be increased to 15mm.

4. Handle assembly to have 60mm square bearing housing with bearing seatings internally ground. Final dimension of bearing seatings 47 -0.017-0.042. The handle assembly to be electrogalvanised to 50 microns (min) thick or painted. Inside of bearing housing not to be electrogalvanised or painted.

(B) Water tank assembly

1. 2-1/2" NB seamless coupler instead of 1-1/4" coupler

2. Height of water tank is increased by 25mm

(C) Stand assembly (Telescopic)

1. Height is reduced by 75mm.

(D) Cylinder assembly

1. Top cap to suit 2-1/2" NB riser pipe.

2. Bottom cap to have conical housing to receive pick up check valve and thread at the bottom to suit 2 1/2" NB intake pipe.

3. Nitrile rubber cup seals and modified spacer.

4. Extended follower with threads to pick up check valve.

5. Two-piece upper valve guide.

6. Check valve assembly. with two-piece valve, conical base, 0' ring, cage and stainless steel lifting rod.

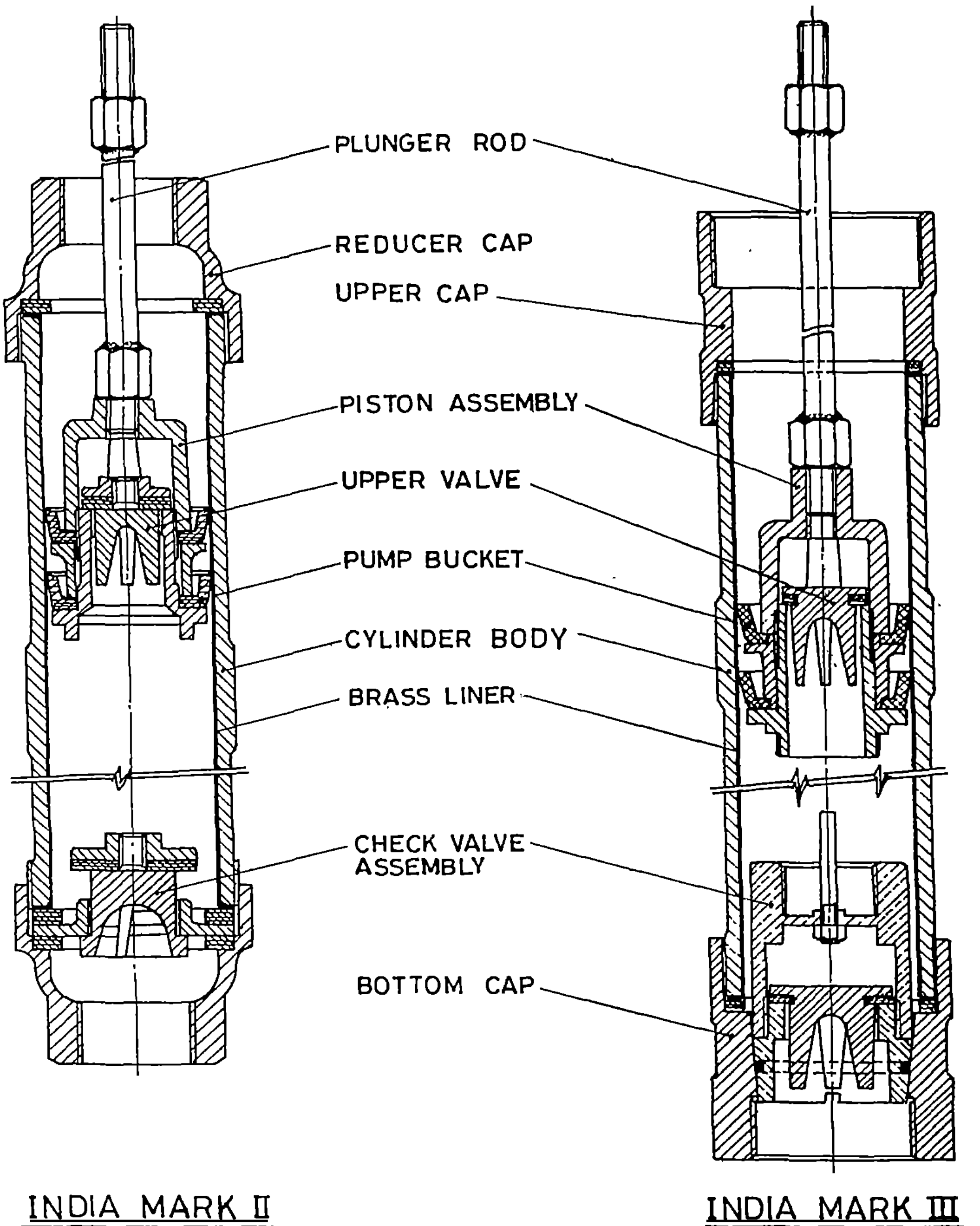
7. Both caps to have hexagonal outside rib for ease of installation and dismantling.

8. O.D. on cylinder not to exceed 91mm.

9. The height of the cylinder is increased by 51mm.

10. 2 1/2" NB pipe, 3M long to be coupled at the bottom of the cylinder as intake pipe.

11. Plunger rod of stainlèss steel.



HAND PUMP PROJECT INT / 087 / 013	
CYLINDER ASSEMBLY	SCALE :- N.T.S.
	DRG. No :-

HANDPUMPS DEMONSTRATION PROJECTS' FINDINGS*

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INTRODUCTION

The development of the India Mark II handpump during 1976-77 represented a major breakthrough for the Rural Water Supply Program in India. At present over 1.5 million India Mark II handpumps are in operation in India alone, serving an approximate rural population of 300 million. Several thousand India Mark II deepwell handpumps are also serving rural communities in many parts of Asia, Africa and Latin America.

Extensive field and laboratory tests have proved that the India Mark II deepwell handpump is a very sturdy and reliable handpump. However, it is not easy to maintain at village level, as it needs heavy tools and special skills for carrying out below-ground repairs. To improve its reliability and maintainability at village level, research and development activities were carried out by different bilateral and multilateral agencies under the guidance of the Government of India (GOI).

As a result of this collaborative effort in the Coimbatore Handpump Field Testing Project, two improvements emerged in the India Mark II handpump design, namely the "Modified India Mark II handpump" and the "India Mark III (VLOM) handpump". Since the field test was carried out on a small scale in a confined area, GOI initiated four large scale Demonstration Projects in cooperation with four State Governments with technical and hardware support from UNICEF and the UNDP/World Bank Water and Sanitation Program.

The four demonstration projects have been in operation since early 1988 and are located in Ranchi district in Bihar, Rangareddy district in Andhra Pradesh, Betul district in Madhya Pradesh and four districts in Maharashtra.

This paper discusses the findings based on one-and-half years of monitoring (up to December 1989) of 174 modified India Mark II handpumps and 155 India Mark III handpumps being field tested in these demonstration projects.

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* The views expressed in this paper are that of the author and should not be attributed in any manner to the UNDP/World Bank Water & Sanitation Program.

OBJECTIVES OF THE DEMONSTRATION PROJECTS

The main objectives of the handpump demonstration projects are:

1. To evaluate handpump performance;

2. To assess spare parts requirement and consumption patterns;

3. To find out actual maintenance costs;

4. To determine Mean Time Before Failure(MTBF);

5. To develop more appropriate platform designs to overcome present deficiencies;

6. To develop a village based handpump maintenance system; and

7. To identify design changes during the course of field testing which could simplify maintenance.

STATUS

All the demonstration handpumps are working satisfactorily except two India Mark III handpumps which were not operational due to the silting/collapsing of the borewell. The demonstration handpumps have been distributed and installed as detailed in Table 1 in the four demonstration projects.

TABLE 1
DISTRIBUTION OF DEMONSTRATION HANDPUMPS

Project area	State	No. of demonstration handpumps	
		Modified India Mark II	India Mark III
Betul	Madhya Pradesh	25	25
Ranchi	Bihar	50	49
Rangareddy	Andhra Pradesh	50	32
Pune	Maharashtra	9	14
Satara	-do-	15	10
Aurangabad	-do-	10	15
Ahmednagar	-do-	15	10
Total		174	155

The quality of borewell water was tested for all the demonstration pumps except for the pumps in the Betul demonstration project. Generally the water quality was found to be good. The important parameters are summarized below:

1. pH value - 7.0 to 8.5
2. Electrical conductivity - 226 to 3870 moh/cm
3. Total dissolved solids - 145 to 2361 mg/l
4. Total iron content - 0.06 to 0.55 mg/l
5. Total chloride as cl - 2 to 1120 mg/l
6. Dissolved oxygen - 1.6 to 6.8 mg/l
7. Total fluoride as F - 0.4 to 5.6 mg/l

The fluoride content and dissolved solids are beyond the acceptable limit in a few borewells in the Rangareddy project area.

METHODOLOGY

The following formats have been used to collect field data from the demonstration handpumps.

1. Village details form;
2. Borewell details form;
3. Pump details form;
4. Inspection and repair details form; and
5. Water quality details form.

The data collected are being analyzed on a modified spread sheet program (Lotus 123 Release 2) using a microcomputer. The findings are briefly discussed here.

HANDPUMP PERFORMANCE

The reliability of a pump can be measured by the number of occasions a pump breaks down or needs major repairs to keep it in working condition. Out of 174 modified India Mark II and 155 India Mark III handpumps installed, 153 modified India Mark II and 122 India Mark III handpumps were working satisfactorily without any failure till the end of 1989. Tables 2 and 3 give the mean annual frequency of visits and replacement of parts recorded per pump respectively.

TABLE 2
MEAN ANNUAL FREQUENCY OF VISITS

Pump Type	Visits/Pump/Year					
	Maharashtra		Ranchi	Betul	Rangareddy	Average
India Mark III	0.187	0.095	0.311	0.243	0.194	
Modified India Mark II	0.308	0.047	--	0.060	0.136	

The average number of visits and frequency of parts replacement recorded are rather low possibly due to the following reasons.

1. The average monitored period for the modified India Mark II and India Mark III pumps is low ranging from 13.7 months to 16.5 months. In fact the average monitored period for the modified India Mark II pumps in the Betul project is only 2 months.

2. In the majority of cases, newly drilled borewells have been used to test the demonstration handpumps.

3. The quality of the water is comparatively good with less dissolved solids in general.

4. Improved designs like nitrile rubber bucket washers, two-piece valve, etc. have been used from the beginning of the project.

5. The average static water level is low i.e. 8.4m for the India Mark III pumps and 9.7 for the India Mark II pumps.

6. Usage of the pumps appears to be low.

SPARE PARTS CONSUMPTION

The average frequency of replacement of parts for both the types of pumps are given in Table 3. The average frequency of replacement of parts for the India Mark III pump is higher than for the modified India Mark II pump, as the average monitored period is higher for the India Mark III pumps.

TABLE 3
MEAN ANNUAL FREQUENCY OF PARTS REPLACEMENT

Part Type	Parts Replaced/Pump/Year	
	Modified India Mark II	India Mark III
Axle	0.004	0.009
Handle assembly	0.013	0.019
Chain assembly	-	0.005
Chain bolt and nut	0.004	0.020
Piston seal (NBR)	0.057	0.091
Rising main (pipe)	0.065	0.053
Rising main (coupler)	0.065	0.053
Connecting rod	0.022	0.044
Piston valve	0.004	0.006
Foot valve O-ring	-	0.064
Cylinder assembly	0.004	0.005
Cylinder cap	-	0.006
Water tank	0.004	0.037
Bolt	0.079	0.191
Nut	0.070	0.005
Total	0.391	0.608

The mean annual frequency of parts replacement recorded for the India Mark III handpump was higher than for the modified India Mark II handpump for the following reasons.

1. Bent connecting rods were used in the India Mark III handpumps in the Betul project,

2. The piston seals were replaced in the India Mark III pumps when 30% reduction in discharge was noticed in the Maharashtra project,

3. Leakage in the foot valve due to use of non-standard 'O'rings; and

4. Use of non-standard GI couplings and improper threading of GI pipes.

MAINTENANCE COST

The existing PHED infrastructure has been used to maintain the demonstration pumps. The exact maintenance cost for both types of pumps cannot be worked out as the information relating to active repair time, travelling time and type of transport used are not currently available.

MEAN TIME BEFORE FAILURE

The Mean Time Before Failure (MTBF) can be defined as the duration for which the handpump operates satisfactorily. The MTBF is an indicator of the reliability of handpumps. The average MTBF for the India Mark III pumps and the modified India Mark II pumps are given in Table 4.

TABLE 4
MEAN TIME BEFORE FAILURE FOR BOTH TYPES OF PUMPS

Pump Type	Mean Time Before Failure in Months				
	Maharashtra	Ranchi	Betul	Rangareddy	Average
India Mark III	15.9	15.2	14.4	16.8	15.4
Modified India Mark II	14.6	14.9	2.0	15.7	12.8

As the majority of the pumps are still working without any failure so far, the average MTBF is expected to be higher than indicated here.

MAINTAINABILITY

The following table details the transport, skills and manpower requirements for both types of pumps. It clearly illustrates that the skills and manpower required are relatively less for the India Mark III pump, as compared to the modified India Mark II pump, depending upon the type of repairs. The need for a mobile maintenance team is substantially reduced in the case of the India Mark III handpump.

TABLE 5
TRANSPORT, SKILL AND MANPOWER REQUIREMENT
FOR INSTALLATION AND MAINTENANCE OF BOTH TYPES OF PUMPS

Sl.	Item	Requirement	
		Mark III	Modified Mark II
1.	Transport required		
	a) For installation	4 wheeler	4 wheeler
	b) For above-ground repair	2 wheeler	2 wheeler
	c) For below-ground repair		
	i) replacement of bucket washers, valves and connecting rod	2 wheeler	4 wheeler
	ii) replacement of riser pipe and cylinder body cap	4 wheeler	4 wheeler
2.	Skill required		
	a) For installation	skilled	skilled
	b) For above-ground repair	semi-skilled	semi-skilled
	c) For below-ground repair		
	i) replacement of bucket washers, valves and connecting rod	semi-skilled	semi-skilled
	ii) replacement of riser pipe and cylinder body cap	skilled	skilled
3.	Manpower required		
	a) For installation	6	4
	b) For above-ground repair	1	1
	c) For below-ground repair		
	i) replacement of bucket washers, valves and connecting rod	2*	4
	ii) replacement of riser pipe and cylinder body cap	6	4

* A block/area mechanic can attend to the repairs with the help of a caretaker/user.

Table 6 gives the average time taken for installation and normal repairs for both types of pumps with cylinder setting at 30 mts. It clearly illustrates that the maintenance of the India Mark III pump is less time-consuming compared to the modified India Mark II pump.

TABLE 6
AVERAGE TIME TAKEN FOR INSTALLATION AND REPAIRS FOR BOTH TYPES OF PUMPS

Sl.	Item	Time taken in manhours	
		India Mark II	Modified India Mark II
1.	Installation of pump	7.5	3.3
2.	Pump bucket replacement	0.5	4.7
3.	Piston/check valve replacement	0.6	4.7
4.	Riser pipe/cylinder cap/ cylinder body replacement	13.0	5.3

HANDPUMP PLATFORM DESIGN

In the standard circular India Mark II handpump platform, it was noticed that the splashing of water outside the platform is considerable, resulting in stagnation of water around the platform. To overcome these problems the following two different designs of platforms were constructed and are under observation.

1. Modified circular platform: The design details are the same as per IS:11004 (PartI) 1985 except, (a) the spout is in the center of the platform instead of the pedestal being in the center and (b) the foot rest size has been increased from 600x600mm to 1000x1000mm and the height by 80mm. The additional cost incurred for construction of this type of platform is around Rs 90. For more design details see Figure 1.

2. Rectangular platform: The design details are the same as per IS:11004 (Part I) 1985 except (a) instead of a circular shape,it is a rectangular shaped platform of size 2000*1750mm, (b)the spout is in the center of the platform and (c) the foot rest size is 1000*1000 mm and the height of foot rest has been increased by 80mm. The additional cost incurred for the construction of this type of platform is around Rs 180. For more design details see Figure 2.

In both types of platforms, the splash of water and consequent stagnation of water around the platform has been reduced considerably. The users find it more convenient to operate the pump as the foot rest is bigger and the banging of the handle at the bottom bracket stop has also been reduced significantly. The rectangular platforms were constructed without the use of any platform shuttering.

VILLAGE-LEVEL HANDPUMP MAINTENANCE SYSTEM

The existing handpump maintenance system is being used to maintain the modified India Mark II and India Mark III demonstration pumps. As more than 90 % of repairs to the India Mark III pumps can be carried out by a village-level mechanic/caretaker with little training, it was envisaged that the village-level handpump maintenance system as explained in Annex I could be introduced. However, since only 25 to 50 India Mark III handpumps were installed in each project area and as these were distributed over a larger area, the village-level handpump maintenance system could not be developed.

It is proposed to increase the number of India Mark III handpumps installed to 250 - 300 handpumps in each project area covering at least one block of a district. The proposed village-level handpump maintenance system will then be introduced in all the project areas.

CONCLUSIONS

1. Out of 174 modified India Mark II and 155 India Mark III handpumps installed, 153 modified India Mark II and 122 India Mark III pumps have been working satisfactorily without a single failure for the past one-and-half years. The performance of both types of handpumps indicates that the reliability of both types of pumps has improved compared to the standard India Mark II handpump.

2. The average MTBF for the India Mark III and the modified India Mark II pumps are 15.4 and 12.8 months respectively. As the majority of pumps are still working without any failure so far, the average MTBF is expected to be higher than indicated.

3. As the average monitored period for the India Mark III pumps is 16.5 months and for the modified India Mark II pumps is 13.7 months only, the incidence of repairs on the demonstration pumps are less. It is necessary to monitor the pumps for at least a period of four years to obtain the realistic average of number of visits/pump/year, spare parts requirement, maintenance costs and life period of wearing pump components.

4. The data collected so far indicate that over 90 % of the repairs can be attended to by a block mechanic with the help of a pump user for the India Mark III pumps and that the mobile team attendance required is reduced by 51 % for the India Mark III pump as compared to the modified India Mark II pump.

5. The users find it easier to operate the India Mark III handpump due to the reduced friction between the connecting rod coupler and the rising main pipe.

6. As the effort required to repair the India Mark III pump is considerably less, it was noticed that users come forward to carry out the below-ground repairs after the simple demonstration. This indicates that the village level handpump maintenance system is feasible.

7. Both the new types of platforms are found to reduce the stagnation of water due to less splash and the reduction in the banging of handle on the bottom bracket stop.

8. The analysis of data collected so far from the four demonstration projects indicates that the results arrived follow the same trend as the Coimbatore Project findings. However, there are variations in the numerical values, since the Coimbatore Project was carried out in a controlled situation and conditions and the static water level, usage of pump, etc. were much higher.

PROPOSED HANDPUMP MAINTENANCE SYSTEM FOR BOTH HANDPUMP TYPES

The proposed maintenance system envisage a gradual change in responsibility and accountability for handpump maintenance from the implementing department to the user community through formation of village Water and Sanitation Committees to take charge of the village handpumps. The proposed maintenance system consists of a Water and Sanitation Committee, Village Mechanics, Handpump Caretakers/Users representative and Back-up Mobile Team as described here.

Water and Sanitation Committee

The committee will have to be formed with the following members for each Gram/Village Panchayat. This should be initiated/formalized by the district level committee through the district development officers and Block Development Officers.

1. Panchayat representative - Chairperson of Committee
2. Two panchayat members (women)
3. PHED representative
4. Health workers (preferably women)
5. Anganvadi workers
6. NGO representative (preferably women)
7. School teachers (preferably women)
8. Caretakers/user representatives

The committee members will be given orientation on the selection of caretakers and village mechanics, handpump repair and maintenance, low-cost sanitation, health education, finance management, handpump spare parts management, etc. as part of formalizing a village committee and creation of greater awareness about the Water and Sanitation Program. This committee will select one or two caretakers/users' representatives for each handpump and one village mechanic for 30 to 35 handpumps who will operate in village clusters. The committee will be encouraged to collect a nominal water charge (say Rs.0.25 per head per month) from each household and pay for the maintenance and repair work carried out by the village mechanics. The PHED will provide the spare parts and tools to the water committee. Later on the committee may be encouraged to pay for the spare parts and tools. The committee will also keep the records on the handpump maintenance carried out and create a village data base. The committee will supervise/monitor the handpump repair and maintenance, sanitation and health education activities. The committee will provide space to store the spare parts, tools and wornout spare parts.

Pump Caretakers/Users Representative

One or two women caretakers will be selected by the committee and they will be given training by the PHED on handpump repair and maintenance, upkeep of surroundings, sanitation, health education, etc. They will carry out minor repairs and do all preventive maintenance like greasing and tightening/ replacing of bolts and nuts and maintain record of repair information possibly on a prescribed card. They will also be responsible for keeping the handpump platform and surroundings clean. The waste water should be used for gardening. If this is not possible, a soakpit should be constructed by the committee. Whenever a major breakdown occurs, she will intimate the water committee. They will also help the village mechanics and mobile team whenever repairs are carried out on the handpump.

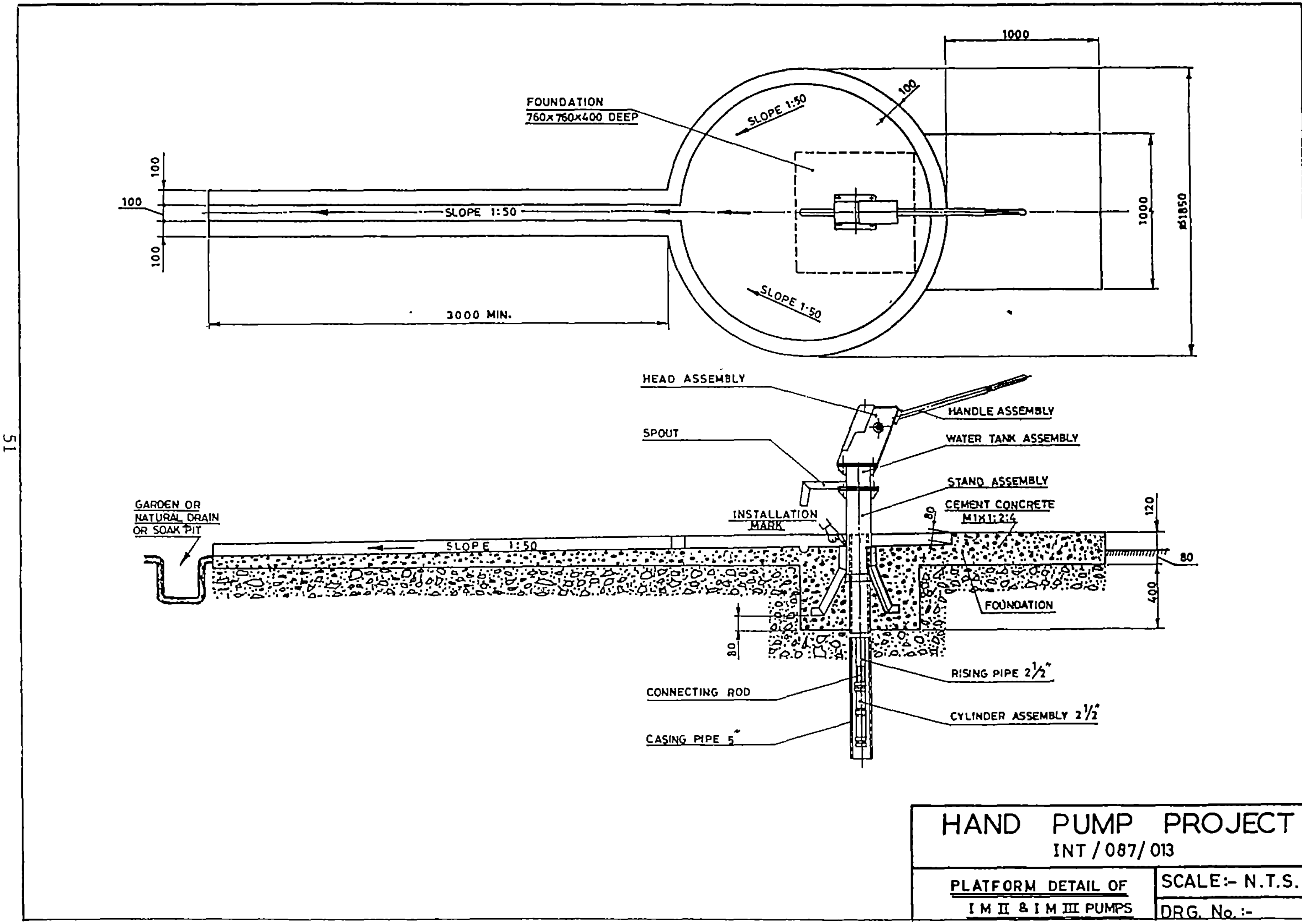
Village Mechanics

The village mechanics will be selected from a cluster of villages by the water committee. Preference should be given to the bicycle mechanic, tractor and pump mechanic, etc. They will be given extensive training by the PHED and ITI to carry out all repairs on the handpump. Whenever the breakdown is reported, the committee will call the mechanic and supply necessary tools and spare parts. The mechanic will carry out the repairs with the help of caretakers and users. One of the committee members will supervise the work and pay for it according to the nature of repairs carried out. Whenever it is not possible to carry out repairs by the village mechanics, the committee will request the back-up mobile team (maintained by the PHED at Tahsil level) to carry out repairs.

Back-up Mobile Team

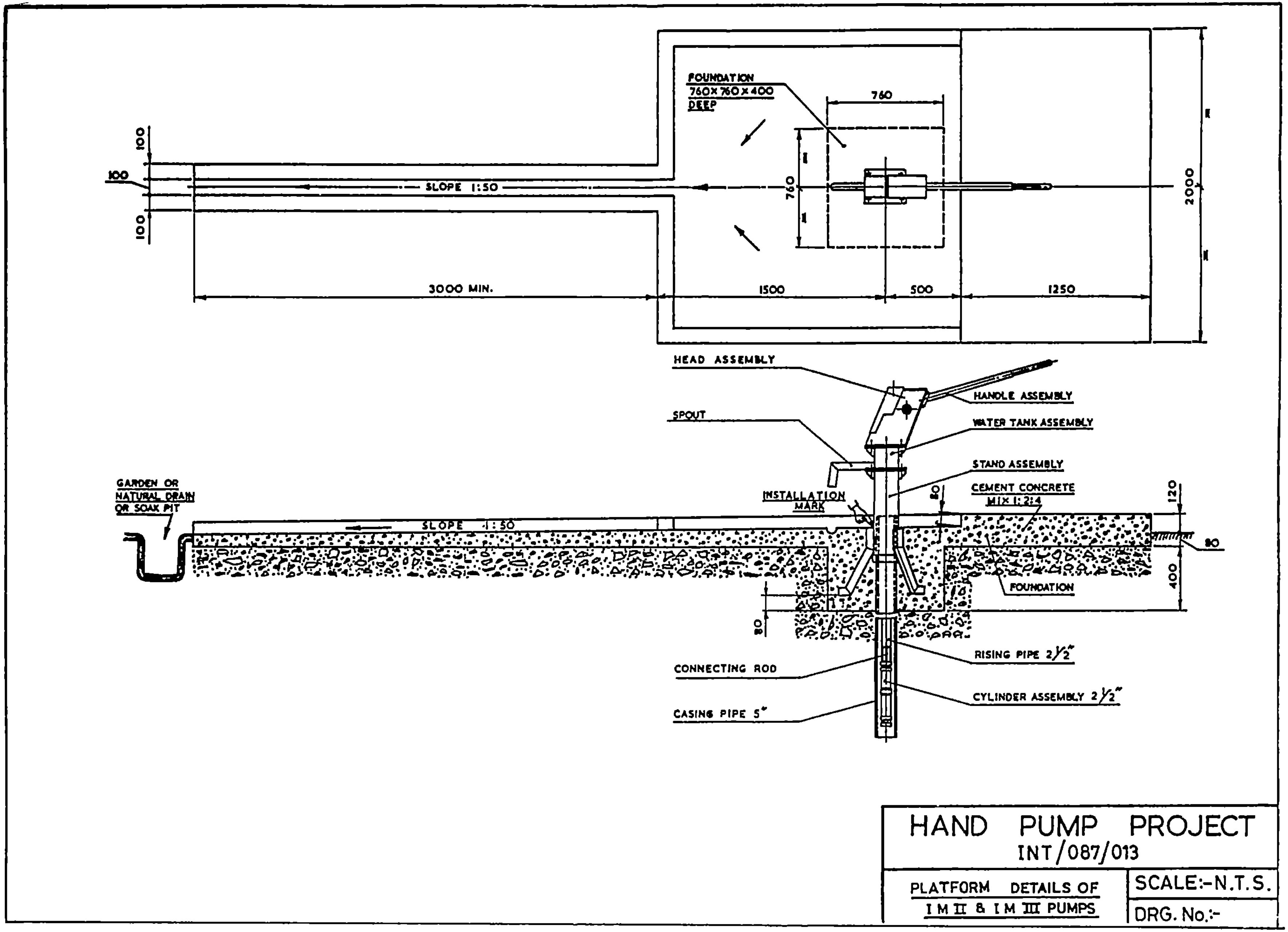
The mobile team will be located at each PHED sub-division(Tahsil) level office. It will carry out new handpump installation and platform construction works. Whenever the repair is beyond the village mechanics' capability, the committee will report to the sub-division office. After the receipt of the report the mobile team will attend to the repairs. It will be equipped with all spare parts for major replacement and special tools to attend the fishing and flushing of borewells. It will distribute the spare parts and tools to the village committee as per requirement and collect the old spare parts and tools. When the new system functions well, at a later stage the PHED may collect the actual cost of the spare parts and tools from the committee. The PHED will be responsible for the purchase of quality spare parts and tools, giving training to the water committees, village mechanics and handpump caretakers. It is recommended to have at least one mobile team for every 1500 handpumps for IM II and 2500 handpumps for IM III.

Figure 1



FOUNDATION
760×760×400 DEEP
SLOPE 1:50
100
1000
100
100
SLOPE 1:50
1000
ø1850
100
SLOPE 1:50
3000 MIN.
HEAD ASSEMBLY
HANDLE ASSEMBLY
SPOUT
WATER TANK ASSEMBLY
STAND ASSEMBLY
GARDEN OR
NATURAL DRAIN
OR SOAK PIT
INSTALLATION
MARK
80
CEMENT CONCRETE
M1X1:2:4
120
SLOPE 1:50
80
400
FOUNDATION
80
RISING PIPE 2½"
CONNECTING ROD
CYLINDER ASSEMBLY 2½"
CASING PIPE 5"
HAND PUMP PROJECT
INT / 087/ 013
PLATFORM DETAIL OF
I M II & I M III PUMPS
SCALE:- N.T.S.
DRG. No. :-

Figure 2



FOUNDATION
760X760X400
DEEP
760
760
100
100
100
SLOPE 1:50
2000
3000 MIN.
1500
500
1250
HEAD ASSEMBLY
HANDLE ASSEMBLY
SPOUT
WATER TANK ASSEMBLY
STAND ASSEMBLY
CEMENT CONCRETE
MIX 1:2:4
INSTALLATION
MARK
GARDEN OR
NATURAL DRAIN
OR SOAK PIT
SLOPE 1:50
120
80
80
400
80
FOUNDATION
RISING PIPE 2½"
CONNECTING ROD
CYLINDER ASSEMBLY 2½"
CASING PIPE 5"
HAND PUMP PROJECT
INT/087/013
PLATFORM DETAILS OF
I M II & I M III PUMPS
SCALE:-N.T.S.
DRG. No.:-

NATIONAL STANDARDS FOR DEEPWELL HANDPUMPS - A REVIEW

D.K. Agrawal
Director
Bureau of Indian Standards

STANDARDIZATION

Standardization is an activity of formulating standards aimed at solving recurring problems by pooling the knowledge and experience of experts in the field. The standards formulated by the Bureau of Indian Standards are reviewed every 5 years as a rule. However, with the advances in technology and improvement in the design of equipment and instruments, the existing standards are amended or revised from time to time.

INTRODUCTION TO DEEPWELL HANDPUMPS

As national importance is being given to the drinking water scheme for the rural areas, the need was felt for the installation of handpumps in different villages in the country for harnessing drinking water from underground resources. As early as 1960, handpumps were being used for lifting water from the wells which were mainly being used by the single family rather than by the community as a whole. As a result of the development, an Indian Standard, IS:9301 on the deepwell handpumps was first published in 1979. These pumps were being used for lifting water from the wells of depth from 20 m up to 50 m. Based on the feed-back due to the implementation of this Indian Standard, a need was felt to review it to bring it in line with the manufacturing practices and the Indian Standard was first reviewed in 1982 incorporating certain modifications. This was further reviewed and a second revision brought out in 1984. A number of modifications were incorporated in the first revision of this standard, of which the following are of specific importance.

1. The requirements of galvanizing was incorporated as the type 'test' and a new clause on 'routine test' included.

2. The 'performance test' of 1979 version was designated as the 'type test' and a new clause on 'routine test' was included.

The second revision of this Indian Standard has been brought out in order to bring it in line with techniques bring employed for the manufacture of the deepwell handpumps. The following are some of the important changes made in the second revision.

1. Tolerances on some of the dimensions have been changed and specified on the basis of IS:919 (Part 1):1963.

2. Stainless steel has been specified as the manufacturing material for the handle axle.

3. Solid triangular gussets at the top and bottom of the handle bracket are provided.

4. Connecting rods and plunger rod have been provided with hexagonal couplers in place of lock nuts.

5. 40 mm tank spout had been specified in place of 32 mm one in order that the tank is immediately cleared of the water and there is no undue splash.

6. Rear two stand legs at 80 degrees has been specified in place of 120 degrees in order to increase the stability of the pump.

7. Painting has been deleted as an anti-corrosive treatment for steel components.

With the improvements in design and developments in technology, this standard was again taken up for upgradation and the revised version is under print which incorporates the following changes.

1. Stainless steel plunger and connecting rods incorporated.

2. Relief groove for handle axle specified.

3. Telescopic stand assembly included.

4. Stand assembly has been modified by providing spikes.

5. Design of reducer cap and cylinder body modified to prevent slippage.

6. Upper valve modified in two parts for eliminating the failure due to unservicing of couplings.

7. Welding of stainless steel components specified.

8. Critical dimensions, in the figures identified for inspection purposes.

9. Nitrite washers have been introduced to improve life of the pump. However, the leather cup washer will be phased out in two years time.

10. Bearing housing has been modified for minimizing distortion due to welding.

11. Third plate has been introduced for easy maintenance.

<u>VILLAGE-LEVEL OPERATION AND MAINTENANCE OF HANDPUMPS (VLOM pumps)</u>

Since the development of the deepwell handpump, considerable progress has been made in its further refinement. Efforts have been made in design improvement to increase reliability and to simplify the maintenance. The outcome is the VLOM pump with an open top cylinder (OTC). Such pumps are designed to make the majority of the handpumps repair possible by local mechanics. Modifications incorporated in VLOM pumps are designed to simplify maintenance procedures and reduce cost. The basic difference between the VLOM and the deepwell pump is that the VLOM has an open top cylinder which helps in pulling out the lower check valve from the ground without pulling out the cylinder/main riser.

The draft Indian Standard on the subject has already completed wide circulation and will be considered at the forthcoming meeting of the Pumps Sectional Committee for finalization.

EXTRA DEEPWELL HANDPUMPS

The static water level in some of the States has fallen even below 40 m. Where it is difficult to operate the deepwell handpumps (according to IS:9301), the extra deepwell handpumps have been designed which allow the use of the existing deepwell handpump head assembly with minimal changes.

The draft Indian Standard Specification on the subject has already completed the wide circulation period and will be considered at the forthcoming meeting of the Pumps Sectional Committee for finalization.

INSTALLATION AND MAINTENANCE

In order to ensure safe drinking water without a break to the rural population, the proper installation and maintenance of the deepwell handpump is of utmost importance. For the guidance of the users and the manufacturers, a code of practice for the installation and maintenance of the deepwell handpumps has been laid down in two parts of IS:11004 wherein Part 1 covers the Installation and Part 2 covers the Maintenance of the deepwell handpumps. Currently, both these Indian Standards have been taken up for upgradation.

NOMENCLATURE

For the proper identification of the components of deepwell handpumps, a separate Indian Standard in which every nomenclature and part classification has been fixed, and which can be utilized in drawing inventory system, data processing, etc. is also under printing.

CONCLUSION

In the area of deepwell handpumps, considerable efforts have been made by organizations like UNICEF and the UNDP/World Bank for further improvements to the design. A Handpump Field Testing Project near Coimbatore has been set up by the Tamil Nadu Water Supply and Drainage Board and M/s Richardson Cruddas (1972) Limited with the objective of carrying out potential improvements in the deepwell handpumps and to make maintenance procedures simpler.

India has the largest national rural water supply program in the world using deepwell handpumps with ISI Mark for the supply of safe potable ground water. There are 55 licensees who use the ISI Mark on deepwell handpumps. Efforts are being made to further improve the design of the deepwell handpumps suitable for operation with maximum efficiency in various parts of the country.

BETUL HAND PUMP DEMONSTRATION PROJECT
EXPERIENCES ON PUMP PERFORMANCE

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Water as we all know is a prime natural resource, a basic ingredient of the life-cycle on earth influencing its type and quality. Unfortunately, it occurs only in a limited quantity on the land surface and is unevenly distributed in space and time. In the context of its sustainable use without significantly affecting the hydrologic cycle, fresh water for the use of man is limited to precipitation on the main land which is the only source of annually renewable fresh water supply to nature. The rising rural population as well as rising standards of living demand intensification of resource use. Many regions of the world are faced with the problem of balancing limited sources against ever increasing needs. A modified handpump like the India Mark III can play an important role in optimizing the limited water sources for the rural population.

HISTORICAL BACKGROUND OF THE PROJECT

The Rural Water Supply Handpump Project was established in 1981 with the goal of analyzing and promoting the reduction of capital and recurring costs of the rural water supply system with wide-scale coverage.

The project was initiated with technological innovations, testings, promoting and demonstrating improved handpump designs and their manufacturing process. For initiation of a village-level maintenance system, a training program was formulated for the district.

The importance of providing a reliable and sustainable ground water supply system and a cost-effective handpump maintenance system has led to the "Village Level Operation and Maintenance" (VLOM) concept.

In late 1983, the Government of Tamil Nadu, UNICEF, UNDP/World Bank Water and Sanitation Decade Program undertook a joint project to field test the India Mark II deepwell handpump and an experimental variation of certain components. Two types of the India Mark II handpump were tested under conditions of actual use in Coimbatore District. As results of the testing were encouraging, the National Drinking Water Mission of the Government of India initiated four demonstration projects in the States of:

1.	Bihar	Ranchi District
2.	Madhya Pradesh	Betul District

3.	Maharashtra	Pune, Satara, Aurangabad and Ahmednagar Districts
4.	Andhra Pradesh	Rangareddy District

The projects are to demonstrate and monitor the above developments of the handpump in cooperation with the four State Governments, UNICEF and the UNDP/World Bank Water and Sanitation Program.

Betul District demonstration project activities were carried out by the Public Health Engineering Department with the coordination of the E.L.C. Water Development Project, a voluntary agency at Betul. To implement the project activities three adjacent blocks of Betul district as mentioned below were selected for the demonstration and monitoring of the handpumps.

1. Betul Block
2. Shahpur Block
3. Ghodadongri Block.

OBJECTIVES

The objectives of the proposed handpump demonstration project are to:

1. Evaluate handpump performance.

2. Assess spare parts requirement and consumption.

3. Determine Mean Time Before Failure (MTBF).

4. Develop a village-level handpump maintenance system.

5. Develop more appropriate platform designs to overcome the present deficiencies and to improve the life span of the handpump components.

6. Identify design changes during the course of field testing to further improve reliability of the handpump.

7. Overcome the problems of installation and maintenance of handpumps at various stages.

DESIGN FEATURES OF THE INDIA MARK III HANDPUMP

The India Mark III handpump is designed to overcome difficulties encountered with the standard India Mark II handpump, especially in the assembly below-ground level. Water lifting elements are to be taken out to the surface by pulling the connecting rods and valve assembly with or without check valve as described without pulling out the rising main assembly. Modifications have been incorporated in the existing components for an improved working system, simplified for easy maintenance by reducing repair time, the manpower requirement and the number of tools required for maintenance.

Maintenance methodology has been accepted by the village blacksmith, cycle repair mechanic and handpump users, especially women with some technical aptitude and after some basic training in India Mark III handpump maintenance.

PROJECT STATUS IN BETUL DISTRICT

Thirty-four India Mark II and 25 India Mark II modified handpumps have been installed with modified platforms between April 1988 and January 1990.

GEOLOGY OF THE DISTRICT

The geological formations in Betul district range in age from Precambrian to recent types of rocks. Rock types that occur in the district are:

1. Granite, Gneiss, Schist and Quartzixites
2. Sandstone and shale; and
3. Basalt.

SITUATION OF THE DISTRICT

Betul district is located on the southern borders of Madhya Pradesh and occupies an area of 10,059 sq.km. Physically, the district lies on the Satpuda Plateau and is traversed by the steeply rising Satpuda Hills.

DESCRIPTION OF TUBEWELL CONSTRUCTION FOR DEMONSTRATION

Fifty tubewells were selected for the installation of test pumps. The year of construction of the tubewells is shown as follows.

1971 to 1975	12
1976 to 1980	6
1981 to 1985	8
1986 to 1988	24

All the tubewells were drilled by the Public Health Engineering Department through private agencies and departmental drilling rigs. The construction of platforms was also carried out by the same agencies.

MONITORING OF THE TEST PUMPS

At the initial stage, the monitoring of only 23 handpumps was carried out due to various unavoidable circumstances. Monitoring is being carried out for each handpump regarding the following information which was recorded in the INSPECTION AND REPAIR REPORT FORM.

A. Date of visit for inspection, preventive maintenance and breakdown repair.

B. Leakage from cylinder or rising main components.

C. Discharge of water in liters at 40 strokes per minute.

D. Handle display to ascertain the ball bearing condition.

E. Static water level fluctuation in different months during monitoring.

Only two handpumps have been repaired after breakdown over the last two years. In the remaining handpumps only preventive maintenance was carried out.

LIFE SPAN OF HANDPUMP COMPONENTS

As stated previously, only two handpumps were repaired after breakdown for the following reasons:

1. Plunger rods were separated from other connecting rods.

2. Plunger yoke body got unscrewed from follower.

The following spare parts were replaced during maintenance.

1.	Nitrile rubber cup seals	3 sets
2.	Check valve '0' ring	7 Nos.
3.	Upper valve rubber seating	1 Nos.

The quantity of the '0' ring replacement is in excess because of its bad quality. After the '0' ring leaves its proper seating it drops to the bottom of the tubewell.

The following are the list of spares replaced due to manufacturing defects, change in design, faulty installation and as part of the preventive maintenance system.

1.	Piston assembly	3 Nos.
2.	Check valve assembly	3 Nos.
3.	Spacer	1 No.
4.	Follower	1 No.
5.	Plunger rod	1 No.
6.	Chain assembly	1 No.
7.	Rising main pipe joints	5 Nos.
8.	M-12 nuts	29 Nos.

PERFORMANCE

The overall performance of the India Mark III and India Mark II modified handpumps is excellent and 100% efficient. In the month of April 1990 all 59 handpumps were monitored for performance and it was found that the discharge of water per minute at 40 strokes varies from 15 LPM to 17 LPM. This shows the efficiency of the assembly below-ground level. As for the assembly above-ground, only one handpump has a handle display of 4.5mm.

TIME CONSUMED FOR REPAIR OF INDIA MARK III HANDPUMPS

Previously, in the experimental period, the time consumption for repairing was more, as compared to the present.

1. Minimum time taken 50 minutes
   Depth of cylinder 36.60 mts.

2. Maximum time taken 105 minutes
   Depth of cylinder 42.70 mts

3. At present, time taken 32 minutes
   Depth of cylinder 33.60 mts

MEAN TIME BEFORE FAILURE (MTBF) FOR INDIA MARK II HANDPUMPS

The average MTBF of the India Mark III handpump is 18 months. The modified India Mark II pumps have been installed only at the end of 1989; all pumps are working satisfactorily without failure.

MODIFIED CIRCULAR PLATFORM

The design detail is as per IS:11004 (Part 1) 1985 specification except that:

1. The spout is in the center of the platform.

2. The foot rest size has been increased from 600mm x 600mm to 1000mm x 1000mm.

SQUARE PLATFORM

The square platforms were of different dimensions.

1. 1750mm x 1750mm
2. 1850mm x 1850mm
3. 2000mm x 2000mm.

The handpump is taken as the center of the platform and the footrest size is being increased to 1000mm but of trapezoidal shape.

RECTANGULAR PLATFORM

The rectangular platforms also differ in size.

1. 1750mm x 1850mm
2. 1850mm x 2000mm.

PLATFORM DESIGNS

In the standard India Mark II handpump platform design, the foot step is not large enough for the handpump to be operated conveniently when the user is standing. The pedestal being at the center of the platform, the splashing of water outside the platform resulted in dirty environmental conditions. Stagnation of water and at later stages soil erosion around the platform was also observed. To overcome these problems, different designs of platforms were constructed. The most effective method was by increasing the size of the footrest which has proved to be the most convenient for the users and has restricted the user hitting the lower handle stopper bracket.

Comparing circular and rectangular platforms

The rectangular platform of size 1750mm x 2000 mm length and having the handpump installed at 1/3 length from the back edge is found to be effective in improving sanitary conditions; this is also liked by the villagers. The wooden frame used for platform construction is also light in weight and quick in operation as compared to the complicated circular frame.

AUGMENTATION OF THE PROJECT

After the achievements and successes of the Mark III handpump, it is proposed to convert the whole Betul block to Mark III handpumps. This will provide almost maintenance-free and easy water supply to villagers. The total cost of the project will be Rs.24.00 lakhs and the project is likely to be completed in two years. The maintenance cost of the handpumps in Betul block which at present is Rs.3.00 lakhs per year, will be reduced to Rs.50,000 through cost-effective maintenance.

TRAINING

Villagers, particularly tribal women, need sufficient training to familiarize themselves with the installation and repair procedures of VLOM (Mark III handpump). To achieve this, twenty training programs will be arranged in different villages by the Public Health Engineering Department in coordination with the WDP, Betul and other public representatives.

The training may also motivate villagers towards improved sanitation behaviour.

CONCLUSION

The India Mark III Village Level Operation and Maintenance (VLOM) type handpump has excellent performance and durability compared to the standard India Mark II handpump. In the last two years some of the Mark III handpumps have been installed in the tribal area of the demonstration project. At the present stage, the users themselves have distinguished the difference in operation and dependability between the India Mark II standard and the India Mark II modified, India Mark III VLOM handpumps.

The India Mark III handpump is preferred by the villagers and they wish to have all the handpumps replaced by this version. Now the situation is that the villagers do not run away when the maintenance team approaches the handpump. On the contrary, they come forward to help the maintenance team because the repair procedure is simple and less time-consuming.

At present, handpump users are well aware of their responsibilities and are eager to actively participate in operating and maintaining the rural water supply system. This achievement was due to a short training program for the villagers just to familiarize them with the anatomy and function of the India Mark III handpump.

As Betul district is full of hillocks and valleys and dense forest areas, some of the villages are even cut off during heavy rains and floods. Installation of the Mark III handpump will not only reduce the maintenance cost considerably but will also provide uninterrupted potable drinking water throughout the year.

In Betul district, due to the fast depletion of underground water, the installation of handpumps in place of power pumps in some villages has been of great help during the current acute water scarcity.

ANNEXURE 1

ESTIMATE FOR ANNUAL MAINTENANCE OF INDIA MARK II HANDPUMP

Quantity	Item	Sub-Head	Unit	Rate	Amount
1 Job	1	Oiling & Greasing of Handpump 4-5 times per year	P.Job	Lump sum	50
As per requirement of parts	2	Replacement of spare parts such as bearing, chain, axle and C.I. cylinder, upper valve guide, check valve guide spaces, follower rubber seat retainer, bucket, etc.	P.Job	Lump sum	300
Job	3	Increasing of riser pipe (32mm dia G.I. pipe 10" length) in the bore average cost of pipe Rs.50/Mt.	P.Job	Lump sum	50
Job	4	Repairing of cement concrete platform, and drain including cost of materials	P.Job	Lump sum	50
Job	5	Transportation of material charges including expenses of P.O.L. etc.	P.Job	Lump sum	40
Job	6	Labour charges for repairing of handpump (salary of mechanic, wage of labourers, etc.)	P.Job	Lump sum	100
		TOTAL		RS.	580
				Approximately	600

(Rupees six hundred only)

MAHARASHTRA HANDPUMP DEMONSTRATION PROJECT
EXPERIENCES OF MAINTENANCE

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INTRODUCTION

The Maharashtra Handpump Demonstration Project was launched on the guidelines of the Government of India given during late 1987, through the Groundwater Surveys & Development Agency (GSDA), Pune, in Satara, Ahmadnagar, Aurangabad and Pune districts, to test and conduct the field trials on the India Mark II Modified and India Mark III deepwell handpumps. This project was monitored by the GSDA, UNICEF and UNDP/World Bank Water & Sanitation Program.

The pumps were installed on the existing borewells which were initially fitted with India Mark II handpumps, so as to compare the performance of India Mark III pumps under common circumstances in the field. Under this project, forty-nine India Mark II Modified handpumps and forty-eight India Mark III handpumps were installed to conduct the test under various conditions.

The first interim report, from inception to December 1989, on the tests conducted, the system adopted for maintenance of these pumps and the observations were submitted to UNDP.

AIM OF THE PROJECT

The project was taken up to evaluate the performance of test pumps, to work out the maintenance cost, to determine the MTBF (Mean Time Before Failure), to identify the design changes, to assess the spare parts consumption and to develop a village-level hand pump maintenance system.

The focus of attention was on the need for introducing a new generation pump which can be repaired at the village level by utilizing the local skill and also to minimize the downtime.

STATUS OF TEST PUMPS

Installation of test pumps, like the India Mark II Modified and the India Mark III handpumps was completed up to October 1988 in three districts and up to January 1989 in the fourth district. These pumps were installed in eleven talukas covering ninety-seven villages which are located on all-season approachable roads. The borewells were constructed in Deccan Trap Formations having a Static Water Level (SWL) range of 2 meters to 30 meters. The ninety two borewells drilled were of 150mm nominal diameter, four borewells were of 100mm nominal diameter and one borewell was of 200mm diameter. The depth of the borewells ranged from 32 meters to 96 meters having the M.S. Black medium class casing depths from three meters to twenty meters.

Water samples from forty eight borewells have been tested and the chemical analysis results have indicated that the water quality is good.

The code numbers indicating district, type of pump (India Mark II Modified or India Mark III) and the serial numbers of pumps in the particular district are painted or punched for identification.

The data regarding list of villages identified, details of borewell, information regarding other sources of water in the village, village details, pump details and water analysis report, were recorded at the district level.

The platforms were constructed adopting three designs as follows.

1.	Standard India Mark II platform circular type	61
2.	Standard India Mark II platform circular type with spout at the center and foot rest of increased size.	26
3.	Square platform with spout in the center and foot rest of increased size.	10

MONITORING OF TEST PUMPS

The monitoring of test pumps was initiated immediately after installation. The following information was recorded during the monitoring of each test pump.

1. Discharge
2. Leakage if any
3. Handle side play
4. Static Water Level (SWL)
5. Repair time
6. Transport type and distance
7. Spares replaced

Since the emphasis was to be on the VLOM system, the selection of the villages was done prior to the installation of the handpump in consultation with the Sarpanch of the village. The pumps were installed departmentally and the selected local man was involved in the construction of the platform and installation of the test pump. Thereby, the man responsible for maintenance and repair at village level was trained in the basic technical know-how. This participation also helped to motivate the local man. The village-level repair kit received from UNICEF was provided to the local man.

The monitoring at the district level was carried out by the Deputy Engineer. The route map was prepared for the mechanic to visit the test pumps and the 'Inspection and Repair Form' was filled in by the mechanic. The mechanic visited the pump periodically and also carried out the repairs wherever necessary, taking the help of the local man.

The mechanic has conducted the following tests during his regular visits to the test pumps.

1. The discharge of the handpump and the discharge for 40 strokes per minute.

2. The pump was also tested for leakages considering the strokes required for priming.

3. Handle side play was checked and the axle was tightened as required.

4. Static water level in the bore was measured during the visits.

5. Regular maintenance carried out by the local man was monitored.

6. The breakdowns if any were attended to with the help of the local man.

A motorcycle was provided to the mechanic to carry the tool kit and the spares during his visit. The average test pumps per district are twenty-four and therefore only one mechanic was deployed for this work. The average period required to cover these pumps was observed to be 4-5 days per month in the district.

MAINTENANCE AND REPAIR ANALYSIS

This analysis is based on monitoring of the test pumps from their inception to December 1989.

India Modified Mark II Pumps

1.	Total number of pumps installed	49
2.	Pumps working without failure	34
3.	Pumps of which bucket washers replaced	10
4.	Pumps of which handle replaced	02
5.	Pumps of which water tank repaired	01
6.	Pumps of which connecting rod sheared	01
7.	Pumps of which riser pipe unscrewed	01
8.	Average MTBF	14.1 months
9.	Range of MTBF	3.8 to 19.3 months

India Mark III Pumps

1.	Total number of pumps installed	48
2.	Pumps working without failure	38
3.	Pumps of which bucket washers replaced	02
4.	Pumps of which handle replaced	05
5.	Pumps of which riser pipe unscrewed	03
6.	Average MTBF	15.5 months
7.	Range of MTBF	8.8 to 19.5 months

These data indicate that handle failure occurred on seven handpumps. This handle failure is abnormal and needs further investigation. Bucket washer replacement is a part of regular maintenance. Riser pipes of four pumps have been unscrewed and this is due to improper coupling. The shear of the connecting rod of one pump is due to improper fitting. The corner of a water tank flange was broken due to loosening of bolts.

In short, if the abnormal failures of handles and riser pipes are treated separately, then the failures observed are due to the regular wear and tear of the bucket washers.

MAINTENANCE EXPERIENCE

1. The frequency of breakdown of the India Mark III pump is very low compared to the India Mark II pump.

2. In India Mark II handpumps, the replacement of bucket washers requires pulling out the riser pipes which needs heavy tools and considerable labour and skill. In case of the India Mark III handpumps, the replacement of bucket washers can be carried out by a single person with light tools. Also, the time required is considerably less.

3. The monitoring of the India Mark III pump is carried out by the mechanic provided with a two-wheeler. The mobile van with a team of 3 or 4 persons and special tools is not required as is necessary in the case of the India Mark II pump.

4. The repairs to the India Mark III pump are carried out at the village level immediately. However, in the case of the India Mark II pump the repairs are delayed due to the reporting system and depending on the availability of the mobile van.

5. The repairs cost of the India Mark III pump is considerably lower due to repairs made at the local level, high MTBF, less labour and minimum spares.

6. Handling hours of the pump are reduced in case of the India Mark III pump as compared to the India Mark II pump due to high discharge capacity.

7. In case of the India Mark II pump, rising pipes are damaged due to the frequent use of pipe wrenches and vice. Also, the threads are damaged due to frequent unscrewing and tightening. These occurrences are eliminated in the case of the India Mark III pump.

8. The direct participation of the local man in maintenance and repairs motivates the community to maintain the pumps and the environment.

9. The repairs to the India Mark III pumps are carried out immediately at the village level and therefore the pump works practically throughout the year satisfies the villagers.

10. The repair system is decentralized in the case of the India Mark III pumps.

11. Local employment can be created through the adoption of the India Mark III pump.

RECOMMENDATIONS

1. India Mark III pumps may be adopted as a replacement to India Mark II pumps.

2. The existing India Mark II handpumps may be rejuvenated to Modified India Mark II handpumps.

3. The existing repair system may be decentralized and the VLOM system may be adopted subsequently.

**MAINTENANCE OF INDIA MARK III HANDPUMPS:
EXPERIENCES FROM THE DANIDA-ASSISTED
ORISSA DRINKING WATER SUPPLY PROJECT**

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SUMMARY

As a field testing program to look for alternatives to the standard India Mark II deepwell handpump, 29 India Mark II handpumps with substantial modifications were installed in Delang block of Puri district, Orissa in 1986 by the Danida-assisted Orissa Drinking Water Supply Project implemented by the Public Health Engineering Department of the Government of Orissa. These modifications to the IM II pump were later incorporated and standardized into the India Mark III hand pump.

Very positive indications of the performance of these pumps were available by 1988, and the project agreed to instal these pumps in one block during 1989-90.

The original 29 pumps were monitored since their installation and handed over to the village-based maintenance system in 1989. The data from the pumps till 31 December, 1989 substantiates that the modified pump has substantial performance and maintenance advantages as compared to the standard IM II Deepwell handpump, to justify the increased cost of some of its components, but more importantly, to be maintained by user groups trained for this purpose.

This paper presents the data gathered over during 1986-89, on the basis of which the above conclusions have been drawn.

Background

The Orissa Drinking Water Supply Project is a bilaterally aided project implemented by the Public Health Engineering Department of the State Government of Orissa, assisted by Danida, Government of Denmark.

The project area is in 20 coastal blocks of Balasore, Cuttack and Puri districts of Orissa, covering about 2,500 villages and serving a population of about 2.5 million people.

Phase I of the project started in August 1985, and was completed by December 1987, with the installation of about 1,650 handpumps in 3 blocks of Chandbali, Rajkanika and Delang.

In Phase II A of the project about 2,200 handpumps have been installed during 1988-90, in 5 blocks of Aul, Rajnagar, Kanas, Brahmagiri, and Puri Sadar.

Among the innovative activities of the project in Phase I, 29 India Mark II handpumps with a number of modifications were installed for field trials in order to verify whether this pump offered a viable alternative suited to the shallow water table conditions of coastal Orissa rather than the standard India Mark II deepwell handpump.

The modifications incorporated in the 29 pumps installed for field trials were:

1. <u>Head</u>: Modified to use "intermediate" or "third" plate, and fitted with light T-bar handle.

2. <u>Water Tank</u>: Modified to accept galvanized iron riser pipe of 2 1/2 inches diameter.

3. <u>Riser Pipe</u>: 2 1/2 inches diameter.

4. <u>Cylinder</u>: Open Top Cylinder, to allow access to the check valve and plunger assemblies without removal of riser pipes.

In the Orissa project, these pumps came to be known as IM II OTC Low Lift Pumps since all the 29 pumps were installed with cylinders at 9 m to 12 m below-ground level. All the installations were completed during 1986 on newly-constructed tubewells in Delang block, Puri district.

Eventually, a number of the above modifications became standardized in the IM III handpump.

<u>Maintenance system</u>

The maintenance of handpumps in the project is done through Self Employed Mechanics or SEMs. An SEM is usually a village artisan - blacksmith, carpenter, cycle or pump mechanic - who is trained by the project in two stages in pump maintenance. While the construction of wells and installation of pumps is continuing in a block, potential SEMs, identified earlier by project staff, are initially trained in groups of 8 to 12 persons, in the preventive maintenance of pumps. They then undergo a probationary period of 2 to 3 months at which time their attitude and aptitude towards pump maintenance is assessed. Successful trainees then undergo a second and more thorough phase of training where they learn to undertake all repairs to pumps, and also the administrative procedures necessary for monitoring and reporting upon the performance of pumps. Upon completion of training, the village artisans are "commissioned" as SEMs by giving them tools, bicycles, spare parts, record books, and contracts to maintain approximately 20 handpumps per SEM, close to their homes, at a fee of Rs.120 per pump per year.

SEMs are expected to visit each pump under their care once a month for preventive maintenance, and report about the performance of each pump to the block Junior Engineer at regular monthly meetings. At these monthly meetings, the SEMs receive spare parts anticipated for use in the coming month, and make appointments with their colleagues for undertaking major repairs to below-ground assemblies.

A group of 25 to 30 SEMs in each block is supervised by a block level Maintenance Junior Engineer who has a pump maintenance crew of 3 persons to assist him. The Junior Engineer's responsibility is to train SEMs, administer and supervise SEMs in his block, make random visits to pumps to verify pump condition and SEMs visits, conduct monthly meetings of SEMs at which time pump reports are taken, spare parts issued, major maintenance appointments made with the JEs repair crew and make blockwise summary monthly maintenance reports for the project head quarters. Payment to SEMs is made from project headquarters, through block level banks, after receipt of monthly reports from JEs. The JE has a motor cycle, and his crew move on bicycles for their supervision and assistance to SEMs for difficult pump repairs.

By 1987, the project had commissioned about 80 SEMs for 1650 hand pumps in the 3 blocks of Phase I of the project. An additional 100 SEMs had been commissioned by early 1990, for the maintenance of the project. This total of about 3850 hand pumps were supervised by 8 block-level Junior Engineers, reporting to one Assistant Engineer at project headquarters.

By the end of 1989, the contracts of about 10% of the SEMs of Phase I blocks had to be discontinued, mainly due to unsatisfactory performance. In most cases, tools and cycles were recovered.

Maintenance and monitoring of pumps

Since their installation, all the 29 pumps were maintained and monitored on a regular basis. Up to the end of 1988, both these functions were done under the direct supervision of the project headquarters. At the time of monitoring visits, preventive maintenance to the pumps was completed, depth of water level in the tubewell was measured, and discharge of the pump was measured for detecting poor performance of below-ground assemblies.

During 1989, the pumps were handed over to the regular maintenance system established by the project, and the pumps were maintained by SEMs. Like all other pumps given in their charge for maintenance, SEMs visited the IM III pumps on a regular monthly schedule to complete preventive maintenance. Repairs due to poor performance and breakdowns of pumps were also undertaken by SEMs with intimation to the block Junior Engineer. Monitoring visits continued from the project headquarters for water level and discharge measurements.

Data from monitoring visits and maintenance records of each pump were tabulated and have been discussed later.

Performance of pumps

Age of pumps: After about 11 months since their installation, the sites of 13 pumps had to be changed due to water quality problems. By the end of 1989, the average age of the 29 pumps was:

Average age of 13 pumps up to their removal 321 days

Average age of 13 pumps after reinstallation, till 31 December, 1989	947 days
Average age of 16 pumps which continued as original installations by 31 December, 1989	1293 days
Average age of 29 pumps by 31 December, 1989	1282 days (42.7 months)

Visits to pumps: Since the pumps were under observation since installation they were supposed to be visited on a monthly schedule.

Routine visits were made for the purpose of completing preventive maintenance and making water level and discharge measurements.

Unforeseen visits were generally made for the purpose of undertaking breakdown repairs.

Other Visits were for purposes such as demonstration, special observations, etc.

The breakup of visits made to the 29 hand pumps since their installation is as follows:

Purpose of Visit	No. of Visits	Percentage
Routine Visits	583	83.4%
Unforeseen Visits	26	3.7%
Other Visits	90	12.9%
TOTAL VISITS	699	100%

The above analysis indicates that an average of 23.4 visits were made to each pump during its average age of 42.7 months by December 1989, i.e. the visit schedule worked out to about once in two months instead of the original plan of monthly visits. Despite this, the percentage of unforeseen visits was quite low, 3.7%, indicating that routine visits provided most of the opportunities to complete necessary maintenance.

Static Water Level measurement: A total of 459 measurements of static water level were made during monitoring visits. The grouping of these observations in 1 m intervals indicates the following:

83.7% of SWL observations were in the range of 0m to 5m

14.6% of SWL observations were in the range of 5m to 7m

1.7% of SWL observations were in the range of 7m to 10m

The single largest group of SWL observations, 30.9% fell in the range of 1 m. to 2 m. below-ground level.

The above analysis indicates that ground water tables were generally close to the ground level, and rarely exceeded 7 m. depth.

Discharge measurement: Discharge measurements made at the time of monitoring visits were divided by the theoretical discharge of a pump cylinder to arrive at the volumetric efficiency of a pump at each visit. A total of 580 computations of volumetric efficiency were available for analysis and yielded the following results:

1.7% of the observations were in the 60% to 90% efficiency range.

94.5% of the observations were in the 90% to 150% efficiency range.

3.9% of the observations were in the 150% to 190% efficiency range.

This analysis indicates that discharges tended to be higher than expected, probably due to the high water table and the good performance of cylinder components.

Maintenance needs of pumps

Maintenance categorization

Whether a pump was working or not, all interventions or interruptions to a pump, which led to any maintenance, repairs or replacements, was considered as "maintenance". The categorization of maintenance has been by Reason and Location. Within these two categories, further distinction was made as follows.

Reason for maintenance	Preventive Maintenance - PM
	PM with Nuts and Bolts replacement - PM N&B
	Poor Performance Maintenance - PP
	Breakdown Maintenance - BD
	Other Maintenance (during demonstrations or inspections) - OTH
Location of: maintenance	Above-ground - AG
	Below-ground - BG
	Below-ground repairs completed using the Open Top Cylinder System - BG-OTC

Below-ground requiring
removal of Riser Pipe - BG-RP

On the basis of this categorization, it was possible to classify each maintenance intervention with a combination of codes for reason for and location of maintenance. The maintenance data was then analyzed under three main areas:

1. Maintenance need

2. Component replacement

3. Selected problems

Results from data analysis

1. Maintenance need

Preventive Maintenance - of the total 42 sites, PM was sufficient for 11 sites that were reinstalled and 1 site that was an uninterrupted installation till December 1989.

Preventive Maintenance along with replacement of Nuts and Bolts - PM N&B was sufficient for 12 out of the total of 42 sites.

Above-ground and Below-ground - AG and BG maintenance interventions were necessary in the remaining 18 out of the 42 sites.

- AG maintenance was needed in 14 out of the 18 sites.

- In AG maintenance, 8 instances were due to Poor Performance- PP, and 4 instances were due to Breakdowns - BD.

- The average time interval between AG interventions was 501 days.

- BG maintenance was necessary in 12 sites with 24 occurrences.

- BG-PP occurred in 10 sites and BG-BD in 4 sites.

- BG-OTC (Open Top Cylinder extraction) was possible in 7 sites, while BG-RP (Riser Pipe withdrawal) became necessary in 10 sites.

- The average time interval between BG interventions was 363 days. While the interval between BG-OTC repairs and between BG-RP was the same, 363 days, the interval between BG-PP was 441 days and between BG-BS it was 1114 days.

- Multiple interventions of AG and BG were needed on 14 out of the 18 sites. Two interventions were recorded on 9 sites and 3 interventions were recorded on 3 sites.

- The average time interval between AG interventions only was 501 days. Between BG interventions only, this interval was 363 days.

2. Component replacement

One-time replacements were needed for:

Upper Valve
Check Valve Assembly complete
Bottom Cap of Cylinder

Low-usage components were:

Inspection cover	3
Inspection cover bolt	2
Chain bolt and nut	2
Sealing ring	4
Plunger rods	4

Other replacements were:

Components	Nos used	Sites used on	Occurr-ences	Average interval
Bearing	9	7	8	443 days
'O' Rings	11	8	11	449 days
Cup Washers	4 pr	3	4	837 days
Riser Pipes	2	2	2	983 days
Pipe Socket	3	2	2	869 days
Conn.Rods	10	3	6	1037 days

Nuts and Bolts: The average need for replacement of nuts and bolts were 2.6 bolts and 3.5 nuts per pumps for the average age of 47.2 months. This works out to 0.7 bolts and 0.9 nuts per pump per year.

3. Selected problems

- Disconnection of the chain resulted in 3 AG-BD
- Disconnections of the connecting rods resulted in 2 BG-BD-RP.
- 1 BG-PP converted to BG-BD-RP because the connecting rod could not be extracted.
- The replacement of 11 'O' rings occurred on 8 sites.
- Corrosion of riser pipes and connecting rods caused maintenance interventions 6 times on 5 sites.
- There were 5 occurrences of the need to clean BG components.

Conclusions

From the above data analysis the following conclusions emerge.

1. Regular preventive maintenance, and replacement of damaged or missing nuts and bolts proved to be adequate maintenance for 57.2% (24 out of 42 sites) of the pumps.

2. 42.8% of the pump sites needed above-ground and below-ground maintenance interventions with an overall interval of 318 days between interventions.

3. When considered separately, above-ground interventions occurred with an average interval of 501 days and below-ground interventions had an average interval of 567 days.

4. Multiple interventions were common when considering all interventions. They occurred in 33% of the total 42 sites.

5. A total of 8 breakdowns were recorded, 4 from above-ground failures and 4 from below-ground failures, for the 29 pumps for the period of about 4 years observation since installation.

6. The relatively high occurrence of repairs due to poor performance, 8 sites with above-ground problems and 10 sites (16 occurrences) with below-ground problems, indicates that preventive maintenance visits played a very important diagnostic role in reducing the frequency of breakdowns.

7. The record of replacement of components indicates that generally their performance was excellent. The replacement of bearing and nitrile cup washers, which are considered as the most frequently needed parts, had very few occurrences. Only 7 pumps needed bearing replacements, and 3 pumps needed cylinder cup washer replacements.

8. Interventions and replacements due to corrosion-related problems were relatively high, resulting in the need to clean riser pipes, replace pipes, rod, and pipe sockets, and below-ground maintenance with riser pipe removal. These interventions accounted for 12 out of the total 42 maintenance interventions. However, this problem is specific to the Orissa coastal area, where corrosion and high iron content cause below-ground assembly maintenance problems in pumps.

9. The need for tools, both standard and special, for the maintenance of the pumps is substantially less, as is also the physical work necessary for pump maintenance. During the period that the pumps have been maintained by SEMs, no specific problems arose with pump maintenance, except for the need for additional man-power at the time of BG-RP maintenance, which was frequent.

10. The above conclusions were generally apparent to the project by the end of 1988, on the basis of which it had been decided that one block would be installed with IM III pumps in low lift application. It would appear that this decision was valid, and by mid-1990, about 150 such pumps were installed in Puri Sadar block, and being handed over to SEMs of that block for maintenance.

EXPERIENCES IN THE HANDPUMP DEMONSTRATION PROJECT IN RANGAREDDY DISTRICT OF ANDHRA PRADESH FOR THE PERIOD FEBRUARY 1988 TO APRIL 1990

T Kanagarajan
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INDIA MARK II HANDPUMP

UNICEF in coordination with various voluntary agencies based in Maharashtra, the Tamil Nadu Water Supply and Drainage Board, Richardson & Cruddas (1972) Limited and MERADO, Madras, developed the deepwell "India Mark II Handpump" during end-1976.

There is no end to the development of any equipment. Therefore, based on field experience and feedback, developments have taken place in the India Mark II handpump design. The purpose of further development is to make it (i) more reliable and (ii) easily serviceable. In order to give options to the users, based on the depth of water table and discharge, it was decided to develop a family of India Mark II pumps, such as (i) Extra Deepwell pump; (ii) "Modified" pump; (iii) "VLOM" India Mark III pump; and, (iv) "Shallow Well" pump.

The mechanical structure of the India Mark II pump needs a minimum of 4 trained, skilled persons to attend to 'curative' maintenance. This requires personnel, tools, time and effort. A need was felt by the users and various agencies involved in the program to develop a deepwell handpump which can be repaired by the villagers themselves. In 1983, UNICEF with the cooperation of UNDP/World Bank Water & Sanitation Program and other agencies involved in developing the India Mark II initiated necessary action to develop a "Village Level Operation and Maintenance" (VLOM) handpump. The field trials in Coimbatore district in Tamil Nadu carried out since 1983 have produced encouraging results. They also helped to develop the standard India Mark II handpump into a modified handpump which can be assembled faster without disturbing the factory-assembled pivotal mechanism.

HANDPUMP DEMONSTRATION PROJECT

Encouraged by the results of these tests, it was decided by UNICEF in 1987 to extend the field testing activities of this VLOM pump and modified India Mark II pump to other parts of the country. Thus, a "Handpump Demonstration Project" was envisaged for implementation in Andhra Pradesh.

OBJECTIVE

The objective of the project is to evaluate the performance of the pumps, assess spare parts requirements, the maintenance costs, determine the meantime before breakdown/repair and evolve a simplified maintenance system.

TIME FRAME

The project is for two years, which has now been extended by another two years

EXPECTED OUTCOME

The expected outcome of the project will be information, conclusions and recommendations on the manufacture, installation and maintenance aspects of handpumps.

Since the outcome will be based on actual field experience, it will be advisable to provide realistic data to user organizations. The conclusions reached by them during and on completion of the project will help in ultimately formulating rural water supply programs with particular regard to maintenance aspects and requirements.

Support UNICEF has provided

1. VLOM India Mark III handpumps including 65mm dia riser pipe - 195 sets

2. Modified India Mark II handpump without riser pipe - 50 sets

3. Swaraj Mazda T-3500 truck - 1

4. Standard tools - 1 set

5. Special tools for India Mark II handpump - 1 set

6. Special tools for VLOM pump - 1 set

7. Pipe stands - 1 set

8. Fishing tools - 1 set

9. Metal stencils for numbering the pump - 1 set

10. Kardex book, formats, folders - as required

11. Training VLOM mechanics - 50% cost.

Support the Panchayati Raj Department has provided:

1. A "special team" consisting of one driver, one mechanic, two helpers and a mason-cum-helper. The team is under the control of an Assistant Executive Engineer, Panchayati Raj, based at Hyderabad exclusively for

this project.

2. Staff salaries

3. Travel and daily allowances

4. Fuel for the vehicle

5. Expenditure towards all handpump installations and maintenance

6. Project office and stores

7. Numbering of borewell handpumps and implementation of Kardex system

8. Training VLOM mechanics - 50% cost

DEVELOPMENT OF THE INDIA MARK II FAMILY

Based on field experience, an "India Mark II Family" with the "standard" India Mark II as the basis seems to have developed.

1. Extra Deepwell India Mark II handpump

2. Modified India Mark II handpump

3. Shallow Well India Mark II handpump

4. Village Level Operation and Maintenance India Mark III Handpump (VLOM India Mark III)

5. Tools and equipment belonging to the India Mark II family are:

   (i) Standard tools
   (ii) Special tools
   (iii) Modified platform shuttering
   (iv) Pipe stands
   (v) Fishing tools
   (vi) VLOM mechanic tools

6. The software components of the family are: standard and VLOM India Mark III pump installation and maintenance manuals, handpump caretakers handbook, VLOM handpump manual, master flip chart, guide to flip chart, text for flip chart, "Water is Life" (handout). and other training materials for engineers, mechanics, Industrial Training Institute instructors and other trainers.

Extra deepwell handpump

In areas where the static water table is very deep, the standard India Mark II pump is hard to operate beyond 140 feet. Therefore, the India Mark II pump called the Extra Deepwell pump has been developed with a counter weight stainless steel connecting rod, 3 leather buckets, heavy duty bearings, 40mm square bar handle, 8mm flanges for pedestal, water tank and head. Currently some of the cost and interchangeability factors are being sorted out so that these pumps can be introduced in selected needy areas in India. Some smaller diameter cylinders have been field tested. This would be suitable for the borewells having lesser yield and deeper static water levels.

Modified India Mark II handpump

Head assembly

(i) An additional flange between the water tank and head assembly. This is to facilitate chain disconnection from the handle and allow the chain to pass through an opening in the base of the head flange, the connecting rod being retained by a normal rod clamp installed on the additional flange. The head assembly with handle can be removed and installed as one piece, avoiding the need to disturb the factory-assembled pivot mechanism.

(ii) Increased stroke length from 100mm to 127mm

(iii) Increased handle bracket opening in the head from 100mm to 127mm. The longer stroke length will reduce the amount of hammering on the bottom handle stop. This will increase the discharge and provide a wide range of user height and use of small strokes.

(iv) Handle assembly to have 60mm square bearing housing with bearing seatings internally ground. This is to reduce distortion due to welding of circular housing.

(v) The overall height of the head has been increased by 10mm to allow for the increased stroke length, i.e. the increased movement of the handle so as to avoid the possibility of striking the inspection cover belt.

Water tank assembly

Height of the water tank assembly has been increased by 25mm. This is to facilitate more storage of water and reduce the likelihood of flooding the head, thereby reducing chain wetting and rusting.

Stand assembly

Height is reduced by 75mm. This is to reduce still further the possibility of hammering the bottom handle stop.

Cylinder assembly

(i) Nitrile rubber buckets. The performance is encouraging.

(ii) Two-piece upper valve guide. This is to eliminate disconnection which is the cause of a small percentage of failures on the standard pump.

'Shallow Well' India Mark II pump

This refers to the modification of the India Mark II for shallow well application where the water table is within 15 meters of the ground surface.

Modified India Mark II pumps with larger diameter cylinders set at shallow depths are being field tested with the intent of eventually standardizing a design for inclusion in the ISI specifications.

Village Level Operation and Maintenance (VLOM) India Mark III handpump

The VLOM pump will conform to IS 9301-1984 in all respects except the following.

1. Head assembly

   (i) Pump head base has a 75mm dia hole instead of a connecting rod guide bush for removal of head and handle assembly together.

   (ii) Handle bracket opening 127mm (stroke length).

   (iii) Additional flange between the head flange and water tank assembly.

   (iv) Handle assembly to have 60mm square bearing housing with bearing seatings internally ground.

2. Water tank assembly

   (i) 65mm nominal bore seamless coupler instead of 32mm dia coupler.

   (ii) Height of water tank assembly is 25mm more than the standard pump.

3. Stand assembly

   (i) Height reduced by 75mm.

4. Cylinder assembly

   (i) Top cylinder cap to suit 65mm NB riser pipe (medium class).

   (ii) Bottom cylinder cap to have conical housing to receive pick up check valve. Other end threaded to suit 65mm NB.

   (iii) Nitrile rubber buckets, with higher wear resistance.

   (iv) Extended follower with threads to pick up check valve.

   (v) Two-piece upper valve guide.

   (vi) Check valve assembly with two-piece valve.

The VLOM pump will facilitate removal of the piston without the need to remove the pipes and cylinder, as in the case of Standard Mark II pumps. The piston connecting rod assembly can be pulled out through the water tank coupling. Only the head assembly has to be removed, that too very easily and quickly. This would mean lesser manpower, tools, time and efforts. This would require intensive training for two villagers to carry out the preventive and curative maintenance by themselves with six simple tools. Instead of training one, as is being done now for Standard Mark II pumps, two caretakers could be trained. The nitrile buckets can be replaced in 30 minutes. Lifting of the connecting rod is easy, as the movement of the upper valve is arrested by the push rod, thus avoiding lifting of the water column. The great advantage for the user is that 12 liters of water is pumped in less than one minute.

Table 1
Comparative cost ratio of Standard Mark II vs (VLOM) India Mark III handpump

			Standard Mark II handpump (Rs.)	VLOM Mark III handpump (Rs.)
1.	Handpump assembly	1 set	2250	2420
2.	32/65mm GI pipe (medium)	24M	1040	2064
3.	Installation cost		130	260
	Total		3420	4744

The extra amount required for the VLOM pump and its installation compared to the Standard Mark II pump is Rs.1324.

MODIFIED PLATFORM

The special team has been trained in the installation of the Modified and VLOM India Mark II pump, pedestal and construction of platform, drain and footstand with modified MS Shuttering. This modification is to enable the users to stand more conveniently on the bigger footstand increased from 60cms square to 100cms square. The center of the platform is the water tank spout instead of the pedestal. This is to reduce/avoid splashing of water outside the platform.

The special team has so far installed 48 modified pumps and 62 VLOM pumps in Hayatnagar, Maheswaram and Medchal Mandals in Rangareddy district. All pumps installed are functioning very well. The handpumps are numbered and a Kardex system has been established for better record retrieval.

VILLAGE LEVEL HANDPUMP MAINTENANCE

These VLOM pumps will help to demystify handpump technology and to develop a package approach to the pump, i.e. tools, equipments, maintenance, spare parts, costing, village based maintenance, etc.

In order to help the villagers in maintaining the VLOM pump, 2 persons from each village where these pumps have been installed were selected and trained as VLOM mechanics. Thus, 64 VLOM mechanics of whom 12 were women were selected and trained in 3 batches, each training program lasting for 4 days. A simple VLOM Mechanic Tool Set consisting of eleven tools has been developed - one set of VLOM mechanic tools and spare parts was provided by UNICEF to the Sarpanches of those villages from where the VLOM mechanics attended the training course. Under this arrangement, the VLOM mechanics collect the tools from the Sarpanch and repair the pumps as and when required. The feedback and the field observations indicate that the pumps are working well and the VLOM mechanics are taking care of preventive and curative maintenance equally well, without waiting for the team. Hopefully the women VLOM mechanics will remain as nodal persons in the maintenance system in the future.

CAPITAL COST (COST OF WELL) FOR BOTH TYPES OF HANDPUMPS (30 METERS OF RISER PIPE)

Cost of one 125mm diameter tubewell to a depth of 50 meters installed with Modified India Mark II handpump

1.	Tubewell drilled in hard rock to 50 meters depth	Rs. 12,000
2.	India Mark II handpump with 32mm riser pipes	Rs. 3,290
3.	Concrete platform and drain	Rs. 1,000
	Total	Rs. 16,290

Cost of one 125mm diameter tubewell to a depth of 50 meters installed with a VLOM handpump

1.	Tubewell drilled in hard rock to 50 meters depth	Rs. 12,000
2.	India Mark II handpump with 65mm riser pipes	Rs. 4,484
3.	Concrete platform and drain	Rs. 1,000
	Total	Rs. 17,484

DESIGN DETAILS OF PLATFORM

Modified platform

All the pumps are provided with a complete concrete platform, drain and footstand as per the new design, i.e. spout at the center of platform and 100x100 cm. footstand.

The engineers appreciate the new design of the platform with the bigger footstand. The users are happy with the new platform as it is very convenient to stand and operate and they find more space to move around in front of the pump. It also helps them to wash clothes in the wider space available now. The splashing of pump water outside the platform is much less.

The platform shuttering have been manufactured with guidance in fiberglass by one of the qualified companies in Hyderabad. The shuttering is being field tested.

RECOMMENDATION FOR ADOPTION OF CHANGES WHICH HAVE PROVED USEFUL BEYOND DOUBT

Platform

The modified platform design with pump spout at the center and 100x100 cm. footstand.

Pump

The stroke length 127 mm. helps to prevent hammering of the handle on the bracket by the users.

The extra plate and bigger hole in the bottom of the head flange will be appreciated. This helps to remove or fix the head without the necessity of removing the handle bearing and axle pin. This also prevents damage to the components.

The bigger water tank

The splashing of water through the gaps between the head and water tank is considerably reduced compared to the case of the standard pump. The people are happy that they are able to collect the water a little faster compared to the standard pump.

Cylinder

Two-piece upper and lower valves.
Nitrile rubber buckets with fibre reinforcement.
Stainless steel piston plunger rod.

SPECIAL TOOLS

For Modified pump: These are suitable as India Mark II special tools.

For VLOM pump:
(i) 65 mm self locking clamp should be strengthened
(ii) 65 mm pipe lifting spanners are good
(iii) 65 mm tank pipe lifter is good

FISHING TOOLS

The new set of fishing tools suitable for 65 mm GI pipes and 12 mm connecting rod have been developed and these are also being field tested.

65 mm PIPE STANDS

These are quite useful.

WATER QUALITY OF EACH BOREWELL AND EFFECT OF CORROSION

Water from each borewell is good and so far no corrosion effect has been noticed.

Comments on modification indicating usefulness, drawbacks and suggestions for change in design, if any.

MAINTENANCE

VLOM pump

Under two-tier system:

I tier : Block Mobile Team

Block Level:

Driver	1
Mechanic	1
Helpers	2
Helper-cum-mason	1

II tier : Village Level

Two VLOM mechanics for each village with VLOM pumps.

The mechanics have been provided with a set of tools and spare parts to carry out major repairs. The need for back up by the mobile teams is very little. This will encourage self-reliance at the village level for VLOM maintenance.

TOOLS FOR VLOM PUMPS

1. Modified platform shuttering
2. Masonry tools (list enclosed)
3. VLOM standard tools (list enclosed)
4. VLOM special tools (list enclosed)
5. VLOM pipe stands (list enclosed)
6. VLOM fishing tools (list enclosed)

Average time taken for installation of each type of handpump

Modified pump	:	45 minutes
VLOM pump	:	90 minutes

Overall time (excluding travel) taken for replacement of cup seals and repair belowground components

Modified pump	:	75 minutes
VLOM pump	:	30 minutes

Type of skills and number of people required for maintenance

Modified pump:	Mechanic	:	1
	Helper	:	2
	Helper-cum-mason	:	1
			4
VLOM pump:	Trained villagers (VLOM mechanics)	:	2

Type of transport used for maintenance

Light commercial vehicle - SWARAJ MAZDA 3.5 tonnes

Mean Time Before Failure (MTBF) for each type of handpump

Modified pump:	More than one year.
VLOM pump :	On an average more than one year.

Cost of maintenance (including labour, cost of spares and transport but excluding project office for two types of handpumps)

MODIFIED PUMPS

Salaries	Rs.5000 per month x 12 months	Rs.60,000
Spares	Average Nil	Rs.20,000
For 48 pumps		Rs.80,000
For one pump per year:		Rs. 1,665

VLOM PUMPS

Salaries	Rs.5000 per month x 12 months	Rs.60,000
Spares		Rs. 400
Transport		Rs.20,000
For 33 pumps		Rs.80,400
For one pump per year:		Rs. 2,424

Note: One team is working for both types of pumps. For these calculations, salaries and transport expenses were taken separately for each case.

REPLACEMENT/CONVERSION OF MARK II TO MARK III

The PRED engineers are satisfied with the VLOM pumps as these are easily maintainable by the villagers. But at the same time, they are not keen to rejuvenate the existing standard India Mark II pumps with the VLOM pumps due to the cost factor and the reliability and credibility still obtaining for the standard India Mark II pumps.

WELL CONSTRUCTION

These wells are constructed in hard rock areas. Borewells have been drilled with DTH rigs. The diameter of the wells are either 4-1/2" or 6". The MS casing pipes have been lowered, on an average, to a depth of six meters.

QUALITY OF WATER

Water from almost all the borewells is potable. There has been no bacteriological or excess mineral content in the water so far.

CONCLUSION

The VLOM India Mark II handpump is infusing confidence in the minds of the villagers regarding a continuous supply of safe drinking water whose mechanism can be repaired by themselves without waiting for an outsider. The excitement generated by a new borewell with the Mark III handpump should be more systematically capitalised upon to help spread health messages. The VLOM India Mark III handpump is playing a vital role in providing safe drinking water especially during the International Drinking Water Supply and Sanitation Decade (1981-1990) and beyond. VLOM India Mark II is tomorrow's pump of the Third World.

ANNEX 1

VLOM MECHANIC TOOLS REQUIRED TO CARRY OUT MAJOR REPAIRS (REPLACEMENT OF RUBBER BUCKETS) OF VLOM PUMP

A.	1.	Connecting rod holding device	1
	2.	M17 x M19 double ended spanners	2
	3.	Rod coupling spanner (small)	2
	4.	Connecting rod lifter	1
	5.	Lifting adaptor	1
	6.	250 mm screw wrench	1
	7.	300 mm pipe wrench	1
	8.	Chain coupler supporting tool	1
	9.	M6 ring spanner	1
	10.	Key for lower valve	1

Note: Weight of all these tools is six kilograms.

B. Spare parts to be provided to VLOM caretakers

1.	Nitrile rubber buckets	2
2.	Lower valve '0' ring	2
3.	Upper valve rubber seating	1
4.	Lower valve rubber seating	1
5.	M19 bolts	2
6.	M19 nuts	4
7.	Multipurpose grease	100 grams

C. Learning materials

1.	VLOM pump manual	1
2.	Caretaker booklet	1
3.	Health folder	1
4.	Calendar card 1989	1
5.	Handpump stickers (round and rectangular)	2
6.	Any other booklets, etc.	

SEQUENCE OF OPERATION FOR REMOVAL OF CHECK VALVE IN VLOM HANDPUMP

1. Remove inspection cover.

2. Remove nylock nut and bolt on handle chain.

3. Remove flange bolts connecting head and water tank.

4. Remove head with handle assembly.

5. Lift chain with help of screw driver.

6. Lift extra plate and connecting rod vice below it.

7. Remove chain, lock nut and plate.

8. Fix the rod lifter to connecting rod.

9. Hold rod lifter and remove rod vice.

10. Lower rod, so that the plunger is resting on the check valve at the bottom of the cylinder.

11. Press rod down with rod lifter and turn it in clockwise direction so that the follower of the plunger gets engaged with internal threads of check valve body.

12. Pull the connecting rods up firmly, so that check valve '0' ring disengages from the lower cylinder cap.

13. Now pull up and remove connecting rods one after another using rod vice and spanners. If the lifting is hard, the check valve body might not have got engaged with the follower.

14. When plunger comes up, check whether the check valve has also come up.

15. While reflexing, after repairs, tighten two or three threads of check valve with follower of plunger, as it has to be separated after fixing the check valve assembly to the bottom cap of cylinder.