HAND PUMP DEVELOPMENT AND TESTING IN SOUTH ASIA:

BACKGROUND DOCUMENTATION

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LOW LIFT, DIRECT ACTION PUMPS1/

1. There is increasing interest in **direct action** pumps for use at relatively **low lifts**, down to about 15 meters. In a direct action piston pump the conventional operating lever has been exchanged for a T-bar handle at the top of the pump rod. This eliminates much of the complexity of a lever action pump, particularly the bearings which are susceptible to wear. In most lever action pumps the lever serves two purposes: It provides mechanical advantage to make it easier to lift the column of water supported by the piston, and it reverses the direction of the operating effort, so that an upward pull on the pump rod corresponds to a downward thrust on the pump handle.

2. Simply eliminating the lever of a conventional pump would result in an unsatisfactory direct action pump. The user would have to exert a very strong upward pull on the pump rods during the delivery stroke, and it is likely that the weight of the rods would send the piston crashing down under the force of gravity on the down stroke. **A good direct action pump design distributes the operating effort between the upward and downward parts of the pumping cycle.**

3. An appropriate distribution of force can be achieved by using light weight, high displacement (volume) pump rods. On the upward stroke the user must overcome both the weight of the pump rod and the weight of the water in the annulus around the rod, which is supported by the piston. If the rod is relatively large it will displace much of the water in the rising main, and the annulus will be relatively small. Clearly, the lighter the rod and the greater its displacement, the less will be the required upward force.

4. Naturally, the "remainder" of the work, which in a conventional piston pump would have been done on the upward stroke must now be done on the downward stroke, since, if the weight of the pump rod is low enough and the volume is high enough, it will float. Therefore, by selecting pump rods of appropriate weight and size, the distribution of the total required operating effort between the upward and downward strokes can be controlled. By redistributing the forces, compared to a conventional lever action pump and by judicious choice of cylinder diameter (around 50 mm) a pump may be designed which is mechanically simple in the extreme and operable comfortably to heads up to 15 meters.

5. Direct action pumps which operate on these principles have been developed in several countries: Ethiopia, Malawi, Tanzania, Canada and Bangladesh. Tubular pump rods of a variety of materials have been used, aluminium, polyethylene and PVC. The latter has given good results in the Tara pump in Bangladesh and has the advantages of **low cost, ready availability and corrosion resistance.** Manufacturing direct action pumps is simple, as the system consists of standard PVC pipe for the most part, a pump stand fabricated from standard steel pipe and moulded plastic pumping elements. **Maintenance is simple for minimally trained caretakers, who can take apart and reassemble the entire system without tools.**

6. There is enormous scope for application of low lift direct action pumps in the Indo-Gangetic plains, where large, high density populations live and where water levels are within 15 meters of the surface. Direct action pumps can be fabricated in most countries without difficulty and the new technology introduced in selected areas in field demonstration projects associated with provincial rural water supply programs.

1/ Edited exerpt from CAIR interim report on light weight pump rod research.

DIRECT ACTION PUMP: INTERNATIONAL DEMONSTRATION SPECIFICATION

INTRODUCTION

1. A reliable direct action pump specification is needed for heads up to 15 meters for demonstration projects many countries, especially in the South Asia region, where there is enormous scope for application. The Tara pump has now been accepted for large scale application in Bangladesh, despite reliability problems with the pumping elements and noticeable abraison between the pump rod and rising main. It is assumed that certain components require higher quality materials and finishes than the 1986 Tara pump specification to ensure satisfactory reliability at the introductory stage to avoid a negative demonstration, and that value engineering at a later stage can reduce costs when the concept is has gained acceptance.

2. Empirical evidence from laboratory and field tests establishes that a pumping stroke length ranging from 30 to 40 cm is preferred by users when engaging a T-bar handle on a lever or T-bar handle of a direct action pump. Combined with a cylinder diameter of 50 mm, adequate capacity may be achieved by increasing the mechanical advantage as a response to increasing head. This means that a standard specification for down hole components may be used at all head ranges, providing the conceptual basis for a family of piston pumps sharing a minimal set of components. This note proposes a specification (see Annex 1) for the direct action member of the family, called here "Brand X". Comments are solicited in order to finalise a specification which will be used in demonstration projects in South Asia during 1987.

DISCUSSION

3. Problems with the Tara pump in Bangladesh tests centered around the foot-valve and piston assemblies. Breakage of the pump rod and connectors has not been a problem, and only minor problems have been noted with the guide bush. However, test pumps in Bangladesh have been exposed to relatively light use (maximum 2 cubic meters/day). In Kenya and Tanzania the guide bush and pumping elements were destroyed by heavy use (8 cubic meters/day) within days. Laboratory tests demonstrated good results in sandy conditions with a nitrile rubber seal and poor results for a leather seal. It is almost certain that rubber guides will be necessary to ensure long term survival of the upper well casing.

4. The Nira direct action pump, specified for 10 meters head, has done well in Africa under conditions of heavy use with relatively high quality materials and good finishes. It is reasonable to assume that a T-bar handle with a much smoother finish than a standard GI pipe, a PE or PU guide bush, closer tolerances on the cylinder and a commercial nitrile rubber seal and the Afridev pumping elements are likely to remedy the reliability problems noted in with the Tara in Bangladesh and Kenya.

5. The Wavin pump has done reasonably well in lab tests, with minor problems associated with the cord packing seal. The small diameter pump rod (32 mm) was joined with epoxy cement and PVC threaded internal connectors, which have since been changed to POM. Epoxy adhesive cement does not degrade PVC locally as does solvent cement at the joint. Although the Wavin pump has a 25% smaller capacity than the Tara pump, users of the two installed in the field test area in Bangladesh have not reacted negatively. This fact reinforces the conclusion that

the Tara pump has excess capacity which may be traded for other desirable features, such as standardization of components, higher reliability and better operating characteristics.

6. The slight geometry changes proposed for "Brand X" will improve the operating characteristics compared to the Tara while reducing its capacity by about 15%. This is because the combined weight of the water in the annulus plus the pump rod is less and the swept volume of the cylinder is less, as shown in Table 1. *More space will be available in the annulus between the pump rod and* the rising main/upper well casing for rubber guides without imposing hydraulic constraints. These geometry changes will fit the pump into the generic concept of a family of piston pumps proposed by the Project.

7. Cost increases over the Tara specification will be most significant for the pumping elements, adding an estimated $30. The SS T-bar handle, SS fasteners, rubber guides and additional PVC material for the larger diameter upper well casing could add another $15. This could bring the cost of the pump module to a maximum of $100.

8. In India small sample orders have been placed for all components execpt the pumping elements, and are expected to be ready during April. Negotiations are underway with state governments (West Bengal, Uttar Pradesh, Bihar) to establish demonstration projects. In Pakistan much the same procedure will be initiated before the middle of 1987.

Table 1

COMPARISON BETWEEN OPERATING PARAMETERS OF TARA PUMP AND BRAND X

Item	Unit	Tara	Brand X
cylinder ID	(mm)	54.3	50
capacity	(l/m)	2.31	1.96
pump rod diameter	(mm)	42.2	40
pump rod weight	(kg/m)	0.48	0.49
buoyant upthrust	(kg/m)	1.33	1.26
total weight of water column and pump rod	(kg/m)	1.46	1.19
Upstroke force (*) at 15 m head	(kg)	21.9	17.9

(*) neglecting friction and assuming a piston setting at static water level

ANNEX 1

DIRECT ACTION PUMP: PROPOSED GENERAL SPECIFICATION 1/

1. Pump stand as in Tara pump, except for the following changes:

   * PE or PU top guide bushing instead of wood;
   * Seam welded SS tubular T-bar handle, 25 mm diameter x 1.5 mm wall instead of 3/4 inch nominal diameter GI pipe;
   * Diameter of hole in pump stand flange increased by 3 mm;
   * Diameter of hole in rubber compression grommet increased by 3 mm;

2. Pump rod

   * ISO PVC pipe 40 x 34, instead of BS 42.2 x 36.8.
   * internal solvent cemented connectors (alternatively, ABS or POM threaded connectors adhered internally with epoxy);
   * Two rubber bungs, one on either side of joint;
   * SS metal fittings in PVC bushes for bottom and top connectors;
   * Nitrile rubber guides, 50 x 40 x 100 mm long, end chamfered 45 degrees;

3. Rising main/upper well casing

   * ISO PVC pipe 63 mm x 57 mm, instead of BS 60.3 x 54.3;

4. Cylinder

   * Drawn SS or extruded brass, 53 x 50 x 1000, housed in 63 x 53 PVC pipe; (substitutes for BS 60.3 x 54.3 PVC cylinder)

5. Pumping Elements

   * Piston/footvalve assemblies and receiver according to Afridev specification;
   * Selection of seals: polymer ring seal, elastomer lip seals.

1/ Please refer to 1986 Tara pump specification.

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FINDINGS OF TARA PUMP TESTING IN MIRZAPUR

PARAMETERS OF FIELD TEST

1. Of an original sample size of 128 TARA pumps and wells a sample of 105 is included in the present analysis, covering the months of August 1984 to July 1986, approximately 23 months, for a total of 2390 pump months.

REPAIRS AND MAINTENACE

2. An intervention is defined as some repair or adjustment to the pump. There were two categories of interventions, essential and optional. Essential interventions were undertaken for two reasons: poor performance, (EIPP) when the pump was capable of pumping water but at a reduced rate of discharge and/or minor leakage, and breakdown (EIBD) when the pump either was not capable of pumping water or the rate of discharge was not acceptable according to a pump test: less than 2 liters/16 strokes at the rate of 30 strokes per minute with a stroke length of 30 cm, or a leakage rate of more than 0.2 liters/minute. Optional interventions included preventive maintenance. "Other" interventions refers to an additional repair undertaken as a result of discovery at the time of an essential intervention. Table 1 below shows that the distribution of interventions is weighted heavily toward poor performance (80%), with breakdowns accounting for only 3%, while optional interventions and "other" (additional repairs) make up the balance.

Table 1

I N T E R V E N T I O N S

Type	Total over period	per cent	per working year	per 500 m3 pumped
EIBD	27	3	0.14	0.12
EIPP	634	80	3.18	2.72
PM	52	7	0.26	0.22
OT	77	10	0.38	0.33
ALL	790	100	3.96	3.39

ATTRIBUTION OF SYSTEM FAILURES

3. Eight installations were withdrawn because leakage tests categorised them as breakdowns and the leaks were not accessible except by destroying the system. In two cases the reason for failure was cracking of the upper well casing which was associated with abrasion by the pump rod. In the remaining cases the reason was due to leaking joints (poor installation work) or leakage in the footvalve receiver. The measured use of the pumps with perforated casing was relatively low : 2.9 and 1.5 m3 per day respectivily.

ESTIMATED LIFETIME OF ESSENTIAL TARA COMPONENTS

4. All parts comprising the standard pump module are accessible for replacement except the upper well casing and the cylinder, which are integrated into the tubewell module and therefore permanently installed. An estimate of the lifetime of these two essential components may be based on the following facts:

* In the Consumers' Association laboratory test the cylinder was operated for 4,000 hours, pumping about 8,300 cubic meters at a simulated head of 15 meters. Assuming an average annual consumption rate from a TARA pump installed in Bangladesh of 750 cubic meters, then 4,000 hours pumping will be equivalent to about eleven years of operation. CATR reported no significant wear on the cylinder during the first half of the test in clear water, but system failure occurred when sand was introduced into the water because the leather cup seal caused the piston to sieze in the cylinder. However, when the seal material was changed to nitrile rubber and a new cylinder was installed, no significant wear was reported in sandy water during the remainder of the test, which was conducted with sandy water.

* In the Mirpur Aguricultural Workshop & Training School (MAWTS) bench test a TARA pump was installed at a twelve meter setting in the test tower, where it was manually operated for nine months at the rate of 0.84 cubic meters per hour, yielding a volume of approximately 5,500 cubic meters. At the rate of 750 cubic meters per year, the equivalent of more than seven years of pumping was simulated in the test.

* Field testing of 128 TARA pumps has been in progress in Mirzapur for more than two years. During that period only two systems failed because of perforation of the upper well casing and none because of perforation or excessive wear on the cylinders.

5. At this stage it is reasonable to expect that the cylinder and the rising main of the standard model will last for more than twelve years if operated under conditions expected to be typical in Bangladesh:

(a) daily consumption	: max 2,000 liters
(b) water quality	: only trace concentration of sand
(c) preventive maintenance	: when required
(d) handling	: no mishandling

6. The following developments are being tested to increase the probability that the upper well casing, cylinder and pump rod will have an extended working life. A positive side effect of these changes is that the operating characteristics of the pump will be marginally improved:

(a) Increased clearance between pump rod and rising main (smaller diameter pump rod and larger diameter upper well casing);

(b) rubber pump rod guides

(c) smaller diameter cylinder (50 mm)

(d) intensified quality Control to ensure straight pipes

ESTIMATED ANNUAL SPARE PARTS COST

7. Empirical evidence from field tests establishes that the working life of the category of components where more than 60 % of the original parts have beem replaced is a range of one to two years. These parts are the footvalve, the piston hair clip, piston valve and piston seal. For those components where the frequency of replacement has been low insufficent data is available to justify an estimate of maximum working life, and the present estimate is is based on a evaluation of field experience and technical judgement. When estimating working life, improvements under development have also been considered. The costs cited in Table 2 are based on MAWTS prices as of July 1986.

MAINTENANCE WORK LOAD

8. The design of the TARA pump is based on the idea that it should be possible for a person to be selected from the user group and trained to carry out all maintenance and repair operations except for unusual modes of failure which require either specialised tools or skills not ordinarily available in the village. The duties of the caretaker are to keep the pump in working order by making necessary repairs or calling the local designated mechanic. For ten pumps in the Mirzapur Field Study groups of three women caretakers have successfully performed all servicing for the past fifteen months. Ideally, a caretaker should be in charge of collecting money from the user group to purchase spare parts. The work load for a caretaker in the Mirzapur field study is estimated as follows:

(a) training and motivation sessions:	3 hr/year
(b) interventions (essential and optional):	2 hr/year
(c) purchase of spare parts, etc.:	1 hr/year

ACCEPTANCE OF TARA PUMP AMONG USERS

9. A survey of 180 households was conducted in the Mirzapur study area, where there are 128 TARA pumps and 44 No. Six pumps and in the comparison area where there are no TARA pumps and about forty No. Six pumps. The purpose of the study was to determine the source of stored water used for drinking or cooking. The survey methodology consisted of asking the householder to identify the source of water stored in traditional vessels and also the use for the water. The conductivity of the water was measured and the results recorded. Surface water will have higher conductivity than ground water, and the aquifer from which the TARA pumps draw water is relatively lower in dissolved solids than that of the No. Six pumps. It was therefore possible to identify the source directly as given in the following table:

Table 3

	W A T E R S O U R C E					
Water	Study Area			Comparison Area		
Use	TARA	No.6	Other	TARA	No.6	Other
Drinking	152	27	1	0	137	27
Cooking	150	25	3	0	104	56

10. Within the Mirzapur study area 164 persons were asked their opinion about handpumps in the area. Those polled had access to 126 TARA pumps and 44 No. Six pumps. The question was asked "Which pump do you prefer".

Table 4

Preference		(%)
TARA	144	88%
No.6	20	12%

WATER CONSUMPTION

11. Table 5 shows the results of three surveys to assess the amount of water pumped from TARA pumps as a function of the size of the user groups. It can be seen that there is an inverse relationship between the size of the user group and the amount of water available per caput. However, for the largest and intermediate size user groups, water consumption has increased substantially over the one year survey period, possibly because of intensive health education. For the largest and intermediate size user groups water consumption per caput has increased, moreso in the larger groups, but the reason for this is not yet clear. Consumption among the smallest user groups has remained more or less stable at around 50 liters per caput per day. The working hypothesis to explain differences in water consumption as a function of user group size is that the smallest number of users find it more convenient to use more water because of (1) closer proximity to the pump, (2) fewer people to compete for access to the pump, (3) lower probability of social conflict compared to a larger group, and (4) less liklihood of intervening physical barriers (surface water, roads, houses, etc.)

Table 5

User group size range	Average user group size	July 1985 (L/cap/day)	Jan/Feb 1986 (L/cap/day)	July 1986 (L/cap/day)	(m3/day)	Number of pumps in sample
8 to 20	12	53	50	50	0.6	24
21 to 35	28	32	29	35	0.9	34
36 to 50	43	27	23	35	1.2	27
51 to 96	82	19	21	31	1.9	18

SUMMARY OF IMPROVEMENTS TO THE INDIA MK II DEEP WELL HAND PUMP

BACKGROUND

1. Field testing of the India Mk II began in late 1983 in Coimbatore as a joint undertaking among the TWAD Board, the UNDP/World Bank Interregional Hand pumps testing project and UNICEF. The objective of the project was to evaluate under actual field conditions design modifications which have potential to improve the India Mk II deep well hand pump. Priority was given to improving the **serviceability** of the pump by making the pump easier to take apart and reassemble, with fewer and less specialised tools and manpower. A second priority was to improve the durability of those components which most frequently need replacement to increase the time interval between repairs. A constraint was imposed on the scope of modifications: that any change to the basic specification should be compatible with existing tooling, and, insofar as possible, be interchangeable with existing stocks of spare parts. The need for caution derives from the large number of standard pumps already installed and escalating yearly production rates (currently 170,000). These pumps and production facilities represent national assets for which stability is essential. Consequetly, gains in productivity are most likely to be achieved by means of careful research and testing and gradual phasing in of thoroughly evaluated improvements.

METHODOLOGY

2. A total test sample size of 80 pumps was proposed for testing, 50 standard pumps and 30 with a variety of experimental modifications. A total of 77 test pumps had been installed as of July 1986. Of these 45 were standard and the balance were modified in some respect. Where a pump with experimental modifications failed, it was replaced with a standard pump. Test pumps were inspected on a monthly basis by project monitoring staff provided by the UNDP/WB Hand Pumps Project. Water quality and water use were monitored. Pumps were repaired at the time of inspection if needed, or when a fault was reported by the caretaker or users. In each case information was recorded about the nature of the defect, date and time required to complete the repair, manpower and tool requirements and spare parts used. The data were then entered into a computer data base for processing. A summary report will be presented in April 1987.

PUMP COMPONENT DEVELOPMENTS

3. A series of small but significant design modifications has resulted from the three years of development and testing work in Coimbatore. These improvements are scheduled for demonstration in several states in 1987. The most important improvements are: substitution of nitrile rubber for leather cup seals; pumping elements which may be extracted through the rising main without removing it; simplified removal of the drive head, and more reliable valves.

4. The two main categories of improvements are:

(a) Easier **serviceability**, which corresponds to greater "user friendliness" from the perspective of maintenance personnel;

(b) Longer intervals between essential interventions to restore normal function.

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COMPARISON BETWEEN OPERATING PARAMETERS OF INDIA MK II AND AFRIDEV

ITEM	INDIA MK II	AFRIDEV	DIFFERENCE (%)
cylinder diameter	63.5	50.0	- 27
stroke length	105	165	+ 57
swept volume	0.33 l	0.32 l	- 3
pump rod diameter	12	8	+ 33
pump rod weight	0.9 kg/m	0.4 kg/m	- 56
combined weight of water column and pump rod	4.1 kg/m	2.4 kg/m	- 42
tension load on RM	3.4 kg/m	2.2 kg/m	- 35

FORCES ON RISING MAIN

1. Given: PVC rising main 63 x 53; head 50 m; setting 60 m; 10 kg friction

			UPSTROKE:	DOWNSTROKE:
Weight PVC/m	(kg)	1.27 x 60 =	76.2	76.2
Weight H2O/m	(kg)		N.A.	2.2 x 50 = 110
Buoyancy	(kg)		- 31	- 31
Friction	(kg)		10	N.A.
			55.2	155.2

2. Given: PVC rising main 75 x 65; head 50 m; setting 60 m; 15 kg friction

			UPSTROKE:	DOWNSTROKE:
Weight PVC/m	(kg)	1.54 X 60 =	92.4	92.4
Weight H2O/m	(kg)	3.3	N.A.	3.3 X 50 = 165
Buoyancy	(kg)	4.4	- 44	- 44
Friction	(kg)	15	15	15
			63.4	213.4

FIELD TESTING OF DEEP WELL HAND PUMPS IN COIMBATORE

BACKGROUND

1. The objective of the project has been to evaluate under actual field conditions design modifications which have potential to improve the India Mk II deep well hand pump. Ideas for modifications came from many sources: Sholapur Well Service, Richardson & Cruddas (1972) Ltd., government field staff, UNICEF and Hand Pump Project staff. Priority was given to improving the serviceability of the pump by making the pump easier to take apart and reassemble, with fewer and less specialised tools and manpower. A second priority was to improve the durability of those components which most frequently need replacement to increase the time interval between repairs. A constraint was imposed on the scope of modifications: that any change to the basic specification should be compatible with existing tooling, and, insofar as possible, be interchangeable with existing stocks of spare parts. The need for caution stems from the large number of standard pumps and spares already installed (almost 1 million) and escalating yearly production rates (currently 150,000). These pumps and production facilities represent national assets for which stability is essential, and that productivity gains are most likely to be achieved by gradual phasing in of thoroughly evaluated design changes with predictable effects.

METHODOLOGY

2. A total test sample size of eighty pumps was proposed for testing, fifty standard pumps and thirty with a variety of experimental modifications. A survey of 150 sites was carried out by the TWAD Board, of which eighty sites were finally selected. A total of 77 test pumps had been installed as of July 1986. Of these 45 were standard and the balance were modified in some respect. Thirteen had 2 1/2 inch diameter GI rising main and open top cylinders; nineteen had 2 1/2 inch diameter PVC rising main and open top cylinders. Twelve of the 13 with 2 1/2 inch diameter GI rising main are working satisfactorily, while only seven of the 19 with PVC rising main are still in service. Where a pump with experimental modifications failed, it was replaced with a standard pump.

3. Test pumps were inspected on a monthly basis by project monitoring staff. Water quality and water use were monitored. Repairs were undertaken at the time of inspection if needed, or when a fault was reported by the caretaker or users. In each case information was recorded about the nature of the defect, date and time required to complete the repair, manpower and tool requirements and spare parts used. The data were then entered into a computer data base for processing.

MEASUREMENT OF WATER CONSUMPTION

4. It is useful to know the rate at which a pump is working to evaluate the wear and breakage of components of the pump. Eight standard turbine water meters have been adapted to measure the discharge of selected pumps over a period of time sufficient to indicate the level of useage of the pump at a particular site. Ten more meters will be installed shortly and the water meters are rotated among test pumps periodically.

WATER QUALITY TESTS

5. The quality of water of 62 well sites has been analysed to determine its

potability content of abrasive solids and chemical reactivity with the materials in the pump. The water in the test area can be classified as mildly corrosive.

PUMP COMPONENT DEVELOPMENTS

OPEN TOP CYLINDER

6. When the standard India Mk II pump needs seal replacement or footvalve repair three or four persons are needed and special tools to lift the rising main (and water column if the footvalve is intact). The Project introduced the "open top" cylinder, i.e., a cylinder and rising main through which the piston and footvalve may be lifted by two persons to the surface without disturbing the rising main. The advantage, in addition to simplifying the maintenance procedure, is to reduce damage to the rising main pipes during disconnection and reassembly, which increases the rate of corrosion on the pipes. Table 1 shows that rising main pipes were a large proportion of the replaced parts.

7. While the 2 1/2 inch diameter GI rising main pipe is almost double the cost of the standard 1 1/4 inch diameter, it is expected to last much longer because of its greater wall thickness and the fact that it will not be disconnected and reassembled repeatedly during cup seal and footvalve servicing. The greater annular space inside the larger pipe will also reduce the chance of abrasion between the pump rod connectors and the rising main.

PVC EXPERIMENTAL BELOW GROUND COMPONENTS

8. The PVC cylnder has been moderately successful. It is inexpensive, chemically inert and may be provided in segments long enough to permit multiple generations of use by shortening the pump rod. There have been however, significant problems with the PVC rising main.

9. Initial problems with the PVC rising main pipe consisted of abrasion of the pipe due to rubbing on the hard rock borehole and failures of various types of joints. Abrasion failures were overcome by providing rubber centralisers at two meter intervals to prevent contact between the borehole walls and the pipe. The major problem with PVC rising mains has been the joints rather than the pipe itself. Several types of joints have been tested: solvent cemented joints, threaded joints, quick coupler joints and a special tension connector. The first three types of joints have not been adequate. The tension connector is adequate from the standpoint of carrying the tensile load, but has leakage problems. The leakage problems may be ultimately overcome with a properly designed static seal. A rubber compression fitting was used to suspend the PVC rising main pipe from the pump stand. It consists of a rubber conical grommet around the pipe which fits into a conical flange. When the flange bolts are tightened, the rubber grommet is compressed and grips the PVC pipe. No failures of the suspension device have occurred during the test period. Despite several important useful characteristics, PVC rising mains in the diameter required by the India Mk II can not be recommended for large scale application until the problems observed in field testing have been solved.

CUP SEALS

10. Leather cup seals of three types of tanning processes were tested: vege-

table tanned, chrome tanned and semichrome tanned leather. The vegetable tanned leather cup seals lasted marginally longer than the other two varieties. Nitrile rubber cup seals were developed and tested in comparison to the leather seals. Although the data is not conclusive yet, it appears that the nitrile rubber seals are more abrasion resistant than any of the varieties of leather seals. Test results demonstrate conclusively that cup seals are the most frequently replaced part in the entire pump system, and that a longer lasting seal will dramatically reduce maintenance costs.

PUMP DRIVE HEAD

11. The drive head of the pump was modified by providing a large opening in the floor to permit the chain on the end of a rod to pass through. An extra plate contains the guide bush and protects the pump from entry of debris from outside. The effect of this modification has been to simplify and speed up disassembly of the pump, whether to repair drive head components or below ground components. The modification has become known as the "quick-change" drive head.

HANDLE ASSEMBLY

12. Many, if not most bearing failures can be attributed to oversized bearing housings. A press fit of the outer bearing race in the bearing housing is essential to prevent bearing rotation in the housing and failure of the bearing. Extensive welding on the present round bearing housing is the cause of a large part of the out-of-tolerance problem. A square cross-section bearing housing was developed, and appears to prevent excessive distortion during welding.

LARGE DIAMETER INTAKE PIPE

13. The problem of entry of abrasive particles into the pump cylinder is dealt with most effectively at the construction stage of the well by enforcing good quality specifications. However, the effects of poor borehole construction on the pump may be minimised by decreasing the velocity of the water at the intake of the cylinder and by increasing the storage volume of the intake pipe. This may be done by increasing the diameter and length of the intake pipe such that the average velocity of the water column below the cylinder is reduced to below 3 cm/second, which will prevent most sand particles from being taken into the cylinder.

FULCRUM BEARING

14. Test results confirm that a single side shielded bearing lasts longer than a double side shielded bearing. It is thought that the lubricant introduced during installation enters the unshielded side more effectively. An experimental journal bearing of engineering plastics has been machined and installed for testing. If the prototype bearing proves to be successful, molds will be made and sample bearings will be installed for further testing.

UPPER VALVE ASSEMBLY

15. The standard piston valve assembly consists of three parts: valve guide, valve seat and rubber valve seat. Disconnection results when wear loosens the peened threaded connection between the guide and the valve seat. The guide and seat have been combined into one piece and the rubber facing slips over the

guide into a groove. Disconnection is now not possible and the metal part of the valve can be used until completely worn out.

CONNECTING ROD

16. The standard pump rod connector consists of one welded socket and a jam nut, which tends to become disconnected during use if not properly tightened. A welded nut was substituted and has virtually eliminated disconnection problems.

SAND TRAP

17. A sand trap was developed by the Sholapur Well Service, which consists of a cylinder and separator attached above a standard cylinder. Sand in the water column settles when pumping stops and the separator directs the settling sand into the trap. This prevents sand from settling on the seals and damaging them when pumping resumes.

SPECIFICATIONS OF DEMONSTRATION PUMPS

OVERVIEW

18. A series of small design improvements to the India Mk II hand pump has been identified and tested in the field for over two years. Some improvements, such as the nitrile rubber cup seal, the "quick change" drive head and improved valves are now accepted as worth incorporating into the standard specification and will be introduced in October to the ISI committee on hand pump standards. More extensive changes to the design to make the pump easier to service are described below as "village level operation and maintenance" or the "VLOM" specification.

19. Four hundred pumps of partially modified and VLOM specifications are proposed for demonstration in four deep well states. The most important difference between the two specifications is that the partially modified specification will have standard 1 1/4 inch diameter rising main, while the VLOM version will have 2 1/2 inch diameter GI rising main and open-top cylinder through which the piston and footvalve may be extracted without having to lift the rising main. Both versions will have "quick change" drive heads, nitrile rubber cup seals, improved bearing housings, improved piston valves and larger bracket openings in the drive heads to prevent the handle from hitting the stops, which is believed to damage the bearings.

PARTIALLY MODIFIED SPECIFICATION

20. Partially modified pumps will conform to IS:9301-1984 except as follows:

PUMP DRIVE HEAD ASSEMBLY

* Drive head flange to have 75 mm diameter hole instead of guide bush;

* Additional flange, similar to the drive head flange of the standard pump, with 73 mm thick piece placed in the centre and guide bush welded on both sides (one end welded to the 73 mm diameter piece and the other to the flange).

* Bracket opening in drive head to be increased to permit greater handle displacement without hitting stops;

* Handle assembly to have 60/63 mm diameter square cross-section bearing housing with bearing seatings internally ground. The handle assembly to be electrogalvanised to 50 microns thick, except for the bearing seatings which will be shielded from electrogalvanising. Final dimensions of bearing seatings will be 47 mm (with a permissable tolerance range of -0.035 to -0.020).

WATER TANK ASSEMBLY

* Height of assembly to be increased by 25 mm;

* Discharge spout to have 90 degree angle.

TELESCOPIC STAND ASSEBMLY

* Height to be reduced by 75 mm.

CYLINDER ASSEMBLY

* Nitrile rubber cup seals;

* Two piece upper valve guide;

* Length of 2 3/4 inch nomiminal diameter pipe threads on reducer caps to be increased by 8 mm.

VLOM SPECIFICATION

21. The fully modified pumps, or VLOM versions, will conform to IS: 9301 - 1984 except for the following:

PUMP DRIVE HEAD ASSEMBLY

* Pump drive head flange to have 75 mm diameter hole instead of guide bush;

* Additional flange, similar to the drive head flange of the standard pump, with 73 mm thick piece placed in the centre and guide bush welded on both sides (one end welded to the 73 mm diameter piece and the other to the flange).

* Bracket opening in drive head to be increased to permit greater handle displacement without hitting stops;

* Handle assembly to have 60/63 mm diameter square cross-section bearing housing with bearing seatings internally ground. The handle assembly to be electrogalvanised to 50 microns thick, except for the bearing seatings which will be shielded from electrogalvanising. Final dimensions of bearing seatings will be 47 mm (with a permissable tolerance range of -0.035 to -0.020).

WATER TANK ASSEMBLY

* 2 1/2 nominal diameter seamless coupler instead of 1 1/4 nominal diameter coupler;

* Height of assembly to be increased by 25 mm;

* Discharge spout to have 90 degree angle.

TELESCOPIC STAND ASSEBMLY

* Height to be reduced by 75 mm.

CYLINDER ASSEMBLY

* Top cap compatible with 2 1/2 inch nominal diameter rising main pipe;

* Bottom cap to have conical housing to receive pick-up (extractable) footvalve. Other end with threads compatible with 2 1/2 inch nominal diameter pipe.

* Nitrile rubber cup seals;

* Extended follower with threads to pick up footvalve;

* Two piece upper valve guide;

* Footvalve assembly with two piece check valve. Conical base with O-ring, cage and stainless steel vertical shaft;

* Both upper and lower caps to have hexagonal outside rib for ease of installation and dismantling.

RISING MAIN

* 2 1/2 inch nominal diameter GI pipes as per IS - 1239 in 3 m lenghts (tolerance range: -25 mm, +0 mm).

TOOLS

* Special tools - one set

INSPECTION AND REPAIR REPORT FOR INDIA MARK II

PUMP ID NO.

INDIA MK II: STANDARD ☐ OTC ☐

PVC - RM ☐

FORM CHECKED BY:
DATE:
PERIOD:

										Design change(if any)		
COMPLAINT DATE(if any):										Sub Compo nent	2nd date	1st date
REPAIR/INSPECTION DATE:												
LEAKAGE (STR/REFILL)												
DISCHARGE (L/CYCLE)												
HANDLE DISPLAY (CM)												
STATIC WATER LEVEL(M)												
LB	CL	CHAIN LUBRICATED								PH		
HD	HA	HANDLE ASSY								HA		
	HB	BEARING								CH		
F	DH	HEAD								PR		
	DC	FRONT COVER								RP		
	DX	AXLE								CO		
RH	CH	CHAIN								PC		
	CP	CHAIN-HANDLE B&N								PA		
PR	PR	PUMP ROD								PV		
RM	RP	PIPE								FA		
	RJ	JOINT								OT		
PS	PL	LEATHER								IP		
	PN	NITRILE RUBBER								ST		
PE	PE	PISTON ASSY								WM		
	PV	PISTON VALVE								PF		
	PB	CYLINDER BODY										
	PC	CYLINDER ASSY										
	BC	BOTTOM /TOP CAP										
FV	FA	FOOT VALVE ASSY										
	FO	FOOT VALVE O-RING										
OT	BR	BOLT REPLACED										
	NR	NUTS REPLACED										
	WT	WATER TANK										
BREAKDOWN OR POOR PERFORMANCE(BD OR PP)												
OTHER REASON (PM OR OT)												
INT. NUMBER												
DISCHARGE (FINAL)												
LEAKAGE (FINAL)												
HANDLE SIDEPLAY(FINAL)												
MANHOURS FOR REPAIR												
NUMBER OF STAFF												
TOTAL PARTS COSTS												
SUPERVISOR NOTES: WRITE DOWN WHAT WAS DQNE TO THE PUMP												

Form-Revision date: 20:01:87