WATER AND SANITATION FOR HEALTH PROJECT

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USAID HANDPUMP PROGRAM IN ECUADOR

WASH FIELD REPORT NO. 123

MAY 1984

Prepared for:
USAID Mission to the Republic of Ecuador
Order of Technical Direction No. 82

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May 10, 1984

Orlando Llenza
USAID Mission
Quito, Ecuador

Attention: Kenneth Farr

Dear Mr. Llenza:

On behalf of the WASH Project I am pleased to provide you with ten (10) copies of a report on The AID Handpump Manufacturing Project.

This is the final report by Ben James and is based on a number of trips by Georgia Tech staff to Ecuador from August 1982 to April 1984.

This assistance is the result of a request by the Mission on January 7, 1982. The work was undertaken by the WASH Project on February 9, 1982 by means of Order of Technical Direction No. 82, authorized by the USAID Office of Health in Washington.

If you have any questions or comments regarding the findings or recommendations contained in this report we will be happy to discuss them.

Sincerely,

Dennis B. Warner

Dennis B. Warner
Director
WASH Project

cc. Mr. Victor W.R. Wehman, Jr.
S&T/H/WS

DBW:ybw

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Prepared for the USAID Mission to the
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Prepared by:

Ben E. James, Jr.

May 1984

Water and Sanitation for Health Project
Contract No. AID/DSPE-C-0080, Project No. 931-1176
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U.S. Agency for International Development
Washington, DC 20523

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In February 1982 WASH was requested to assist USAID/Ecuador to develop a local manufacturing capability for the AID handpump. A local manufacutring program originally began in Ecuador in 1979 but was discontinued because the manufacturer could not produce enough handpumps to sustain a country-wide effort.

Subsequently, Order of Technical Director No. 82 was issued, requesting WASH to select two new manufacturers, provide the necessary technical assistance, develop quality control and installation and maintenance job aids, and install and monitor 25 handpumps. WASH asked the Georgia Institute of Technology, which has extensive experience in similar programs, to carry out this task. The manufacturers were selected in August 1983 and technical assistance was provided until April 1984.

The principal results of this effort are the following:

- Two manufacturers, Tirado Hermanos and Metalurgica Ecuatoriana, capable of making the USAID-design handpump to specification.
- Eleven Peace Corps Volunteers assigned to IEOS and five health educators from the Vozandes mission who can train local groups in installation and maintenance.
- Job aids for manufacturing quality control and installation and maintennace.
- The initial stages of developing a counterpart, the National Polytechnical School.

In the course of this project there were many lessons learned. The recommendations fall into three areas: the scope of work, the Ecuador handpump program, and future AID handpump programs. Below are the main recommendations:

Scope of Work

- Companies evaluated for production of handpumps should include those having only foundry or machine shop operations, in addition to those that combine both capabilities, in order to increase the number of manufacturers and foster competition.
- Pilot manufacturing programs should precede anticipated large orders to assure that there is a large-scale production capability.
- The manufacturing quality control and installation and maintenance job aids produced for this project should be tested again to verify their effectiveness and assure their applicability.
- Adequate time and resources should be allocated, if development of a technical counterpart is to be an important factor in similar future programs.

Ecuador Handpump Project

- The Ecuadorian National Polytechnic School should be further developed as a counterpart to provide technical assistance.
- Tirado Hermanos should be monitored for adherence to the existing contract schedule for 1,000 pumps.

Future AID Handpumps Projects

- An objective system of ranking candidates should be applied to the future selection of manufacturers.
- Investigation of alternative materials and components for AID handpumps should be conducted in order to ameliorate current difficulties with castings, pins, and bushings.
- Initial pump orders with new manufacturers should not exceed 100, and subsequent orders should either be limited to 500 or include equitable price change clauses.
- Commercially available, compatible pump components should be purchased, rather than manufactured, where practical.
- Job aids developed for the Ecuador project should be used for future AID handpump projects.

ACKNOWLEDGEMENTS

Georgia Tech extends its appreciation to Dr. Kenneth Farr and Herbert Caudill of the AID Mission in Ecuador for their assistance, patience, and kindness in carrying out the work under this program. Georgia Tech also acknowledges the untiring efforts of the secretarial staff in the office of Dr. Farr who were uncomplaining while making travel reservations, placing long distance calls, typing, and acting as translators.

Georgia Tech enjoyed working with the manufacturers in Ecuador and treasures the bonds of friendship that developed with the workers and the owners.

Finally, Georgia Tech would like to acknowledge the sympathetic and skillful approach taken by Mr. Fred Rosensweig, the WASH project manager, as he strove to obtain meaningful results from many diverse impression and findings.

LIST OF ACRONYMS

USAID	United States Agency for International Development
IEOS	Instituto Ecuatoriano de Obras Sanitarias
OTD	Order of Technical Direction
S&T/H	Science and Technology, Health
WASH	Water and Sanitation for Health Project

Chapter 1

INTRODUCTION

The AID handpump is a single-action, reciprocating, positive displacement pump designed in 1966 by Battelle-Columbus Laboratories for the U.S. Agency for International Development (AID). Specifications for the design included long life under severe operating conditions, easy maintenance using simple tools and unskilled labor, potential for manufacture in developing countries, and easy operation by women and children. The shallow-well (SW) version, with the piston and cylinder assembly incorporated into the above-ground pump stand, is suitable for wells where groundwater is at depths of less than 26 feet (see Figure 1). For the deep-well (DW) version, the piston and cylinder are positioned below the water level allowing pump operation to depths in access of 100 feet (see Figure 2).

In 1976 AID contracted with the Georgia Institute of Technology to carry out field testing activities in developing countries. Under the initial Georgia Tech contract, the AID handpump was manufactured and field tested in Nicaragua and Costa Rica. After recommended design changes, it was introduced in the Dominican Republic, Indonesia, the Philippines, Honduras, and Sri Lanka. A handpump program in which pumps have been installed but not manufactured is currently in progress in Haiti, and an apparently unsuccessful program was recently phased out in Tunisia.

The AID pump programs require the local manufacture of pumps and spare parts, depend on local technicians for installation and maintenance of the pumps, and sometimes expect users to monitor the pumps. Because the programs depend heavily upon the expertise and resources of the nation involved, the projects have met with varying degrees of success.

Experience around the world has shown that some initial failures were rooted in the lack of the capacity to produce pumps of acceptable quality. In other cases the pumps were improperly installed and maintained despite painstaking efforts on the part of outside experts working with local officials and technicians. In still other cases the pumps and/or their parts simply wore out from use and inadequate maintenance. The latter problems appear to be the most frequent because of the logistics required to maintain installed pumps and the difficulty developing countries have in managing such projects. Despite setbacks, however, there is encouraging evidence that some countries are developing the capability to implement and maintain handpump programs.

The AID handpump program in Ecuador was initiated in response to specific requirements of the USAID funded "Integrated Rural Health Delivery" project. The Project Paper stated "This project will finance improvements of institutional capabilities to carry out development programs at the national, regional, and local levels as well as field level demonstration activities in low cost primary health care, water supply, sanitation and nutrition interventions. The project specifically called for the funding of two types of water supply systems; simple gravity flow aqueducts and wells with handpumps. The AID handpump was selected and plans were made to develop a local manufacturing capability for the pump.

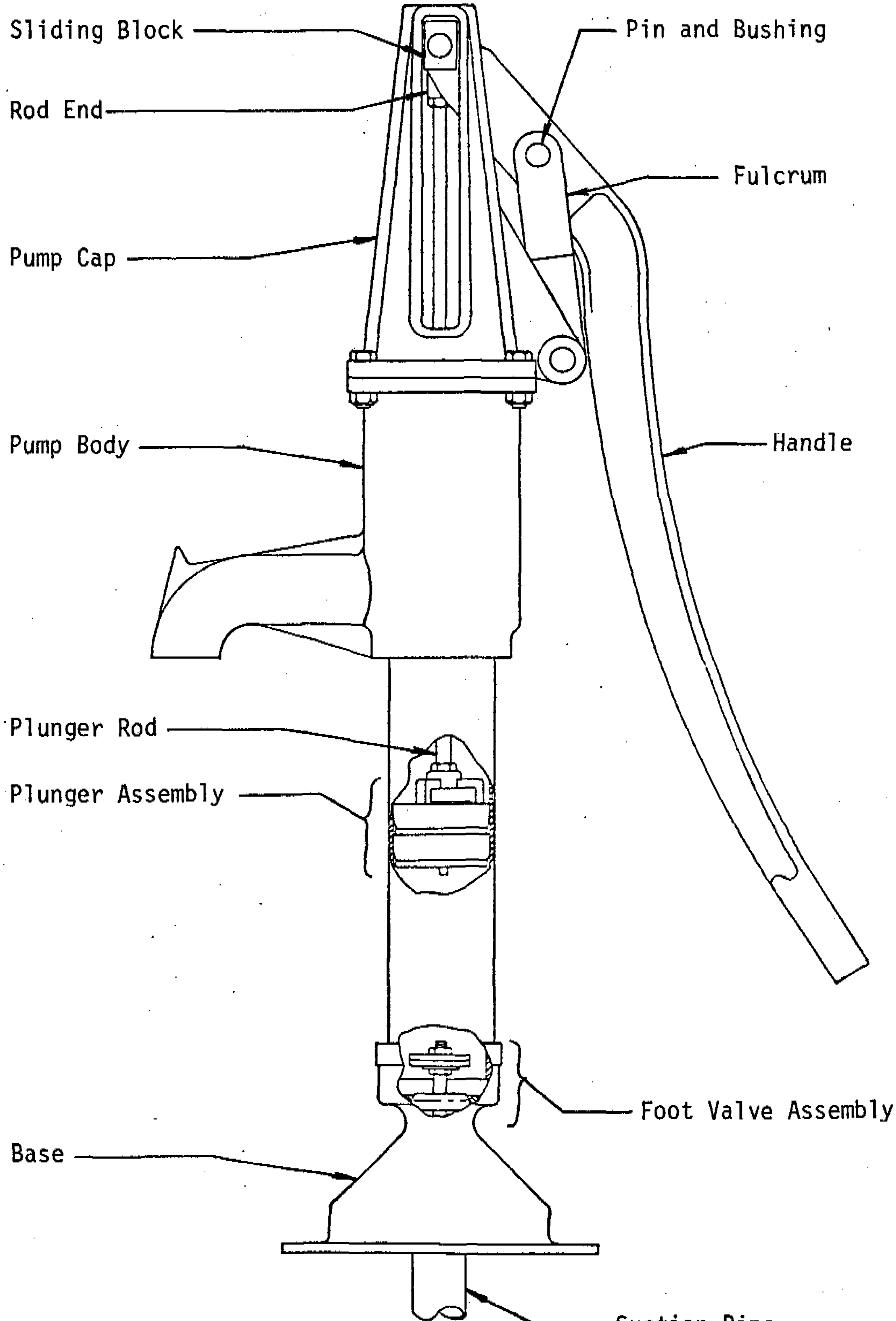

Figure 1. AID Shallow-well Hand Pump

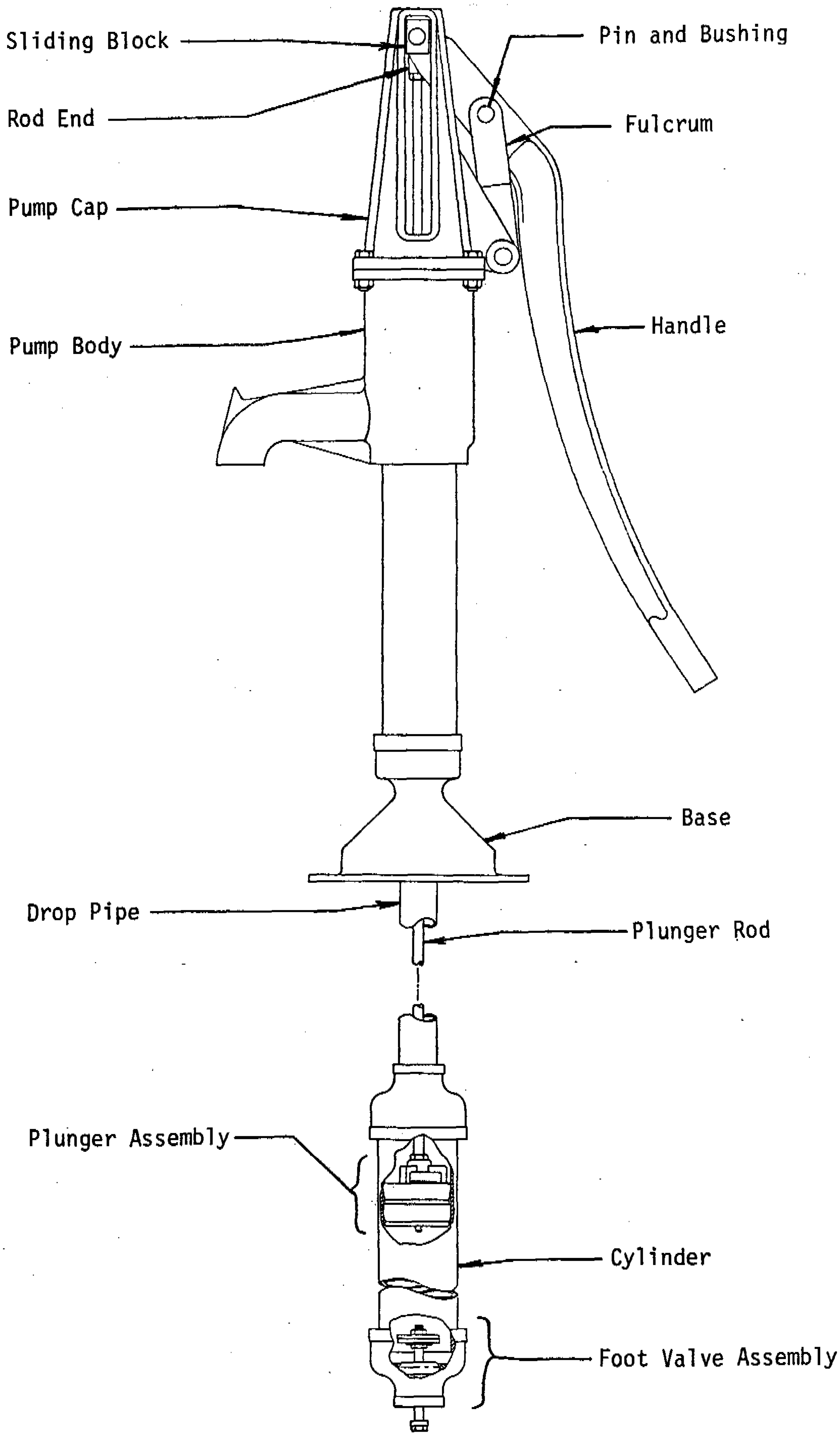

Figure 2. AID Deep-well Hand Pump

Chapter 2

PROJECT BACKGROUND

2.1 Events Leading to the OTD

The USAID handpump program in Ecuador began in 1979 when the USAID Mission in Quito contracted the services of Georgia Tech. The work program of this contract included:

1. Feasibility study.
2. Handpump manufacture.
3. Roboscreen manufacture.
4. Robovalve manufacture.
5. Installation of handpumps and roboscreen.

As a first step, a manufacturing feasibility study was conducted in order to provide recommendations to the AID mission in Quito and, in turn, to IEOS (Instituto Ecuatoriano de Obras Sanitarias). These recommendations were to include a list of local manufacturers who could produce the AID handpump and robo devices to specification and in quantities sufficient to sustain a country-wide handpump installation program (see Appendix A).

The Escuela Politecnica Nacional (National Polytechnic School), an engineering college in Quito, was selected to manufacture the handpumps. An educational institution rather than a profit seeking company was selected due to the excellent foundry facilities located on the campus of the school. The school officials also felt that this arrangement would provide enhanced training for their students in foundry and machine shop practices and would provide them with extra income. Unfortunately, this entire arrangement was less than satisfactory. When the educational objectives of Politecnica began to conflict with the production objectives of USAID, the education objectives enjoyed a higher priority, as well they should. The original order for 110 pumps was placed with Politecnica in November 1980. By the spring of 1982 only 47 had been produced and even those had been machined and assembled by Georgia Tech personnel and their subcontractors. By then it was obvious to all concerned that Politecnica was not a viable source of supply for AID handpumps in Ecuador.

2.2 Scope of Work

On February 9, 1982 OTD 82 was issued and WASH requested Georgia Tech to carry out the following scope of work:

1. Assist USAID/Ecuador in selecting two Ecuadorian foundries for the manufacture of handpumps, the foundries to be selected through a competitive bidding process.

2. Provide technical assistance to two Ecuadorian foundries to establish local manufacturing capability for the AID handpump, assistance to the two foundries to be provided over a four to six month period.

3. Provide technical assistance and training to Vozandes Hospital, Peace Corps, the Government of Ecuador, IEOS, and other Ecuadorian organizations in handpump site development; handpump installation, operation, maintenance and repair; water disinfection; and water quality analysis.

4. Develop a quality control manual for the local manufacture of the AID handpump.

5. Develop an installation, operation, and maintenance manual for the AID handpump which uses a task and performance oriented training approach.

6. Attempt to develop an Ecuadorian counterpart in order to optimize supervision and quality control aspects of the handpump program.

7. Continue field monitoring and evaluation of AID handpumps manufactured by the Escuela Politecnica Nacional (National Polytechnic School) and perform the initial monitoring of 25 AID handpumps manufactured by the competitively-selected foundries. Provide feedback to manufacturers when manufacturing defects are found.

8. Locate well sites, install handpumps and roboscreens, and set up a monitoring program for up to 20 sites with the 25 newly-manufactured handpumps.

9. Prepare an oral report after each 50 person-days of effort. Written reports are required when 100 person-days have been completed and again at 200.

10. Prepare a final report covering all phases of the handpump program.

Georgia Tech personnel planned to select the sites for the installation of the 25 handpumps in May 1983. At that time, Mr. Herbert Caudill of USAID/Ecuador informed Georgia Tech that this element of the work program was not appropriate under current conditions. Therefore, items 7 and 8 of the above scope of work were cancelled.

2.3 Organization of the Report

Chapter 3 covers the approach, activities, and significant events involved in carrying out this activity. Chapter 4 presents the outcomes and conclusions drawn from this effort. Chapter 5 includes recommendations for follow-up work in Ecuador as well as recommendations for improving technology transfer programs of this type in other countries.

Chapter 3

METHODS/PROCEDURES

3.1 General Approach to Technical Assistance

In conducting AID handpump technology transfer programs, Georgia Tech research staff generally follow the sequence of activities outlined below:

1. Georgia Tech assesses the pump production capability of several manufacturers and recommends one or more of these manufacturers for selection by AID to make the pump for host country use.

2. Georgia Tech provides mechanical drawings and a prototype pump to the selected manufacturer(s) and discusses in detail the manufacturing, assembly, and finishing of the pump.

3. The manufacturer fabricates the pump. This process involves casting and machining iron and brass components and procurement or fabrication of other materials and parts. The machining involves cutting, grinding, turning on a lathe, milling, drilling, and threading. The fabrication process also involves hardening and tempering steel pins and bushings for the pump's mechanical linkages.

4. As the manufacturer completes some initial pumps, Georgia Tech personnel inspect them very carefully. This opportunity is used to orient and train the manufacturer in quality control, product inspection, and testing.

   Based on inspection of the initial pumps, Georgia Tech personnel identify the principal difficulties encountered by the manufacturer, determine the reasons for the difficulties, and work out a mutually-acceptable program of intensive technical assistance. Executing this specific technical assistance element is the major component of Georgia Tech's program and is the most time-consuming.

5. Once the manufacturer completes the order of pumps, Georgia Tech personnel conduct final inspection and acceptance testing. Again, Georgia Tech uses this opportunity to train the manufacturer in these last critical steps in the pump production process.

6. If a host-country agency is purchasing the pumps, Georgia Tech trains the agency's personnel in the pump acceptance procedure. This enables the agency to ensure that only reliable pumps reach the field. The agency's personnel will be responsible for accepting or rejecting the pumps and for approving or withholding payment to the manufacturer.

   If the pumps are purchased on behalf of AID, Georgia Tech personnel may be engaged later to train agency personnel when the host-country agency begins to order pumps.

7. In order to obtain information on the performance of the locally manufactured pump and on the acceptance and use of the pump by the local people, Georgia Tech personnel assist host country personnel in selecting

field test sites and in installing the pumps. This involves a sanitary survey, site selection and characterization, slab (for dug wells) or apron (for tube wells) construction, pump installation, and well disinfection. Host country personnel are trained as these activities are performed.

8. Together with host-country personnel, Georgia Tech maintains and monitors the field test sites. Feedback on the pump's performance, acceptability, and maintainability is provided to the AID Mission, the host country agency, and the pump manufacturer.

9. If necessary, additional technical assistance is provided to the manufacturer or host-country personnel to resolve any difficulties revealed by the field testing.

10. Finally, Georgia Tech prepares a report documenting its activities. Drawing from the experience, the report formulates conclusions which are specific to the activity and/or are applicable to AID's overall handpump technology transfer program. Recommendations are made concerning both the specific country's water supply programs and future activities under AID's technology transfer program.

The initial program of technical assistance is usually a pilot program in that a relatively small number of pumps is involved. It is as much for demonstration and data collection as it is for developing local manufacturing capability. A follow-up program of technical assistance is sometimes recommended to help AID, the host country government, and the manufacturers. The follow-up program not only deals with the problems identified in the pilot program, but also addresses problems associated with the increased size and complexity of large-scale, full-production programs involving thousands of pumps.

3.2 Specific Approach in Providing Technical Assistance in Ecuador

3.2.1 Host-Country Production Capability Assessment

Based primarily on information and experience gained during part of 1980 and on experience with the National Polytechnic School pumps, IEOS (Ecuadorian Institute for Sanitary Works) requested bids for 1,000 pumps in April 1982. After bids were submitted, Georgia Tech was asked to evaluate the capability of four manufacturers who responded (Metalurgica Ecuatoriana, Siderurgica Guayaquil, Ferroaleacion, S.A., and Ing. Nelson Ioaza). This evaluation was conducted in May 1982 by Mr. Phillip Potts of Georgia Tech and by Mr. Justin Whipple of ICAITI (Instituto Centroamericano de Investigacion y Technologia Industrial), a consultant to Georgia Tech (see Appendix B). In the resulting report to Dr. Kenneth Farr, Chief Health Officer of the USAID Mission in Quito, it was concluded that Metalurgica Ecuatoriana, a foundry/ machine shop located in Quito, was superior to the other three manufacturers with respect to the ability to produce 1,000 AID design handpumps to specifications and in a timely manner. However, IEOS decided that all of the bids were too high and declared the bidding process void. Under Ecuadorian law and practice, this declaration than enabled IEOS to purchase the 1,000 handpumps with a "sole source" contract. Georgia Tech was then asked to evaluate two manufacturers who had not previously submitted bids and to re-evaluate one manufacturer from the previous solicitation. In June 1982, this evaluation of Tirado Hermanos, Hansa S.A., and Metalurgica Ecuatoriana was conducted by Georgia Tech (see Appendix C). The conclusions reached from this evaluation were:

- Hansa S.A. should be eliminated from further considerations.
- Metalurgica Ecuatoriana had existing capability to manufacture AID handpumps.
- Tirado Hermanos had the potential capability to manufacture AID handpumps providing they were given adequate technical assistance.

Due to a large difference in the quoted prices of the two qualified manufacturers, Georgia Tech recommended that a major portion of the pump order be placed with Tirado Hermanos and that they be provided with intensive technical assistance. In order to assure a second source of handpumps, it was further recommended that a minor portion of the pump order be placed with Metalurgica Ecuatoriana and that they be provided with technical assistance as required.

Based on the findings of this second evaluation and on resubmitted bids, USAID/Quito and IEOS decided to place an order for 1,000 handpumps with Tirado Hermanos, located in Ambato, and an order for 50 handpumps with Metalurgica Ecuatoriana, located in Quito.

3.2.2 Technical Assistance to Manufacturers

Metalurgica Ecuatoriana was a relatively large foundry-machine shop complex that not only did special order ferrous and non-ferrous casting and machining but produced an extensive line of heavy wood-working machinery. The owner and his son, both engineers, managed the company. Their foundry and machine shop were well-equipped and managed. The major technical assistance given this company was the provision of a set of jigs and fixtures which had been fabricated in Honduras during a similar handpump project. These jigs and fixtures insured that the drilled bolt holes in the pump body, cap, and base were uniform and dimensionally correct. This tooling also insured dimensionally correct bushing holes in the fulcrum, handle, and pump cap. Very little technical assistance was required for this company to produce an acceptable AID design handpump.

Tirado Hermanos is a relatively small foundry machine shop that specializes in casting and machining replacement parts such as large gears, truck brake drums, and various machine parts. The company is managed by three brothers who also work in the foundry and machine shop. Extensive technical assistance was provided this company in areas of foundry processes, heat treating, jigs and fixtures, quality control, cost control, and production control.

3.2.3 Training for Ministry of Health (IEOS) Personnel

Training Programs

In some AID handpump projects in other countries, many handpumps were accepted by government agencies without quality verification. In addition, AID handpumps were installed and maintained according to the whims and varied past experience of installation and maintenance crews. Training in acceptance inspection of the AID-design handpumps (see Appendix D) was therefore provided for USAID and IEOS personnel and in AID handpump installation and maintenance for Vozandes Hospital personnel and Peace Corps volunteers assigned to IEOS. The training programs were designed and conducted in these two areas so that there would be a higher probability of trouble-free pumps being installed in the field and of proper installation and maintenance. The ultimate objective of all of this training would be to insure a relatively trouble-free source of water for Ecuadorians in rural areas.

Training Manuals

Rather than develop detailed manuals which might never be used, WASH instructed Georgia Tech to develop job aids with the assistance of a training specialist. Job aids were therefore developed for two segments of the handpump program in Ecuador. One set of job aids was for the manufacture of the handpump and was to include documentation of the manufacturing process, quality control procedures, quality characteristic criteria for castings, and acceptance inspection procedures, and criteria. The other set of job aids was for the installation, maintenance, and repair of the AID handpumps. It included the critical steps for pump installation, testing, maintenance, and repair for the AID deep well pump as manufactured in Ecuador. (Copies of these job aids are available from WASH on request.)

3.2.4 Field Performance Evaluation of Locally Manufactured Handpumps

It was initially planned to select 20 well sites and install 25 locally manufactured handpumps. This was to have served two purposes. The first was to provide training for host-country personnel on handpump installation, maintenance, and repair. The second purpose was to provide feedback to the manufacturer on possible deficiencies in the quality of the handpumps. This element was cancelled in early 1983 at the request of the AID mission in Ecuador. The major reason for this cancellation was the flood conditions existing in the proposed test area.

3.3 Field Activities

3.3.1 Technical Assistance to Ecuadorian Manufacturers

Technical assistance given to the two handpump manufacturers in Ecuador generally fell into four categories:

- Foundry processes
- Machine shop processes
- Production management
- Quality control procedures

Foundry Processes

Little time was required in assisting Metalurgica Ecuatoriana. This company had much more experience than Tirado Hermanos, and the management of this company was not receptive to outside assistance. Unfortunately, Metalurgica Ecuatoriana experienced many of the same problems as Tirado Hermanos in their foundry processes. Most notably, it experienced porosity in thin sections of its castings.

Tirado Hermanos, on the other hand, had a comparatively primitive foundry. Much time was spent during the early stages of the technical assistance activity in helping this company improve its patterns and molding techniques in order to reduce porosity in the castings. Later in the project, the services of a foundry expert on the staff of the National Polytechnic School of Quito were obtained (see Appendix F). These services included investigating and documenting the complete foundry processes of Tirado Hermanos. This included physical and chemical analyses of the molding and core sands, coke, bentonite, and scrap metal used in the production of gray cast iron. After this preliminary investigation, the foundry expert conducted trials in the foundry and made recommendations to Tirado Hermanos based on these trials. These recommendations, if followed, will greatly increase the quality of their cast iron components.

Machine Shop Processes

The only assistance given Metalurgica Ecuatoriana on machine shop processes was in providing them with a set of jigs and fixtures for correctly drilling holes in the base, cap, handle, and handpumps. When the pumps were inspected for acceptance, there were no defects found attributable to machine shop processes.

Considerable assistance was given to Tirado Hermanos in the machine shop processes used to manufacture the AID handpump. As with Metalurgica Ecuatoriana, a complete set of jigs and fixtures was provided to this company. They in turn modified some of the drill jigs to make them compatible with their equipment and traditional machining methods. This did not present any problems. Most of the machine shop assistance given to this company involved changing their one-of-a-kind procedures and philosophy to mass production techniques that insure component part interchangeability. Considerable assistance was provided in the process of heat treating the pins and the bushings. Later in the project, a series of production gauges to be used in conjunction with job aids manufacturing was designed, built, and provided to this company. These gauges, if properly utilized, will provide greater assurance that the handpumps are built to specification and thus their component parts are interchangeable.

Production Management

Due to the extremely short manufacturing time required to produce 50 handpumps, Metalurgica Ecuatoriana was given no assistance in areas of production management. Assistance in production management was provided to Tirado Hermanos, however. Unfortunately, this assistance was not as effective as that provided in areas of manufacturing technology. One of the primary constraints was in the level of knowledge of basic production management possessed by the Tirado Brothers. These three men had started their business as shop workers and had developed what management skills they had by trial and error. To have made any meaningful progress in developing their production management knowledge and skills would have required a major commitment of time and resources that had not been anticipated. The two major achievements in the area were in showing this company how to systematically develop a process for determining product cost and stimulating them into developing a basic system of inventory management.

Quality Control Procedures

There was no assistance provided to Metalurgica Ecuatoriana on quality control procedures other than furnishing them with information on acceptance criteria and a plan for final acceptance inspection of AID handpumps. Tirado Hermanos was provided this same information in the "AID Handpump Manufacturing Quality Control Job Aids." A complete set of production gauges, dedicated to AID handpump specifications, was also given to the company to be used with the manufacturing and quality control guide. One of the owners and two of the more qualified machinists were provided training in handpump quality control using the Spanish language edition of the "AID Handpump Manufacturing Quality Control Job Aids."

3.3.2 Technical Training for IEOS Personnel

Training was provided for IEOS personnel in handpump acceptance inspection and in handpump installation and maintenance. In order to increase the effectiveness of this training and in order to provide for host-country continuity after the termination of this technical assistance effort, two job aids were developed.

Acceptance Inspection Training

Beginning in January 1983, nine IEOS engineers were trained in AID handpump acceptance inspection procedures in three separate sessions. This training consisted of both lectures and "hands-on" practice. As part of this training program design, quality characteristics (see Appendix D) were defined and acceptance/rejection criteria were established. It is felt that at least two of those people trained in acceptance inspection could now effectively train other IEOS engineering personnel in this skill.

Installation and Maintenance Training

In October 1983, a two-week participant-centered workshop on pump installation, maintenance, and repair was conducted for nine Peace Corps Volunteers attached to IEOS, two other volunteers attached to the Ministry of Agriculture, and five health educators from the Vozandes Mission in Quito. The workshop was conducted by Alan Pashkevich of Georgia Tech and Andrea Jones, a training specialist. The goal of the workshop was to give the participants skills to plan, implement, and follow up village-based handpump projects as well as to provide the necessary technical skills and knowledge. The participants carried out such tasks as troubleshooting and repairing broken pumps, constructing well aprons, installing a deep-well pump, conducting a community project feasibility assessment, analyzing feasibility data, creating a project work plan, and designing and rehearsing training programs for pump caretakers and users. The intent was to use these participants later as trainers of installation and maintenance teams as plans for installing the handpumps became more defined. The workshop is discussed in WASH Field Report No. 110 "A Workshop on Handpump Installation and Maintenance in Riobamba, Ecuador" (Water and Sanitation for Health Project, Arlington, Va.).

3.4 Significant Problems

Many of the significant problems encountered during the handpump program in Ecuador have also been encountered in AID handpump programs in other countries. The resolution of identical problems, however, varies from country to country and from manufacturer to manufacturer. The following is a brief description of the major problems encountered in Ecuador and the attempts to solve them.

3.4.1 Casting Porosity

This problem is inherent in the design of the AID handpump. Even in developed nations, porosity is a traditional problem in foundries producing gray cast iron. Porosity can be caused by many things--excessive sand moisture, incorrect mold venting, too low a temperature of the molton iron, and so on. The problem in many developing-nation foundries in general and in the foundry of Tirado Hermanos in particular is that they have learned to live with porosity. Most of the parts that they cast are so overdesigned that the strengh lost by excessive porosity does not affect the ultimate function of the cast iron part. When internal porosity in a casting is exposed by machining it is usually filled with putty, painted, and forgotten. The AID handpump, however, is very unforgiving of porosity in critical areas. Excessive porosity around the areas where the hardened steel bushing is to be pressed in will cause the casting to rupture as the bushing is being inserted. Excessive porosity in the clevis area of the handle and fulcrum will likely result in premature failure. Porosity in the portions of the base, body, and cylinder caps where threads will be cut will likely result in severe leaks.

It is very difficult to convince foundrymen who have traditionally ignored porosity that porosity in AID handpump components is not acceptable.

In an attempt to reduce porosity significantly in the cast iron pump components produced by Tirado Hermanos, the National Polytechnic School in Quito was contacted, and the services of a foundry expert on their faculty was obtained. The recommendations of this expert (see Appendix I), if followed by Tirado Hermanos, should significantly reduce porosity.

3.4.2 Heat Treating

Properly heat treating the pins and bushings in AID handpumps has been a problem in every country where this pump has been manufactured. This is a dual problem in that heat treatable steel is usually scarce and expensive in developing countries. In addition, manufacturers generally do not have the equipment or the experience to treat the pins and bushings to the specified hardness. Much time was spent advising Tirado Hermanos on the type of steel to use for the pins and bushings and then training them in heat treating techniques using the primitive equipment available. A portable hardness tester was acquired from the United States and provided to Tirado Hermanos so that they could correct their processes to achieve the specified hardness. This company still cannot meet the hardness specifications consistantly and, until they can purchase adequate heat treating equipment, variations from the hardness specifications will continue.

3.4.3 Pump Manufacturing Cost

One of the most significant problems with handpump manufacture in Ecuador is the current rate of inflation. When the Tirado Hermanos submitted their quotation of 7,500 sucres each for 1,000 pumps in the spring of 1982, the offical rate of exchange of the Ecuadorian sucre was 33 sucres to one U.S. dollar. By the spring of 1984 the sucre's unofficial rate of exchange had been as high as 100 sucres to one U.S. dollar. Also, fuel and power prices have increased. The Tirado Hermanos soon found that they were losing money selling pumps to IEOS for 7,500 sucres and requested a contract amendment so that the price could be increased. IEOS immediately rejected this request based on lack of justification. At this point Georgia Tech provided assistance to Tirado Hermanos in preparing a detailed product cost analysis similar to that done for another pump manufacturer in Honduras (see Appendix G). This cost analysis was submitted to IEOS and in 1983 IEOS amended the contract so that the pump price could be increased to 10,000 sucres. While this new price does not make pump manufacturing a profitable venture for the Tirado Hermanos, it will reduce their losses considerably.

3.4.4. Quality Control

Because of the nature of the business of Tirado Hermanos, they are accustomed to making only one- or two-of-a-kind of cast or machined parts. This company is in the business of supplying replacement parts. The ultimate test of quality is whether or not the replacement part worked. If the customer returns and complains that the part does not work, it is remachined until it does. Quality control consists primarily of the operator checking his own work. With this kind of background, Tirado Hermanos set out to build 1,000 units of a product with many components that had to be interchangeable.

Fortunately, a set of jigs and fixtures had been provided to this company as part of the initial technical assistance effort. This insured that certain drilled hole dimensions were correct but did not insure complete part interchangeability. Several steps were taken to improve quality control procedures for this manufacturer. First, an acceptance inspection plan was designed to help the manufacturer know what was expected of him and to help the customer (IEOS) know what to accept and what not to accept. Acceptance criteria for the major quality characteristics of the pump components were provided. Training was then provided to IEOS personnel and Tirado Hermanos personnel on acceptance inspection procedures. This inspection program has been used on all pumps delivered by Tirado Hermanos to IEOS. Later in the project, a set of production gauges was designed and manufactured. They were used to insure that certain critical dimensions of pump components met specification. Manufacturing quality control job aids were then produced as training aids in the use of jigs, fixtures, gauges, and inspection procedures.

3.4.5 Pump Foot Valve

As originally designed, the AID handpump incorporated a leather flapper-type foot valve. In every country where the AID handpump has been produced, the flapper-type foot valve has been the pump component which has given the most trouble. In AID shallow-well pumps, failure of the foot valve requires only a short time to replace. In AID deep-well pumps, however, the entire drop pipe, drop rod, and piston assembly must be removed to replace the foot valve. This can necessitate the use of a tripod, much equipment, and several workers for four or more hours. In a recent AID handpump project in the Philippines, a poppet-type foot valve was developed and used with success. In order to prevent problems in Ecuador with the leather flapper-type foot valves, a poppet-type foot valve was designed based on the Philippine foot valve. This valve was then tested in the laboratories of Georgia Tech under varying conditions of water pH and salinity. When it was felt that the poppet-type valve was reliable, a quotation was obtained from Tirado Hermanos on the cost to produce it (see Appendix H). Costs were also obtained on foot valves readily available in Ecuador but manufactured in Taiwan. The cost of the poppet-type foot valve was quoted by Tirado Hermanos to be 520 sucres while the general price of a 1-1/4" Taiwan made foot valve in Ecuador was around 700 sucres. This information was presented to IEOS through its AID liaison engineer and the decision was made locally to change the design from a leather flapper-type foot valve to the brass poppet-type foot valve that was to be manufactured by Tirado Hermanos.

Chapter 4

OUTCOMES AND CONCLUSIONS

4.1 Outcomes

4.1.1 Manufacturing Capability

In early 1982 two trips were made to Ecuador to evaluate several foundry/ machine shops as to their ability to manufacture AID handpumps of acceptable quality in meaningful quantities (1,000 pumps per year)(see Appendix C). Beginning in August 1982, the two manufacturers selected to produce AID handpumps were given technical assistance. This technical assistance has resulted in two local manufacturers now capable of producing the USAID design handpump to specification.

4.1.2 Training

Training has been rendered in handpump inspection and handpump installation and maintenance. Six people from USAID/Ecuador and four from the Ecuadorian Institute of Sanitary Works (IEOS) are qualified to inspect handpumps for acceptance. Eleven Peace Corps volunteers working with IEOS and five health educators from the Vozandes Mission have been trained in handpump installation and maintenance and represent a resource when installation and maintenance activities get underway.

4.1.3 Job Aids

Job aids have been developed for both handpump manufacturing quality control and handpump installation and maintenance. Both sets of job aids have been field tested with the intended users in Spanish and then revised based on data gathered during the test. Both sets are generic and can be used without modification in other countries where the USAID handpump has been or will be introduced.

4.1.4 Counterpart Development

Initial efforts have been made to develop a reliable counterpart organization in Ecuador that could provide continuity to the pump manufacturing management and technical assistance program. Ing. Lenin Ubidia, Dean of the Mechanical Engineering Department of the National Polytechnic School, has expressed a strong interest in developing a technical extension service for Ecuadorian industry. If this program could be developed by the school it could very easily become a reliable source of assistance to handpump manufacturers.

4.2 Conclusions

4.2.1 Economic Factors

Rapid inflation has seriously affected the handpump program in Ecuador. It has been difficult for Tirado Hermanos to manufacture pumps with 1984 labor, materials, and overhead costs and sell them at a price based on 1982 costs. Had the order of 1,000 pumps been produced in a more timely manner, their losses would have been minimal. However, many delays caused by equipment breakdowns in the foundry, unavailability of materials, and national labor unrest have necessitated a time extension on their contract with IEOS. The company is now in a poor cash flow situation. They must therefore load their factory with as many "short cycle" quick small jobs as possible. Even though they receive partial payments on accepted return lots of handpumps, it takes up to 12 weeks for Tirado Hermanos to receive payment from IEOS. At this time it does not appear that this situation will change. To date, 340 pumps have been produced and accepted by IEOS. The entire order of 1,000 pumps must be accepted by IEOS by June 30, 1984 or Tirado Hermanos will be considered in default of their contract. This could have serious consequences on their future business opportunities with IEOS.

4.2.2 Production Factors

It is very difficult for a traditional job shop manufacturer to rapidly adapt to mass production techniques. In many developing countries, foundry/machine shop combinations (when they can be found) usually specialize in one or two kinds of replacement parts. Tirado Hermanos was this kind of company. They produced replacement gears, truck wheel drums, and machine parts. All of these parts are usually cast from gray iron and then machined to duplicate the dimensions of the part to be replaced. The skilled machinists in their machine shop could understand only the most simple mechanical drawings. It is very difficult to convert this type of job-shop into a "mass-production" shop. For example, although a machinist could spend much time duplicating a gear, he would not be too careful when drilling holes in fifty pump handles. The concept of parts interchangeability is also difficult to communicate. The men who assemble the handpumps (usually the lowest skilled) assume that their job is to make everything fit properly. As a result, if component parts are machined improperly they will grind, redrill, and file until the part fits on that particular pump and provide very little if any feedback to management that one of the component manufacturing processes is out of control. This can cause many problems with maintenance after the pump is installed. Much progress was made with Tirado Hermanos toward developing mass-production methods for handpumps. However, manufacturing practices and management philosophies developed over the past 20 years are not easy to change. It is doubtful that Tirado Hermanos would ever accept another order for 1,000 handpumps with the rigid pricing the delivery schedule required in their contract with IEOS. Even Metalurgica Ecuatoriana, which produces their own line of woodworking machinery, found it difficult to meet the rigid requirements of quality and delivery schedules.

4.2.3 Counterpart Development

It was very difficult to find a potential counterpart in Ecuador. At first, it was anticipated that engineers from IEOS might fill this role. However, since most of IEOS technical staff's background is in civil and sanitary engineering, manufacturing does not seem to be compatible with their main interests. Several of their technical staff were trained in handpump acceptance inspection and performed well. When a group of pumps were ready for inspection, however, it was very difficult for them to break away from their normal duties to schedule an inspection. For these reasons, it is felt that IEOS would not have the interest or the manpower to become an effective counterpart. The most likely prospect to fill a counterpart role would be the National Polytechnic School in Quito. One member of the mechanical engineering faculty, working as a consultant to Georgia Tech, is currently addressing foundry problems at Tirado Hermanos. As mentioned above, Ing. Lenin Ubidia, Dean of the Mechanical Engineering Department, has expressed a strong interst in developing a technical extension service for Ecuadorian industry. If this program could be developed by the national Polytechnic School, they could very easily become a reliable source of assistance to handpump manufacturers.

In the case of Ecuador, actively undertaking a counterpart development program would have been extremely time consuming and would have taken away from the time spend in providing technical assistance to the manufacturers. In addition, there must be some type of incentive for an organization to be willing to become so involved. There was no incentive on the part of IEOS since this technical assistance activity would not have been compatible with their personnel skills or interests. The only incentive that the National Polytechnic School had was financial. It is highly unlikely that the dean of the Mechanical Engineering Department would have agreed to provide the service of his foundry expert had the school not been financially rewarded. USAID Mission personnel should have much more responsibility in identifying counterparts than an outside contractor such as Georgia Tech because of their familiarity with local organizations and their potential.

Chapter 5

RECOMMENDATIONS

5.1 Scope of Work

5.1.1 Manufacturer Evaluation

Background

In this and other handpump projects the selection of a suitable manufacturer was based on a company's having both foundry and machine shop capabilities. This drastically restricted the number of eligible companies. Many host-country companies have excellent foundries but inadquate machining facilities; others have excellent machine shops but poor foundries.

Recommendation

In future evaluations, candidate companies should not be required to have both foundry and machine shop. Machine shop prime contractors might buy castings from a separate foundry. Foundry prime contractors might have the machining done elsewhere. The prime contractor (whether foundry or machine shop) would have the ultimate responsibility for price, quality, and delivery. This method would provide a greater number of candidate companies and encourage more realistic prices because of increased competition.

5.1.2 Technical Assistance

Background

In AID handpump projects in some other countries, a pilot manufacturing program was initiated whereby a small quantity (50-150) of handpumps were ordered. During the manufacturing of these few pumps intensified technical assistance was provided. This technical assistance included foundry processes, heat treating, development of production tooling (jigs and fixtures), and quality control procedures. When it was felt that the company had properly developed its manufacturing process for handpumps, the AID Mission was notified.

Recommendation

It is strongly recommended that the pilot manufacturing program be used on all handpump projects in the future. When this step is omitted (as it was with Tirado Hermanos) and a large order for handpumps is placed with a relatively small company insurmountable obstacles arise for the company involved, for the technical assistance agency, and for host-country government agencies. The local manufacturer must rapidly assimilate radically new knowledge and procedures while trying to meet delivery schedules and to overcome the negative cash position caused by increased material inventories. The technical assistance personnel must provide effective training while at the same time pushing to meet production deadlines and trying to locate supplies of critical materials. Finally, the host-country agencies may have difficulty rescheduling the site preparation teams if pumps are not delivered on time.

5.1.3 Training in Installation, Maintenance, and Repair

Background

The manufacture and installation of handpumps is a part of a major water and sanitation program now being conducted by the Ecuadorian Ministry of Health (IEOS). At the outset of this project, training in handpump installation, maintenance and repair, water disinfection, and water quality analysis was to be provided for personnel from the Ecuadorian Ministry of Health, Peace Corps, Vozandes Hospital and other Ecuadorian organizations. This training was to be in conjunction with the installation of 25 of the newly manufactured handpumps. Because of adverse weather conditions in the test site area and other factors, the installation of the 25 pumps and the associated training was cancelled. Subsequently, sixteen persons (Peace Corps volunteers and Vozandes health educators) were given handpump installation and maintenance training during a ten-day workshop.

Recommendation

As part of a large scale installation program of the AID handpumps manufactured in Ecuador, training should be given to personnel at all levels involved with the pump program. This should range from the village caretaker level to the IEOS engineer responsible for the project.

5.1.4 Manfacturing Quality Control Job Aids

Background

The manufacturing quality control job aids which were produced for the Ecuador handpump project were designed and prepared over several months. These job aids are generic in nature and were produced in both English and Spanish. In early 1984 they were tested in the factory of Tirado Hermanos and found to be, in-general, effective. Unfortunately, only a few of the gauges could be tested because of the limited number of production processes being used in handpump manufacture at that time.

Recommendation

As soon as practical, all these job aids should be tested with another handpump manufacturer for effectiveness.

5.1.5 Installation, Maintenance, and Repair Job Aids

Background

These job aids were prepared concurrently with the manufacturing quality control job aids and are also generic in nature. The installation and maintenance ones were also prepared in both English and Spanish. The job aids are primarily graphic. Key points, however, are stressed in brief but explicit captions. These job aids were field tested during the handpump installation and maintenance workshop conducted in October 1983.

Recommendation

The installation, maintenance, and repair job aids are now ready for application in other countries. Before they are used extensively in other countries, however, they should be field tested with a small representative group of trainees in these countries to insure that they are fully applicable to the situation and to the culture.

5.1.6 Counterpart Development

Background

When developing handpump manufacturing capability in a developing nation, an in-country counterpart organization should also be developed concurrently to provide project and program continuity. Because of conflicting priorities and financial limitations of potential counterparts, this goal is seldom realized. Past experience has shown that developing an effective counterpart capable of providing management and technical assistance to manufacturers requires sustained effort over a long period of time.

Recommendation

If a technical counterpart is considered to be essential to the ultimate success of a handpump or other water and sanitation program, adequate time and funds must be allocated. The time and funds spent can be minimized if significant assistance is provided by AID missions and local governmental organizations. Both generally have wide and accurate knowledge of possible counterparts and can provide valuable assistance in evaluating their potential.

5.2 Future of the Ecuador Handpump Project

5.2.1 Counterpart Development

Efforts should be continued to promote and support the National Polytechnic School as a counterpart. It would be appropriate for USAID to provide some type of funding so this school could take on technical assistance activities. After initial funding, the school should be encouraged to seek continued funding from both the Ecuadorian government and private industry.

5.2.2 Training

Efforts should be made by the IEOS liaison engineer within the AID mission in Ecuador to continue the training of IEOS personnel in pump acceptance inspection. Efforts should also be made in getting the Peace Corps volunteers already trained in handpump installation and maintenance to conduct training sessions for other host-country personnel.

5.2.3 Tirado Hermanos

Because of the financial condition of this handpump manufacturer, its production should be monitored very carefully. If the order for 1,000 pumps is not completed on schedule, the company will be considered in default under Ecuadorian law and its bonding agency will have to indemnify IEOS. If this occurs, it will no longer be bondable (a requirement for government contractors) and will therefore no longer be a source of supply of handpumps. It is recommended that a representative of either IEOS or AID/ Ecuador contact this company at least once per week to expedite pump delivery.

5.3 Future Aid Handpump Projects

Based on the lessons learned during the Ecuadorian handpump project and on handpump projects in other countries, the following brief recommendations are made or restated. These recommendations, if followed, will minimize or eliminate many of the problems encountered on this and other handpump projects.

5.3.1 Manufacturer Evaluation

Initial feasibility studies should be objective and, whenever possible, utilize a weighted point system so that the results can be presented numerically. When point systems are not practical, company rankings should be used and the ranking system explained in detail.

5.3.2 Management Assistance

Production management assistance should be provided to the manufacturer during the earliest stages of the project. In the past, production management assistance was given only after serious problems had developed in that area. Production management assistance would include such areas as inventory control, cost control, production scheduling, performance measurement, quality control, methods improvements, maintenance scheduling, and the establishment of standards.

5.3.3 Alternate Materials

A program should be initiated by AID to investigate other materials and components for AID handpumps. Most of the manufacturing problems stem from poor iron casting quality and associated problems in machining. A substitute for hardened pins and bushings should also be sought. Proper steel for hardening is expensive and difficult to find in developing nations. In addition, very few manufacturing operations have proper heat treating facilities.

5.3.4 Production Orders

The initial order for handpumps from a company should not exceed 100 pumps. Only after a company has demonstrated the ability to mass produce handpumps with good interchangeability of parts should production orders be placed. Even then, with the changing economic conditions in many developing nations, production orders should not exceed 500 pumps unless equitable price escalation clauses are included as part of the contract.

5.3.5 Purchase Components

Commercially available pump components should be used when economically feasible. For example, it may be desirable to utilize commercially available foot valves if the price is competitive with a locally manufactured foot valve and if the source of supply is reliable.

5.3.6 Job Aid Utilization

Job aids for manufacturing processes and handpump installation and maintenance which were developed for the Ecuador handpump project should be utilized extensively at the onset of all AID handpump projects.

5.3.7 Manufacturing Tooling

Manufacturing tooling which consists of jigs, fixtures, and production gauges should be provided at the onset of all AID handpump manufacturing projects.

APPENDIX A

FEASIBILITY OF LOCALLY MANUFACTURING AID HAND-OPERATED WATER PUMPS AND ROBO DEVICES IN ECUADOR

Prepared by

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The United States Agency for International Development
Washington, D.C.

Contract No. AID/ta-C-1354

International Programs Division
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY
August 1980

Summary

The purpose of this report is to present findings of a three-man team assigned to determine the feasibility of locally manufacturing the AID hand-operated water pump, the Roboscreen (a plastic well screen/filter), the Robovalve (a plastic water faucet) and the Robometer (a user-activated water meter) in Ecuador.

While available data varies from source to source in exploring the need for water supply programs in Ecuador, it is quickly recognized that much should be done to improve conditions for Ecuadorian citizens, especially those in the rural areas, in providing safer, more convenient water. The leading causes of death (though only ½ of all deaths are medically certified) are related to underdevelopment and poor environmental conditions and are often preventable: diarrheal diseases, respiratory illnesses, measles, nutritional deficiencies and pneumonia. Health status, of course, is conditioned by a large number of variables such as rural versus urban setting, educational levels, income and numerous other socio-economic factors, in addition to the availability of health services. But the factors of most widespread impact on the disease problems and which are largely within the health sector's responsibility bureaucratically, are environmental sanitation and water supply. Household connections to public water supplies in 1978 covered 85% of the urban population, but for the 56% of the national population living in rural areas, coverage is a dramatically low 16%. The effects of lack of access to potable (or any quality) water on not only health but overall economic development can hardly be overestimated.

Fortunately, considerable activity is underway or being planned for improving the above situation by the Government of Ecuador as well as development agencies (USAID/Ecuador, CARE and the Community Development Department of Voz Andes Hospital, for example). Because there is a great need for improved water supply in Ecuador and because there is activity underway or being planned by the Government of Ecuador and development agencies, it seems natural that local manufacture of as much as possible of the needed hardware should be stressed.

The manufacturing capabilities of foundries, machine shops and plastics manufacturers are more than sufficient for local manufacture of the AID hand pump, the Robovalve, the Roboscreen and the Robometer. The lowest estimated cost, during this study, for manufacturing the AID hand pump by an Ecuadorian foundry and machine shop was 4,000 sucres ($150 U.S.) a rather high cost when compared to the cost of manufacture in Indonesia ($60 U.S.) and Sri Lanka ($75 U.S.); however, there are other foundries and machine shops not visited that are located in remote areas in Ecuador which may have adequate facilities and lower prices (because of lower wage rates and overhead). The Robovalve cost, estimated at $.84 (U.S.) and $1.32 (U.S.), also appears somewhat high; but, when considering its possibilities for years of maintenance-free operation, it can be very cost effective (locally available metal faucets in Ecuador cost between four and five U.S. dollars in the retail market).

Cost estimates were not obtained for the Roboscreen because the PVC pipe manufacturer interviewed (CORNELSA) could not provide the dies for such a product (the dies could be made in another country and then imported into Ecuador, but the cost for such an operation is unclear). Nevertheless, the cost for the Roboscreen, excluding dies, when used either as a well screen or as a filter for hand pumps should be less than $2 (U.S.) per linear foot (as compared to $40-$50 U.S. per linear foot for some commercially-available well screen) and the Roboscreen will not corrode since it is produced from plastic.

Cost estimates also were not obtained for the Robometer because of the inavailability of a proper prototype. However, it is felt that this device could be manufactured in Ecuador for less than $50 (U.S.).

Based on the above, it appears that a pilot program involving the local manufacture of 100 AID hand pumps, 2,000 Robovalves and 1,000 feet of the Roboscreen in Ecuador would be very worthwhile. Because of a lack of a fully developed prototype of the Robometer, it is recommended herein that four or five be made in the United States and field tested in Ecuador for social acceptability as well as technical feasibility. As the manufacturing process is carried out, the finished products should then be incorporated into water supply programs either currently underway or planned for the future. With regard to the AID hand pump there are several programs that would be particularly appropriate for its use:

WASH

MEMORANDUM

TO: Victor W.R. Wehman, Jr., P.E., R.S.
WASH Project Manager

FROM: David Donaldson
Associate Director

SUBJECT: Hydropneumatic Pump and Robo Valves

DATE: 17 May 1984

From the attached letter you can see that the hydropneumatic pump has been dismantled and stored along with the remaining Robo valves.

Please advise WASH as to what your office would like to be the disposition of these materials for the short term (immediate to six months) and for the long term (after six months).

We will await your reply prior to advising the University of Maryland.

DD:da

cc: Phil Potts/GIT

1. Center for Rehabilitation of Manabi hand pump program

2. Salcedo Integrated Rural Development Project

3. Quimiag-Penipe Integrated Rural Development Project

4. USAID/Ecuador and IEOS capability development program which includes design testing and evaluation of potable water and excreta disposal systems

5. Voz Andes Hospital Community Development Program

6. CARE OPG in Chimborazo Province

In addition to the above, an attractive and promising alternative is to get the Peace Corps in Ecuador involved in rural water supply programs through the use of the AID hand pump and Robo devices. While the Peace Corps in Ecuador is not presently involved in water supply programs, there is at least one in-country volunteer with a bachelor's degree in civil engineering and a master's degree in sanitary engineering who could easily plan and implement programs involving the AID hand pump and Robo devices.

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

August 3, 1982

Mr. Fred Rosensweig
Water and Sanitation for Health Project
1611 North Kent Street, Room 1002
Arlington, VA 22209

Dear Fred:

Enclosed for your files are reports covering a May visit by Mr. Justin Whipple and myself to Ecuador (OTD No. 82) to evaluate foundries/machine shops interested in manufacturing the AID hand pump. You may remember from past correspondence that a foundry not inspected during the May trip was inspected in late June by Mr. Ben James and actually chosen for manufacture of the pump (a report by Ben will be forwarded to you shortly).

Enclosed also is a copy of the original bid request that was published in an Ecuadorian newspaper, <u>El Comercio</u>, April 2, 1982.

Yours truly,

Phil Potts

Phillip W. Potts
Technology Applications Laboratory

PWP/lbh

Enclosures

Ing. Whipple

Dr. Kenneth Farr
Chief Health Officer
US AID Mission to Ecuador
c/o American Embassy
Quito, Ecuador

SD/STI/1766 1982.05.24

Dear Dr. Farr:

During the week of May 10, investigations were conducted by Georgia Tech, ICAITI, IEOS and AID personnel in Quito and Guayaquil for the purpose of effecting a comparative technical qualifications analysis of the potential pump manufacturers who responded to the IEOS request for quotation. These included the following:

1. METALURGICA ECUATORIANA, Cia. Ltda; Quito

2. SIDERURGICA GUAYAQUIL; Guayaquil (quotation submitted by Ing. Dajo Velez)

3. FERROALEACION, S.A.; Guayaquil (two quotations submitted by Ings. Bolívar Calle Hidalgo and Rodolfo González A.)

4. Ing. Nelson Icaza; Guayaquil

Although IEOS personnel made every effort to contact Ing. Nelson Icaza, he could not be located.

All physical installations pertinent to the project of the other three potential manufacturers were visited, and a comparative evaluation of the technical qualifications of these firms has been made. Descriptive information covering the visits, and details of the evaluation will be presented in a report to be submitted at a later date.

. . . .

For your information, the evaluation has clearly shown METALURGICA ECUATORIANA to be far superior to the other two alternatives as far as technical and physical capacity for pump manufacture is concerned, and this firm is considered fully capable of carrying out the desired production program. This conclusion, of course, is based entirely upon technical considerations; the price quoted, the firm's financial situation and other non-technical aspects have not been considered.

FERROALEACION, S.A., in addition to other problems, tends to specialize in aluminum products, and at present does not have adequate capacity for gray iron casting. This alternative definitely should not be recommended.

Although SIDERURGICA GUAYAQUIL has a better foundry situation than FERROALEACION, S.A., they do not have adequate machining facilities, and their present plans for subcontracting some machining operations to a local custom job shop would have to be improved and certain guarantees established before this alternative could even be considered. At best, this would be a high risk operation, and would represent greater technical assistance costs.

Two other Quito firms that did not participate in the bid (HANSA SIDERURGICA and FUNDICIONES Y MAQUINAS FUNYMAQ) were also visited. Both firms expressed interest in manufacturing the 1 000 pumps and plan to submit quotations to IEOS next week. HANSA, however, can only offer cast steel parts instead of the specified cast iron components, and this will not be acceptable.

FUNYMAQ has a better foundry machine shop facility than either of the Guayaquil firms that were evaluated. FUNYMAQ presently has some problems due to a lack of physical space, and could only carry out the pump production program by reducing its present production of traditional cast iron products. This firm should be rated below METALURGICA ECUATORIANA as far as technical qualifications are concerned, but could be considered as an alternative if negotiations fail with METALURGICA ECUATORIANA.

Sincerely yours,

Justin H. Whipple
ICAITI

JHW/cch

cc: SD/STI
Archivo

Phillip W. Potts
Georgia Institute of Technology
May 14, 1982

EVALUATION OF FOUNDRY-MACHINE SHOP FACILITIES FOR THE MANUFACTURE OF 1 000 AID HANDPUMPS IN ECUADOR

I. General

The following firms or individuals responded to the request for quotation published by IEOS in April, 1982:

1. Metalurgica Ecuatoriana Cía, Ltda.
2. Ingeniero Dejo Velez.
3. Ingeniero Bolívar Calle Hidalgo and Ingeniero Rudolfo Gonzalez (1).
4. Ingeniero Nelson Icaza.

The production facilities of the first three of the above were visited during the week of May 10. Although IEOS made every effort to contact the 4th Bidder, he could not be located.

II. Description of the installations

The pertinent characteristics of the three potential manufacturers are the following:

1. Metalurgica Ecuatoriana Cía. Ltda.

A. General considerations

Metalurgica Ecuatoriana is a relatively large foundry-machine shop complex located in South Quito. They presently produce a line of woodworking machine tools, and other cast products including pipe accessories, grates, manhole covers and industrial parts.

The owner, Ing. Figueroa Gomez and his son manage the operation with the assistance of a metallurgical engineer who controls the foundry process.

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(1) Although Engineers Calle and Gonzalez submitted individual quotations, they informed that they are now partners and should be considered as only one possible manufacturer.

B. Foundry Department

The foundry has two cupola furnaces, each with 2 000 kg per hour capacity. They normally pour two days each week, alternating furnaces. In recent weeks they have been producing about 16 000 kg of gray iron castings per week.

The foundry also has crucible furnaces adequate for bronze casting.

The area available for preparing sand molds is quite large. Some wooden mold frames are used, but most molds have more modern metal frames. Jolt-squeeze type molding machines are available for mechanical tamping of the sand molds.

Local sand and bentonite are used for molds. Raw materials for the castings include local scrap iron and imported pig iron, coke and additives. Ing. Figueroa stated that he has no supply problems with any of these materials.

Parts in stock previously cast by the foundry were inspected and the quality appears to be fairly good. However, some pieces with porosity defects were observed.

C. Pattern shop

Metalurgica Ecuatoriana has a well-equipped pattern shop with all necessary wood-working machine tools. They employ seven pattern makers. Some appear quite young and are probably Apprentices.

They have a crucible for casting aluminum and are accustomed to fabricating aluminum patterns for repetitive runs.

Patterns in stock were of satisfactory quality.

D. Laboratories

Metalurgica Ecuatoriana has a small laboratory equipped for testing molding sand mixes as well as for control of the metallurgical composition of the melt. ASTM standards are in use.

E. Machine shop

The machine shop is quite well equipped with the following types of machine tools available:

7 Lathes
4 Milling machines
5 Shapers
1 Planer
2 Radial Drilling Machines
1 Pedestal Drill Press
1 Bench Drill Press

According to Ing. Figueroa, many of the machines currently are underutilized, and ample capacity is available for machining pump components.

Ing. Figueroa also stated that, as a result of their experience in manufacturing woodworking machinery, they are accustomed to using jigs and fixtures in their machining operations to guarantee part interchangeability.

F. Heat treatment

Metalurgica Ecuatoriana plans to heat treat the pump pins and bushings in their own plant. The equipment available for this operation is a small laboratory-size electric oven. They have a hardness tester to verify compliance with hardness specifications.

G. Assembly, painting and testing

Sufficient space appears to be available for the assembly, painting and testing operations of the pump manufacturing process.

2. Ing. Dejo Velez
Guayaquil, Ecuador

A. General considerations

Ing. Dejo explained that he submitted his bid in collaboration with Ing. René Ramírez, owner and sole manager of the foundry Siderurgica Guayaquil, who will be responsible for casting of the pump parts and a fraction of the machinery operations. Since his machine shop is very small, some of the machining will be subcontracted to a local machine shop (TMI).

Ing. Dejo owns a small metal stamping plant also located in Guayaquil, and will provide space for the pump assembly, painting and testing operations.

B. Foundry

Siderúrgica Guayaquil has one cupola furnace of 2 000 kg/hour capacity, (exactly 50% of the capacity of Metalurgica Ecuatoriana), and normally pours metal twice a week. They also have crucibles for bronze and aluminum casting.

The mold area is small and rather cluttered. Wooden mold frames are used and molds are hand-tamped.

Ing. Ramírez indicated that he has no supply problems with molding sand, coke, scrap iron or other materials.

Parts in stock previously cast by Siderurgica Guayaquil were inspected and quality appears good. They normally produce grates, manhole covers, pipe accessories and machine parts.

C. Pattern shop

Siderurgica Guayaquil has a small pattern shop with a wood lathe and hand tools available. They employ one Master patternmaker. Wooden patterns in stock are of acceptable quality. They also fabricate aluminum patterns for repetitive runs.

D. Laboratories

Siderurgica Guayaquil does not have a quality central laboratory. They do own a microscope and an impact-type hardness tester.

E. Machine shop

The machine tools located in Siderurgica Guayaquil include:

2 Lathes
1 Drill press
1 Cut-off saw
1 Small hydraulic press
1 Eccentric press

Since the above equipment obviously is insufficient, they plan to subcontract some machining operations to the firm "Taller de Mantenimiento Industrial, TMI".

TMI was visited and the existence of the following equipment verified:

4 Lathes
1 Small milling machine
1 Shaper
1 Drill press
1 Surface grinder

The Chief mechanic informed that TMI is familiar with the use of jigs and fixtures to guarantee part interchangeability. He also informed that they are very busy at the present time, working an average of 12 hours per day.

F. Heat treatment

Ing. Dejo plans to purchase alloy steel for the pump bushings and pins from the local firm "Distribuidora Sutein C.A.", located in Guayaquil. This firm offers a heat treatmet service, and can harden the pins and bushings under a sub-contract.

SUTEIN was visited, and the existence of an adequate heat treatment service was verified.

G. Assembly, painting and testing

Siderúrgica Guayaquil obviously does not have adequate space available for these operations. Ing. Dejo, however, can provide space in his metal stamping plant also located in Guayaquil.

3. Ingenieros Calle and Gonzalez

A. General considerations

Ing. Bolivar Calle is the owner of the foundry FERROALEACION, S.A. and would be responsible for casting the pump parts, and would provide space for assembly, painting and testing operations.

Since, their machine shop is small, most of the machining operations would be subcontracted to a local firm "Taller Ramos", located in Guayaquil. Ing. Gonzalez informed that Ing. Calle is also part owner of Taller Ramos.

B. Foundry

FERROALEACION, S.A. has two crucibles (250 kg each) which can be used for aluminum, bronze or iron casting (1). They normally pour three of four times each week, producing about 500 kg each day. The firm also has an injection casting machine for mass producing aluminum parts in permanent molds. They appear to specialize in aluminum casting and suggested that fabrication of an aluminum pump be considered.

(1) Diesel-air process-not coke fired

The molding area is fairly large and concrete-surfaced. Only aluminum parts were available for inspection. The Plant Foreman indicated no material supply problems.

C. Pattern shop

FERROALEACION S.A. has a small, well-equipped pattern shop and employs 1 to 3 patternmakers. Patterns in stock were of acceptable quality.

D. Laboratories

FERROALEACION, S.A. does not have a quality control laboratory.

E. Machine shop

The FERROALEACION, S.A. machine tools include two lathes, one drill press, and three small hydraulic presses.

Taller Ramos has the following equipment:

- 5 Lathes
- 2 Drill presses
- 1 Cut-off saw
- 2 Small milling machines

The Shop Supervisor at Taller Ramos claims to be familiar with the use of jigs and fixtures for part interchangeability purposes.

F. Heat treatment

Ing. Calle plans to use the same SUTEIN service as described in the previous section.

G. Assembly, painting and testing

Some space is available for these operations at FERROALEACION, S.A. However, as an alternative, they may use a small warehouse located at the rear of Taller Ramos.

III. Comparative evaluation

1. Foundry capacity

The lot of 1 000 pumps represents a total weight of gray iron castings of about 42 000 kg.

Metalurgica Ecuatoriana has the greater capacity of the three bidders, and normally produces 16 000 kg per week or, approximately 800 000 kg/year. The pump production, therefore, would only represent a little over 5 % of their present production capability, and should be quite easily absorbed into their production schedule.

Siderurgica Guayaquil has half the capacity of Metalurgica Ecuatoriana, and the pump production should represent, therefore, 10-12 % of their normal production capacity. This still appears to be an acceptable level, and the foundry should be able to compensate for this increase in production.

FERROALEACION, S.A., on the other hand, has only two low capacity crucibles available, capable of producing about 1 000 kg/day. At their present rate of production, the lot of 1 000 pumps theoretically could represent between 30 to 40 % of their production capacity. Since, according to the Plant Manager, they presently use the crucibles three days per week for aluminum casting, the percentage shown could be a real problem.

Based upon the above, and considering possible foundry rankings on a scale of 0 to 10, ratings for the three foundries, as far as capacity is concerned, are estimated as follows:

Metalurgica Ecuatoriana	9
Siderurgica Guayaquil	6
FERROALEACION, S.A.	0

2. Pattern making

All three foundries have their own pattern shops, and all have made acceptable quality patterns in the past. Metalurgica Ecuatoriana has more equipment and personnel; Siderurgica Guayaquil has the least. Estimated ratings are as follows:

Metalurgica Ecuatoriana	9
Siderurgica Guayaquil	6
FERROALEACION, S.A.	8

3. Quality control

Only Metalurgica Ecuatoriana has a Quality Control Laboratory and, therefore, must be ranked above the other two foundries. However, as far as porosity is concerned, pieces cast by Metalurgica Ecuatoriana do not appear to be much different from those produced by Siderurgica Guayaquil. It should be remembered that porosity is probably due to operational deficiencies outside of laboratory control, such as:

- Inadequate venting of the sand mold, thereby permitting air entrapment to occur

- Excessive cooling of the metal due to workers taking too much time to transport the molten metal to the mold

Estimated ratings are:

Metalurgica Ecuatoriana	4
Siderurgica Guayaquil	0
FERROALEACION, S.A.	0

4. Machining capability

Only Metalurgica Ecuatoriana has an "in-house" machine shop adequately equipped for all pump machining operations. The other foundries must subcontract at least some of the machining to local shops engaged in custom work.

Rating:

Metalurgica Ecuatoriana	9
Siderurgica Guayaquil	3
FERROALEACION, S.A.	3

5. Heat treatment capability

Both Guayaquil firms plan to use the heat treatment services provided by Distribuidora SUTEIN for hardening the pins and bushings, and this appears to be a very acceptable solution to the heat treatment problem.

Metalurgica Ecuatoriana plans to use a small electric oven in its possession for this operation, and will only be able to process small batches. The 1 000 pump lot includes about 12 000 pins and bushings, and, considering that the same oven must be used for both hardening and tempering operations, it appears that this could be a potential production bottleneck.

Rating:

Metalurgica Ecuatoriana	3 (1)
Siderurgica Guayaquil	9
FERROALEACION, S.A.	9

(1) It was verified by telephone that Distribuidora SUTEIN offers the same heat treatment service in Quito as in Guayaquil. If Metalurgica Ecuatoriana were selected for pump manufacture, it is recommended that they be strongly encouraged to utilize the SUTEIN service instead of their own facility.

6. Availability of space for assembly, painting and testing operations

All three foundries have a solution to the space problem. Since Metalurgica Ecuatoriana has the only adequate "in-house" solution, it must be rated somewhat above the other two alternatives.

Rating:

Metalurgica Ecuatoriana	6
Siderurgica Guayaquil	4
FERROALEACION, S.A.	4

IV. Evaluation Summary

The ratings shown in the previous section are summarized in the following table:

Aspect	Metalurgica Ecuatoriana	Siderurgica Guayaquil	FERROALEACION S.A.
Foundry capacity	9	6	0
Pattern making	9	6	8
Quality control	4	0	0
Machining capability	9	3	3
Heat treatment	3	9	9
Space availability	6	4	4
Total	40	28	24

As can be seen, Metalurgica Ecuatoriana is far superior to the other two alternatives as far as technical and physical capacity for pump manufacture is concerned. The inadequate capacity of the FERROALEACION, S.A. alternative is considered sufficiently serious so that this firm definitely should not be recommended.

V. Other foundries

Two other Quito firms that did not participate in the bid (HANSA Siderurgica and Fundiciones y Máquinas FUNYMAQ) were also visited. Both firms expressed interest in manufacturing the 1 000 pumps and plan to submit bids to IEOS.

FUNYMAQ has a better foundry-machine shop facility than either of the Guayaquil firms that were evaluated. This foundry would have to be rated below Metalurgica Ecuatoriana as far as technical qualifications are concerned, but could be considered as an alternative if negotiations fail with Metalurgica Ecuatoriana.

FUNYMAQ presently has a severe physical space problem, and probably could only carry out the pump production program by reducing its present production of traditional cast iron products. With this type of situation, they might insist upon a high price.

HANSA Siderurgica appears to have the capacity and technical know-off for pump manufacture. They only have two lathes in their machine shop, however, and this could be a potential production bottleneck. The principal problem is that HANSA does not produce cast iron and can only offer cast steel pump components. Steel has better physical properties than cast iron, but is not as resistant to corrosion; also, a cast steel AID pump has never been field tested. Assuming all other factors to be equal, the substitution of a non-field tested material would not be considered acceptable. If, however, the price quoted is very attractive, this policy could be reviewed.

Phillip W. Potts
Georgia Institute of Technology

Justin H. Whipple
ICAITI

El Comercio 2 de abril 82

MINISTERIO DE SALUD PUBLICA

IEOS

INSTITUTO ECUATORIANO DE OBRAS SANITARIAS

CONVOCATORIA PARA CONCURSO INTERNO DE OFERTAS

El IEOS convoca a concurso de ofertas para la fabricación de 1.000 BOMBAS MANUALES para le extracción de agua de pozos someros en zonas rurales.

El fabricante deberá tener un taller de fundición con capacidad disponible adecuada para la producción de 100 bombas por mes (aproximadamente 9.000 libras mensuales de piezas fundidas).

A todas las empresas interesadas en participar en el presente concurso, se les proporcionará un juego de los planos preliminares que les servirá como base para las estimaciones de costos y plazos de entrega. Además podrán observar en el Instituto una bomba modelo completa.

Se proporcionará asistencia técnica al fabricante en cada etapa de la producción de las primeras 25 bombas.

Las empresas interesadas podrán retirar los planos preliminares y formulario de oferta, previo al pago de s/. 500.00 no reembolsables, a partir del día lunes 5 de abril de 1982, de las oficinas de la Dirección Ejecutiva del Instituto Ecuatoriano de Obras Sanitarias (IEOS) situada en el primer piso del edificio N° 684 se la calle Toledo, intersección Lérida, de la ciudad de Quito.

Las ofertas se presentarán hasta el día lunes 3 de mayo de 1982 a las 10h00, en las oficinas de la Dirección Ejecutiva del IEOS.

Las ofertas que se presenten después de las 15h00 del día 3 de mayo del presente año en que se cerrará el concurso, no podrán ser consideradas, lo mismo que aquellas que no fueren presentadas en las oficinas de la Dirección Ejecutiva del IEOS o que hayan sido franqueadas por correo.

Conviene hacer conocer a los interesados que la demanda de bombas manuales es permanente y por tanto la fábrica tendrá mercado futuro para su producto.

La adjudicación se hará después de verificar la capacidad de la Empresa ganadora.

Dr. Francisco Huerta Montalvo,
MINISTRO DE SALUD PUBLICA.
PRESIDENTE JUNTA DIRECTIVA IEOS.

Ing. Carlos Ordóñez Beltrán,
DIRECTOR EJECUTIVO DEL IEOS.

A-2957-014

APPENDIX C

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

August 20, 1982

Mr. Fred Rosensweig
Water and Sanitation for Health Project
1611 North Kent Street, Room 1002
Arlington, VA 22209

Dear Fred:

Enclosed is a copy of Ben James' trip report covering June 28-July 2, 1982. Also enclosed are test results of iron and steel castings brought back to Atlanta by Ben. The tests are representative of iron and steel castings, and they, basically, support findings of Ben's trip.

Please advise if you have any questions. If not, you might want to send a copy of the trip report and the test results to Ken Farr and Herb Caudill.

Yours truly,

Phil Potts

Phillip W. Potts
Technology Applications Laboratory

PWP/lbh

Enclosures

OTD No. 82
Project A-2957-015

BEN E. JAMES, JR.
ECUADOR TRIP REPORT
JUNE 28 - JULY 2, 1982

The purpose of this third of 12 authorized trips under Order of Technical Direction (OTD) No. 82 was to further investigate the AID hand pump manufacturing capabilities of foundries/machine shops in Ecuador.

MONDAY, June 28

I left Atlanta about midnight Sunday and flew to Miami where I caught an Ecuatoriana flight to Quito with a stop in Guayaquil. I arrived at the Quito airport about 7:30 in the morning, Quito time, processed through customs and took a taxi to the USAID Mission office. Herb Caudill and I then talked briefly about OTD 82 and the schedule he had prepared for proposed foundry inspections.

We were to visit the Hansa Steel foundry and Metalurgica Ecuatoriana today. Tuesday we will go to Ambato which is about three hours south of Quito to visit the Tirado Brothers foundry. Wednesday we are scheduled to take metallurgical samples to a testing lab. Thursday we will have a conference call with Vic Wehman and Phil Potts at 9:00 in the morning, Quito time. Friday morning I will return to the United States.

After we got squared away with the proposed schedule, I gave Herb the foot valves for Jon Seval (Voz Andes Hospital) and also the pressure guage for Arthur Bordreaux (Peace Corps) that I brought down with me.

After lunch I met with Herb and Jay Anderson (USAID/Ecuador). Later, Herb and I went to the Hansa foundry, producer of steel castings.

This particular operation seems to be very well run and has some nice equipment. However, they are primarily set up to produce forgings such as anvils, shovels, machetes, and other small agricultural tools. They have an arc-type electric furnance which produces a fairly high quality, high strength maganese steel, primarily used for the tooling for their forging dies. They also produce some high carbon steel castings which are later forged into agricultural implements.

The foundry operation is not a high production foundry but rather a small job shop foundry. The space on the foundry floor is somewhat limited. I didn't see much of the traditional mold-making equipment such as a jolt-squeeze machine, or core-making equipment. They had a small laboratory which was primarily a wet chemistry lab. A hardness tester was available in this lab. A device that supposedly provides an automatic readout on the carbon content of the steel in the furnace was also in use. From what I was able to gather, most of the analytical work is done by wet chemistry as opposed to spectrography.

I saw a nice tool room for making the tooling that they use, such as their forging dies and their cut-off dies, but I didn't see any evidence of production tooling such as heavy lathes, drills, or mills. In further discussions with the engineer in this factory (who also seems to be the plant manager) it was indicated that these tool room lathes and drills would be used for the production of hand pumps.

I asked him about the cost of his castings and by the time we got through converting into dollars, the delivered cost of rough castings to be machined totalled about 60¢ a pound. This compares with about 50¢ a pound in Honduras.

I also spoke to the engineer/manager about the possibility of making cast steel which would be more corrosion-resistant. He indicated that the addition of a little copper would accomplish this--an assertion that merits further inquiry.

I obtained a sample of some cast steel that is supposed to be in the 20 to 30 point range of carbon. I will take that back to Atlanta for analysis.

I think this company has the ability to manufacture AID hand pumps but it would always be very much of a sideline item. If they were given an order for 1000 pumps with a specific delivery date, I'm afraid that if anything went wrong with the regular forging production, the pumps would have to take second position with respect to the standard product which is agricultural implements. With this foundry we could expect the surface quality of the steel casting to not be as high as the surface quality of the cast iron. A major concern is the possibility of increased rusting of the steel casting as opposed to the cast iron. Another concern about this firm is their ability to machine the parts once they have been cast.

Herb and I learned that the AID hand pump has been quoted here at somewhere in the cost range of about 7500 to 8000 sucres, which would convert to about 240-250 U.S. dollars. This compares very closely with the projected cost of the AID hand pump in Honduras.

I went back to the hotel after we visited Hansa as there was not enough time to visit Metalurgica Ecuatoriana. We are planning on leaving for Ambato at 7:15 in the morning to see Tirado Brothers.

TUESDAY, June 29

Very early in the morning Herb Caudill and another man from IEOS came by to pick me up to go to Ambato, a three hour drive. Ambato is a relatively large city with hotels asnd all of the amenities necessary for us to place personnel there for pump manufacturing activities.

The foundry which is run by three brothers is relatively simple. The cupola looks good and the staff obviously know how to make good cast iron. Some of the foundry manufacturing methods are rather primitive. They use either wood patterns or aluminum patterns hand-rammed. They do not have a jolt-squeeze machine nor use match-plate type patterns. The quality of the sand used in this foundry leaves a little bit to be desired and cores are produced by the sodium silicate/CO_2 method. This does not make a very strong core and it could cause some quality problems in the casting. Their current production consists of manhole covers, grates for sewers, tannery equipment, large bull-ring type gears, brake drums for trucks, etc.

What this firm lacks in the foundry is more than made up for in the machine shop. They have an extremely nice machine shop with at least eight engine lathes, 2 large horizontal mills, small vertical mills, drill presses, a large horizontal boring machine and machining center, 3 or 4 shapers, and a small, relatively short, bed planer.

The cost of castings delivered to the factory by this firm would be equivalent to about 40¢ a pound. Their labor cost with the multiplier put in for all the fringe benefits and vacations for a simple skilled machinist would run somewhere in the neighborhood of \$1.25 to \$1.50 per hour. I brought back a sample of their cast iron for analysis.

Generally, I was impressed with the overall operation. The only reservation that I have at this time about their ability to mass produce the castings is due to the lack of a jolt-squeeze machine and good core-making equipment.

Very late in the afternoon we left Ambato and drove back to Quito. Tomorrow we plan on visiting and evaluating the final foundry at Quito which is Metalurgica Ecuatoriana.

WEDNESDAY, June 30

I met with Herb Caudill at the USAID Mission and we discussed some of the activities of yesterday when we visited the foundry in Ambato. We also tried to find the reports by Justin Whipple on the visits that he and Phil prepared in May but the only thing we could locate was a brief letter.

We had some trouble getting a car from the motor pool for our third factory visit (Metalurgica Ecuatoriana). This seems to be chronic problem here at the mission. I came back up to Herb's office to wait for the car and tried to place a call to the United States to Terry Moy. I wanted to find out the status of the 25 pumps that were supposed to be shipped from Honduras to Ecuador. We were unable to get through to Terry and went back downstairs to the motor pool and finally obtained a car.

We drove out to Metalurgica Ecuatoriana and met with the two principals. I believe they were the owners as well as the managers. This foundry and machine shop is very modern. They have two cupolas with plenty of capacity, and very modern molding equipment. However, they also use the same sodium silicate/CO_2 core process as the Tirado Brothers employ in Ambato. Even with this method of making cores, they seem to get a very good product.

We also looked at the pattern shop which is quite adequate. They have the facilities for producing castings utilizing permanent patterns of aluminum match-plates and a jolt-squeeze machine. Also, the sand conditioning equipment was very adequate.

The machine shop was more than adequate with several lathes, milling machines, boring machines, and drill presses. Their layout was quite good.

This company produces their own line of woodworking machinery. This activity requires about 30% of their current foundry capacity and about 60% of the current capacity in the machine shop. However, of the total production capacity, they are now using only 7% of their capacity in the foundry and only about 52% of capacity in the machine shop. There should be no problem in producing AID hand pumps in relatively large quantities.

The labor cost for a skilled machinist in this plant including all benefits, vacations, etc., runs about 16000 sucres per month or about $1.60 equivalent per hour. The cost of the castings in this factory was given to us at roughly 50 sucres per pound (83¢ a pound) for iron and about 100 sucres per pound ($1.72 a pound) for brass.

I showed the pictures of the jigs and fixtures which were made in Honduras to the company management and they were extremely eager to learn more about them. They borrowed the pictures long enough to Xerox copies.

Since this company has every intention of manufacturing AID hand pumps whether USAID orders them or not, they will probably make their own jigs and fixtures. They have already produced four AID pumps on their own from patterns which they also made. Unfortunately, the fulcrum had an incorrect dimension and the pumps can't provide a full stroke. The fulcrums will need to be reworked.

Without a doubt, this company has the capability to manufacture the AID pump in relatively large numbers and of acceptable quality.

After visiting this company, we came back to the USAID office and later I returned to the hotel. After lunch I went back to the USAID office and we were able to get our call through to the United States. Unfortunately, Terry Moy was not in the office and Phil did not know the status of the pumps being shipped from Honduras. However, tomorrow we are going to have a conference call at 10:00 Ecuadorian time so Phil is going to have Terry call me at 9:00 Ecuadorian time to give us an update on the pumps being shipped from Honduras to Ecuador.

Herb Caudill and I then had a long discussion about the three foundry/machine shops we had visited. Conclusions reached by this particular time are given below. (1) The steel foundry should be eliminated completely from all consideration. This foundry does not have adequate machining facilities, and the foundry portion of the business is just a sideline and not one of their main concerns. (2) The Metalurgica Ecuatoriana foundry, which we visited today, already has the capability of manufacturing pumps of acceptable quality in desired quantities. (3) The Tirado Brothers in Ambato that we visited yesterday also has the potential ability, assuming the provision of technical assistance, to manufacture pumps of acceptable quality in required quantities.

Since I was not asked to get involved with the price situation I didn't concern myself too much with that. However, it is something that cannot be ignored when developing recommendations. The price of the pump from Metalurgica Ecuatoriana is about $60.00 more than the price of the pump from Tirado Brothers. I feel that it might be a good idea for the contract to be placed with Tirado Brothers, even though they are about 75 miles from Quito, and provide them with technical assistance to build the capability of manufacturing pumps. In addition, a small amount of technical assistance, such as with tooling, could be provided to Metalurgica Ecuatoriana to increase their ability to manufacture a quality pump as they are already going to sell pumps to another government agency. This would give us a double capability of pump manufacturing in this country at no extra cost. There is also a strong possibility that once we have this dual capability within the country, competition between Tirado Brothers and Metalurgica Ecuatoriana will force the price of the pump down to a more realistic level.

In the evening I met again with Herb and with Jim Bell, Director of the Peace Corps Water Pump Program.

THURSDAY, July 1

I went to the office of the USAID Mission early in the morning. Terry Moy called at about 9:00 Quito time and informed me that he had been in touch with Porfirio Sanchez (ICAITI) concerning the pumps that were to be shipped from Honduras to Ecuador. I was informed that Porfirio did not really know the status and hadn't been able to get in touch with Bill Smith of

USAID/Honduras. He felt, however, that the pumps would be shipped out by next Wednesday; they seem to be held up at the airport. I apologized to Herb Caudill about the delay in getting the pump but there's really nothing more we can do right now. Herb and I discussed the activities of the past three days and my evolving recommendations.

Later, a little after 10:00 Quito time, Phil Potts and Vic Wehman reached us on a conference call. Herb, Vic Wehman, Phil and I discussed my findings here in Ecuador. Basically, I recommended that the Hansa cast steel foundry be dropped from consideration and that either of the other two foundries, Metalurgica Ecuatoriana or Tirado Brothers, would be acceptable. Since the Metalurgica Ecuatoriana was already going to build the pumps, it would probably be a good idea to place the order and provide technical assistance to Tirado Brothers in Ambato and also to provide a minimum amount of technical assistance to Metalurgica Ecuatoriana. Ultimately, then, we could have two sources of pumps in Ecuador.

I also recommended that we buy two sets of fixtures from Honduras and ship them down here so that we could start production as soon as possible. This seemed agreeable to Vic and Herb. Herb indicated that he is going to try to get the contract signed with Tirado Brothers by next Friday. After that is signed, he will notify Georgia Tech and we will be able to send Alan Pashkevich here to begin the process of pump manufacturing. Meanwhile, I'm going to start the process for getting two sets of fixtures built by Senor Mata at Funymaq at San Pedro Sula in Honduras.

Later, Herb and I discussed the general procedure and he appeared very pleased with the way things have developed. I think we will be in very good shape with the sources of pumps in Ecuador. It's not going to be an easy task, initially, getting the high quality out of Tirado Brothers because we are going to have to provide a lot of technical assistance. However, it won't be any more difficult than in many of the other countries where we have done the same thing.

I left the USAID office in the afternoon and returned to the hotel to complete preparations for an early morning departure.

FRIDAY, July 2

I got up very early in the morning and after having breakfast, checked out of the hotel and took a taxi to the airport. I checked my bags, went through immigration, and sat down for a fairly long wait. I finally caught the plane to Miami. After a lay-over in Miami, I took an Eastern flight and landed in Atlanta in the early evening.

APPLIED TECHNICAL SERVICES, INCORPORATED

1990 Delk Industrial Blvd., Marietta, Ga. 30067 • (404) 952-8705

CERTIFIED TEST REPORT

REF. 83-426 DATE July 12, 1982 PAGE 1 OF 3

CHEMICAL ANALYSIS

CUSTOMER: Georgia Tech Engineering Experiment Station, Technology Applications Laboratory, Atlanta, Georgia 30332 Attn: Ben James

ORDER NO.: Verbal PART NO./NAME: A, B

MATERIAL DESIGNATION: Cast iron

SPECIAL REQUIREMENT: N/A

LAB COMMENT: Analyzed by spectrographic, atomic absorption, combustion, and wet chemical techniques.

TEST RESULTS

IDENTIFICATION	C	Mn	Si	Ni	Cr	Mo	Cu	Mg	P	S
	COMPOSITION - WEIGHT %									
ALLOY OR SPEC. REQ. (1)										
A	3.2	0.51	2.45	0.14	0.22	0.03	0.23	<0.02	0.15	0.22
B	2.9	0.72	2.20	0.16	0.24	<0.02	0.26	<0.02	0.20	0.13
			*****LAST ITEM******							

TIRADO Ref. Ecu

Bernice K Wise
Notary Public, Georgia, State At Large
My Commission Expires Mar. 22, 1983

(1)

Prepared by: Phillip Rogers P. E. Rogers

Approved by: [signature] W. H. Lewis

APPLIED TECHNICAL SERVICES, INC.

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CERTIFIED TEST REPORT

REF. 83-426 DATE July 12, 1982 PAGE 2 OF 3

CHEMICAL ANALYSIS

CUSTOMER: Georgia Tech Engineering Experiment Station, Technology Applications Laboratory, Atlanta, Georgia 30332 Attn: Ben James

ORDER NO.: Verbal PART NO./NAME: C

MATERIAL DESIGNATION: 1020 carbon steel

SPECIAL REQUIREMENT: N/A

LAB COMMENT: Analyzed by spectrographic, combustion, and wet chemical techniques.

TEST RESULTS

	COMPOSITION - WEIGHT %									
IDENTIFICATION	C	Mn	Si	Ni	Cr	Mo	P	S		
ALLOY OR SPEC. REQ. (1)	0.18 0.23	0.30 0.60	--	--	--	--	0.04 Max.	0.05 Max.		
Hansa C	0.22	0.38	<0.07	<0.02	0.07	<0.02	0.019	0.049		
				*****LAST	ITEM*****					

Notary Public, Georgia, State At Large
My Commission Expires Mar. 22, 1983

(1) Metals Handbook, Vol 1, 8th edition.

Prepared by: P. E. Rogers

Approved by: W. H. Lewis

APPLIED TECHNICAL SERVICES, INC.

APPLIED TECHNICAL SERVICES, INC. ATLANTA, GA.

INSPECTION REPORT

Ref. 83-426 Date July 12, 1982 Page 3 of 3

PURCHASE ORDER = Verbal

DATE REPORTED: 7-12-82

Georgia Tech Engineering Experiment Station
Technology Applications Laboratory
Atlanta, Georgia 30332

SHIPPER NO.: N/A

PART SUBMITTED: N/A

Attention: Ben James

MATERIAL: N/A

Inspection Procedure

MAGNETIC PARTICLE ☐
PENETRANT ☐
ULTRASONIC ☐
RADIOGRAPHIC ☐
OTHER Core Hardness ☒

SPECIFICATION: N/A

Inspection Results

PART IDENTIFICATION	QUANTITY	RESULTS	REMARKS
A	1	R_c 22.0	
B	1	R_c 22.0	
C	1	R_b 62.5	

Bernice K. Wise
Notary Public, Georgia, State at Large
My Commission Expires Mar. 22, 1983

Prepared by: Phillip Rogers P. E. Rogers

Approved by: W. H. Lewis

APPLIED TECHNICAL SERVICES, INC.

APPENDIX D

OUTLINE
AID HAND PUMP ACCEPTANCE INSPECTION TRAINING PROGRAM

Objectives - By the completion of this training the participants will be able to:

1. Inspect 2 hand pumps per hour
2. Insure that 98% of the accepted pumps will be operable in the field
3. Determine and inform the manufacturer of corretable faults with any pump components
4. Understand the difference between critical, major and minor quality characteristics in the pump components

Activities -

1. Introduction of trainers and trainees
2. USAID hand pump program background
3. Rationale for training
4. Course expectations
5. Training topics
   A. Tools used for inspection
      1. Demonstration
      2. Practice
   B. List and explain characteristics (critical, major and minor) examined for pump acceptance
      1. Dimensions
      2. General appearance
      3. Porosity
      4. Leather quality
         a. flapper valve
         b. cups
      5. Pin and bushing hardness
      6. Thread quality
      7. Cylinder
      8. Function (pump water)
   C. Dimensions (critical and major)
      1. Cap holes
      2. Body holes
      3. Fulcrum holes
      4. Handle holes
      5. Base holes
   D. General appearance
      1. Excessive mold flash
      2. Burned sand adhering to casting
      3. Rough pitted (not porous) surface
   E. Porosity
      1. Porosity defined
      2. Porosity limits defined
      3. Critical areas of pump (with regard to porosity) defined
      4. Repair or destroy

F. Leather quality
   1. Flapper valve
   2. Cups
      a. thickness
      b. flexibility
      c. dimensions
G. Pins and Bushings
   1. Hardness
      a. thickness
      b. flexibility
   2. Dimensions
      a. pin into bushing fit
      b. pin warpage
      c. length & cotter pin holes
H. Thread Quality
   1. Define acceptable and rejectable thread shape
   2. Define limits of "hand tight" engagement test
I. Cylinder
   1. Thread quality of cylinder and end caps
   2. Cylinder bore condition
   3. Poppet valve underside and plunger follower top surface
   4. Cup dimensions and quality
   5. Plunger rod thread length
   6. Assembled piston to cylinder fit
J. Functional Test
   1. Pump water
   2. Flapper (check) valve leak down
K. Repair Options
   1. Brazing
   2. Nickel alloy welding
   3. Remachining
L. Records Keeping
   1. Pump numbering
   2. Rejection notification procedures
M. Acceptance Inspection Plan
N. In-Factory Practice

ACCEPTANCE INSPECTION PLAN

1. Randomly select sample; 20% of lot

2. Inspect the following quality characteristics

   A. Handle/fulcrum articulation for smoothness and rod end not hitting top of pump cap.

   B. General surface appearance of castings for excessive roughness (subjective measurement) excessive flash, casting distortion, etc.

   C. Thread quality and fit on stand to body and stand to base.

   D. Dimensions of holes in cap and holes in body. Assure ability to rotate cap on body 360° with good hole pattern fit.

   E. Dimensions of holes in base

   F. Porosity in critical areas.

   G. Pin and bushing hardness

   H. Cylinder
      1. Thread quality
      2. Bore quality
      3. End cap flapper valve system
      4. Poppet valve and seat quality
      5. Pump leather quality
      6. Plunger rod thread dimension and quality
      7. Piston assembly to cylinder snug fit

3. If any of the 20% sample pumps has one of the quality characteristics fail, that entire pump will be rejected and that quality characteristic inspected on every pump in the entire lot. The inspector has sole authority to determine disposition of the failed part, repair, or scrap.

4. Each pump in the lot will be numbered. All pumps in the lot to be inspected will have no paint or thread sealer or putty of any kind in evidence when inspected. After the lot has been accepted, each pump will be painted and the pump number painted or stenciled on in a contrasting color on the pump body.

Function: Acceptance Inspection Testing
Group: Inspectors of Sponsoring Agency (IEOS)

TASK	CRITERIA
1. Examine motion of handle/fulcrum assembly	A. Smooth motion, no catching on burrs, etc. B. Fulcrum to limit motion of handle so that rod end does not contact cap
2. Examine surface finish of external parts and piston assembly	A. No burned sand adhering to casting, relatively smooth surface B. Parting line flash removed C. No obvious distortion of parts
3. Examine threads in base, stand and body	A. No voids or badly broken threads in threaded area B. No putty or filler evident C. 3" pipe section and 1 1/4" drop pipe must have 4 threads showing when hand-tightened into base or body
4. Rotate cap on body to check hole spacing	A. Cap must fit in all four positions
5. Check dimensions on anchor bolt holes in base	A. Using a standard base or a template, line up base holes
6. Inspect for porosity in critical areas	A. Must meet porosity criteria of casting criteria sheet
7. Inspect pins and bushings	A. Pins and bushings must be to hardness of 40-45 and 60-65 R_C respectively B. Bushings must be press fit in cast iron part

	C. Measure dimensions and warpage on gages
	D. Cotter pins must be easily removed from pins; cotter pins not to drag on cast iron parts
8. Inspect cylinder	A. No putty, voids, sealer in threads
	B. Cylinder ID smooth and without excessive ripple
9. Inspect plunger assembly	A. No holes, voids or porosity on valve contact surface of follower or underside of poppet valve
	B. No holes or excess porosity in plunger cage; no machined sharp corners inside cage
	C. All flash removed from brass parts
	D. Leather cups not ragged, torn or stretched; ID to just fit over follower
	E. Piston fits snugly into cylinder
	F. Plunger rod threads not misthreaded and do not protrude into cage
10. Inspect foot valve	A. Valve seat has no holes or imperfections
	B. Rubber or leather on valve smooth
11. Wet test pump	A. Pump must deliver water
	B. No leaks at base/stand/body connections
	C. Foot valve must not appear to leak over 5 minute period

FUNCTION: Assemble Pump
GROUP: Factory Assembly Team

TASK	CRITERIA
1. Inspect sub-assemblies a. head assembly	A. All parts assembled in correct order
b. piston assembly	B. No cracks in press fit parts
c. foot valve assembly	C. Foot valve must not appear to leak over 5 minute period
2. Inspect Assembled Pump	A. Handle/fulcrum to have smooth motion; no catching on burrs, etc.
	B. Fulcrum to limit motion of handle so that rod end does not contact cap
3. Wet test pump	A. Pump must fill 5-gal container in 18-25 strokes
	B. No leaks at base/stand/body connections

POROSITY CRITERIA

Acceptable:

holes less than 1 mm diameter
and
greater than 1 cm from each other

Not Acceptable:

1) In critical areas holes greater than 1 mm diameter but less than 3 mm diameter
and
more than 4 holes per squre centimeter

2) In critical areas holes greater than 3 mm diameter

3) Any holes in threads

4) Any holes in valve seat

Crtical Areas:

1) areas around every bushing
2) neck of base
3) forks of handle and fulcrum
4) tapering section of handle

APPENDIX E

Chapter 3*

WORKSHOP

3.1 Workshop Goals

The overall workshop goals were for participants to:

1. Identify resources necessary for a village handpump project.
2. Conduct an assessment for project feasibility and determine next steps.
3. Identify and apply strategies for involving the community in all phases of the handpump projects.
4. Survey, evaluate, and select sites for handpumps including an assessment of the quantity and quality of water needed to warrant installing pumps.
5. Develop a project cost estimate.
6. Develop work plans and logistics necessary for project start-up.
7. Prepare selected sites for receiving handpumps.
8. Install locally available deep well pumps and disinfect the well.
9. Operate, maintain, troubleshoot, and repair handpump.
10. Design a user education strategy.
11. Develop skills for training village caretakers in appropriate maintenance and repair tasks.
12. Identify alternative strategies for solving most common non-techincal problems which develop before, during, and after handpump installation.
13. Monitor and evaluate the effectiveness of the handpump project.
14. Develop an awareness of national and regional handpump program resources.

The workshop goals represented a balance between the more technical aspects of handpump projects and the planning and educational skills needed to put the technical skills into practice. This balanced approach was particularly appropriate in this workshop as the participants would likely be involved in planning and getting communities interested in projects. Most, but not all, of the participants were also likely to become involved in the actual implementation of a handpump project. Thus, it was important to give participants a strong base in the technical skill areas while not neglecting the planning and community development and education component.

*From WASH Field Report No. 110, "A Workshop on Handpump Installation and Maintenance in Riobamba, Ecuador," Andrea Jones and Alan Pashkevich.

3.2 Participants

There were 16 participants in the workshop with the following breakdown:

- 5 Peace Corps Volunteers working as engineers for provincial offices of the Instituto Ecuatoriano de Obras Sanitarias (IEOS)
- 4 Peace Corps Volunteers working as promoters for provincial offices of IEOS
- 2 Peace Corps Volunteers assigned to provincial offices of the Ministry of Agriculture
- 5 members of the Voz de los Andes mission who were either health educators or health practicioners.

A list of the participants' names and locations is included as Appendix A.

The participants represented a diversity of experiences and education. Six of the Peace Corps Volunteers were engineers; two of the Voz de los Andes staff were nurses. All of the Voz de los Andes staff had experience and training in health education. One of the Voz de los Andes participants and one Peace Corps Volunteer had significant handpump installation and repair experience. Another participant had strong general construction skills. The design of the workshop captalized on these strengths as much as possible by having participants serve as resources to one another.

3.3 Training Staff

The staff consisted of two individuals, one an engineer knowledgeable in handpumps (technical trainer) and the other a trainer skilled in workshop design and delivery (trainer). The technical trainer had the advantage of having worked previously in Ecuador in providing technical assistance to a foundry manufacturing the AID handpump. He took lead responsibility for the apron construction and pump installation as well as the other technical sessions. The training specialist took a lead role in the community organization and education sessions as well as providing overall coordination for the workshop.

In addition to the core training staff, three water technicians from the Quechua Association assisted in the construction aspects and, as part of the Quechua Association's regular program, were responsible for follow-up user education and maintenance of the two handpump sites worked on during the course. As the installation of a handpump is, of necessity, only one step of an on-going community development project and requires follow-up maintenance and education, the presence of an institution like the Quechua Association was essential to the success of this kind of course. Before the course started and during the first week of the course, the technicians worked with the community to finish the lining of the wells. This made it possible for participants to begin their work with apron construction. At the end of the course, the technicians also worked with the community to do some finishing work on one site and to pour the apron and install the pump on the second site. Without this kind of back-up support the demands of the construction and installation activities would have been overwhelming for the trainers and the participants.

3.4 Logistics

The training site was located on the compound of the Quechua Association in Colta. It was there that the construction materials, pumps, and tools were stored and many of the technical sessions were held. The two wells were located close to one another, one kilometer away from the training site at the Quechua Association, in an area called Leonpul. Since participants were staying in hotels in Riobamba, they were transported to Colta every morning, and used the vehicles driven by La Voz de los Andes participants to go back and forth from the well sites to the training site. Classroom facilities were available at the Quechua Association, but due to the cool weather and draftiness of the rooms, classroom meetings were held in the living room of a Voz de los Andes staff member who lived on the Quechua Association compound. Logistics were complicated by the need to coordinate the arrival and transporting of tools and materials, some of which were not obtained until after the course had started. Despite the availability of pickup trucks and drivers from the IEOS office in Riobamba, more than once the schedule was held back by the temporary unavailability of transportation.

The procurement and delivery of materials and tools was a major problem encountered in the workshop. Because there was no one located in Riobamba to supervise this process, both trainers were forced to do it and thus spend time that would otherwise have been productively devoted to the workshop itself. In similar workshops in the future, a full-time logistics or site coordinator should be hired prior to the workshop to take charge of procurement, transportation and other related tasks.

3.5 Schedule

The workshop schedule is presented in Figure 1. This schedule represents what actually occurred, and does not include several sessions that were not pilot tested in this workshop. Sessions were held all day, starting at 8:30 a.m., breaking for lunch, and all through the afternoon until 5:00 or 6:00 p.m.

3.6 Methodology

The training was experiential and participatory in nature. Participants were given opportunities to practice mechanical and construction skills since six pumps were available for practice sessions on barrels, and two actual well sites were worked on. Participants had the opportunity to construct the aprons, tops, and covers for both wells and to install a deep well pump at one of the sites at a depth of 26 meters. This well also served as a model for disinfection procedures. They also had several sessions on planning various aspects of handpump projects including community involvement, estimating resources, education activities, and technical issues. The emphasis throughout was on the practical aspects of handpump projects. Specific activities

WORKSHOP ON HANDPUMP INSTALLATION AND MAINTENANCE

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Oct. 17 DAY ONE	Oct. 18 DAY TWO	Oct. 19 DAY THREE	Oct. 20 DAY FOUR	Oct. 21 DAY FIVE	Oct. 22 DAY SIX
Introduction to the handpump workshop	Determining well recharge rate; Worksite orientation	Constructing the apron (cont.)	Preparing for conducting initial village assessment for project feasibility	Analyzing the project feasibility assessment results	Developing a construction work plan; mid-point workshop evaluation and review
Implementing water supply programs with handpumps	Constructing the apron	Constructing the apron (cont.)	Conducting the the assessment for project feasibility	Field visit: lining a hand-dug well Developing a project cost estimate	Constructing the the apron
Oct. 24 DAY EIGHT	Oct. 25 DAY NINE	Oct. 26 DAY TEN	Oct. 27 DAY ELEVEN		
Installing the handpump (practice)	Installing the handpump and disinfecting the well (field work)	Maintaining and repairing the pump	Developing and implementing user education strategies		
Disinfecting the well	(cont. as above)	Training the caretakers	Evaluating the handpump project Workshop evaluation		

included construction, installation and maintenance practice, trouble shooting, field visits, small group tasks, role-playing, and full group discussions and presentations.

Two aspects of the methodology deserve particular attention. First, several methods were used to teach course content. When practicing handpump installation and maintenance, each step was demonstrated and then performed by the small groups. On the actual well project work, however, demonstration was not used. Instead, the technical trainer gave a short explanation of the various steps involved, including drawings when necessary. Next, participants volunteered to take the responsibility for various tasks, with the criteria that they receive as much experience in as many different parts of the construction process as possible. During the construction and installation processes the technical trainer observed, asked questions, and made suggestions as necessary. After each field session, a short classroom review session was held to discuss participants' problems and to share newly acquired knowledge and experience. Before the participants went out in the field again to complete a given task, they were asked to identify what remained to be done and to plan with the trainer how it would be accomplished.

Second, the workshop emphasized the project approach throughout. Participants were not taught simply what was involved in installing a handpump, but how to carry through a community handpump project. All steps of the project cycle including initial assessments, community involvement, planning, implementation, maintenance, user education, and project evaluation were covered so that the participants would see their roles in the broadest sense and not only in a limited technical way.

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
Atlanta, Georgia 30332

February 6, 1984

Ing. Lenín Ubidia, Decano
Facultad de Ingeniería Mecánica
Escuela Politécnica Nacional
Quito, Ecuador

Estimado Ingeniero Ubidia:

Queremos por la presente solicitar la asistencia técnica por parte de la Faultad de Ingeniería Mecánica a la empresa "Tirado Hermanos" de acuerdo a los siguientes antecedentes y Ambito de Trabajo:

Antecedentes:

La institucion academica "Georgia Institute of Technology" ("Georgia Tech") ha estado apoyando un proyecto de fabricación de bombas manuales en el Ecuador. Georgia Tech ha estado trabajando a traves del Instituto Ecuatoriano de Obras Sanitarias el cual contrató con la firma "Tirado Hermanos" de Ambato la fabricación de mil bombas manuales. La empresa "Tirado Hermanos" cuenta con una fundición que adolece de ciertos problemas técnicos. Con el afán de superar estos problemas, Georgia Tech desea obtener los servicios de personal idóneo de la Facultad de Ingenieria Mecanica, Escuela Politécnica Nacional, para que provea la asesoría adecuada a Tirado Hermanos para el mejoramiento de la fundición.

+ Ambito de Trabajo:

La Facultad de Ingeniería Mecánica suministrará un individuo capacitado en el area de fundiciones metalicas diez dias laborables completos de asesoría técnica en Ambato a la empresa Tirado Hermanos sobre los siguientes aspectos:

1. Determinación de la arena mas adecuada para la elaboración de moldes, incluyendo sugerencias relativo a lugar de obtención.

2. Elaboración más eficiente de noyos.

3. Tipo de ladrillo y cemento refractario incluyendo sugerencias relativas a lugares de obtención.

4. Evaluación global de la fundición, y formas de mejorar la operación total.

5. Cualquier otra inquietud de la empresa que pueda resolverse dentro de los dias laborables estipulados.

El costo total de todos los sueldos, habitaciones de hotel, viajes y otros gastos no debera exceder $1200.00 (mil doscientos dolares USA). Además, la factura final debera contener una relación detallada de todos los gastos incurridos.

Agradecemos su colaboración en este proyecto.

Sin otro particular, quedo de usted.

Atentamente,

Ing. Ben James
Technology Applications Laboratory

BEJ/lbh

cc: Mr. Phillip W. Potts
Mr. Fred Rosensweig/WASH
Mr. Herb Caudill/USAID Ecuador

3-14-84

WORK SCHEDULE

THE MECHANICAL ENGINEERING FACULTY WILL PROVIDE AN INDIVIDUAL QUALIFIED IN THE AREA OF FOUNDARY WORK FOR ~~■~~ TEN COMPLETE WORKING DAYS TO PROVIDE TECHNICAL ASSISTANCE FOR THE HERMANOS TIRADO SHOP IN ~~ABATO~~ AMBATO COVERING THE FOLLOWING ASPECTS.

(1) DETERMINING THE MOST ADEQUATE SAND FOR THE MANUFACTURE OF MOLDS, INCLUDING SUGGESTIONS ON A PLACE OF OBTAINING THE SAND.

(2) ~~MOST~~ MORE EFFICIENT MANUFACTURE OF CORES.

(3) TYPE OF BRICK AND (FIRE-RESISTING) REFRACTORY CEMENT TO BE USED AND SUGGESTIONS ON LOCATING THESE MATERIALS.

(4) OVERALL EVALUATION OF THE FOUNDARY AND WAYS TO IMPROVE THE TOTAL OPERATION.

(5) ANY OTHER PROBLEM THE ENTERPRISE MIGHT HAVE THAT CAN BE RESOLVED IN THE AVAILABLE WORKING DAYS.

THE TOTAL COST OF SALARIES, HOTEL, TRIPS AND OTHER EXPENSES SHOULD NOT EXCEED $1,200.00 USA DOLLARS. ALSO, THE FINAL EXPENSE ACCOUNT SHOULD CONTAIN A DETAILED ACCOUNT OF ALL EXPENSES MADE.

ESCUELA POLITECNICA NACIONAL
Facultad de Ingeniería Mecánica
APARTADO Nº 2759
QUITO - ECUADOR

JUN 20 RECD

Of. IM 83-493

Quito, 7 de Junio de 1983

Señor
Ben E. James Jr.
A.I.D.
Edificio Computec
Ciudad

Atención : Sr. Herb Caudill

Dando trámite a su solicitud verbal, hago saber a Ud. que los honorarios por un día de Asistencia Técnica, son de : S/10.000,oo (Diez mil sucres) más víaticos por un ingeniero.

De Ud.

Atentamente,

Ing. Lenin Ubidia
DECANO

ape/

HAVING PROCESSED YOUR VERBAL INQUIRY, ~~I~~ I LET YOU KNOW THAT THE FEES PER DAY OF TECHNICAL ASSISTANCE ARE S/. 10,000 (TEN THOUSAND SUCRES) PLUS EXPENSES PER ONE ENGINEER

NOTE: EXPENSES ARE LODGING, MEALS AND TRANSPORTATION.

Indústrial Metal Mecánica«TIRADO»Hnos. Cia. Lta.

CONSTRUCCION Y REPARACION DE MAQUINARIA AGRICOLA E INDUSTRIAL

DIRECCION OFICINA Y TALLERES: CONTROL NORTE Km.4½ Teléfonos: 824230 - 820490

AMBATO - ECUADOR

Ambato, 24 de Mayo de 1.983

Sr.
Director del I E O S
Quito.

Señor Director:

Por intermedio de la presente, nos es grato saludarlo, a la vez que nos permitimos adjuntar a ésta, un análisis de los Costos de producción, que vienen a respaldar nuestra solicitud de aumento en el precio de Venta de las Bombas de agua.

Ratificando nuestra aseveración y como es de conocimiento y sentir general de todos los ecuatorianos, la escalada de los precios de todos los bienes, los mismos que han cambiado toda estimación de Costos anteriores.

Pués basándonos en el análisis adjunto, como usted verá, nuestro margen de utilidad de un 7,26 % es demasiado exiguo; pero que, - por la cantidad contratada en unidades y por nuestro afán y buen criterio de servicio a la comunidad, estamos fijando este precio de venta de $ 12.200,oo (DOCE MIL DOSCIENTOS OO/100. SUCRES.)

Esperando vuestra conformidad a lo indicado, expresamos nuestros sentimientos de aprecio y estima a su persona, quedando ante Ud.

Muy Atte

[illegible] TIRADO U
GERENTE GENERAL

JV.ms

Industrial Metal Mecánica «TIRADO» Hnos. Cia. Lta.

CONSTRUCCION Y REPARACION DE MAQUINARIA AGRICOLA E INDUSTRIAL

DIRECCION OFICINA Y TALLERES: CONTROL NORTE Km. 4½ Teléfonos: 824230 - 820490

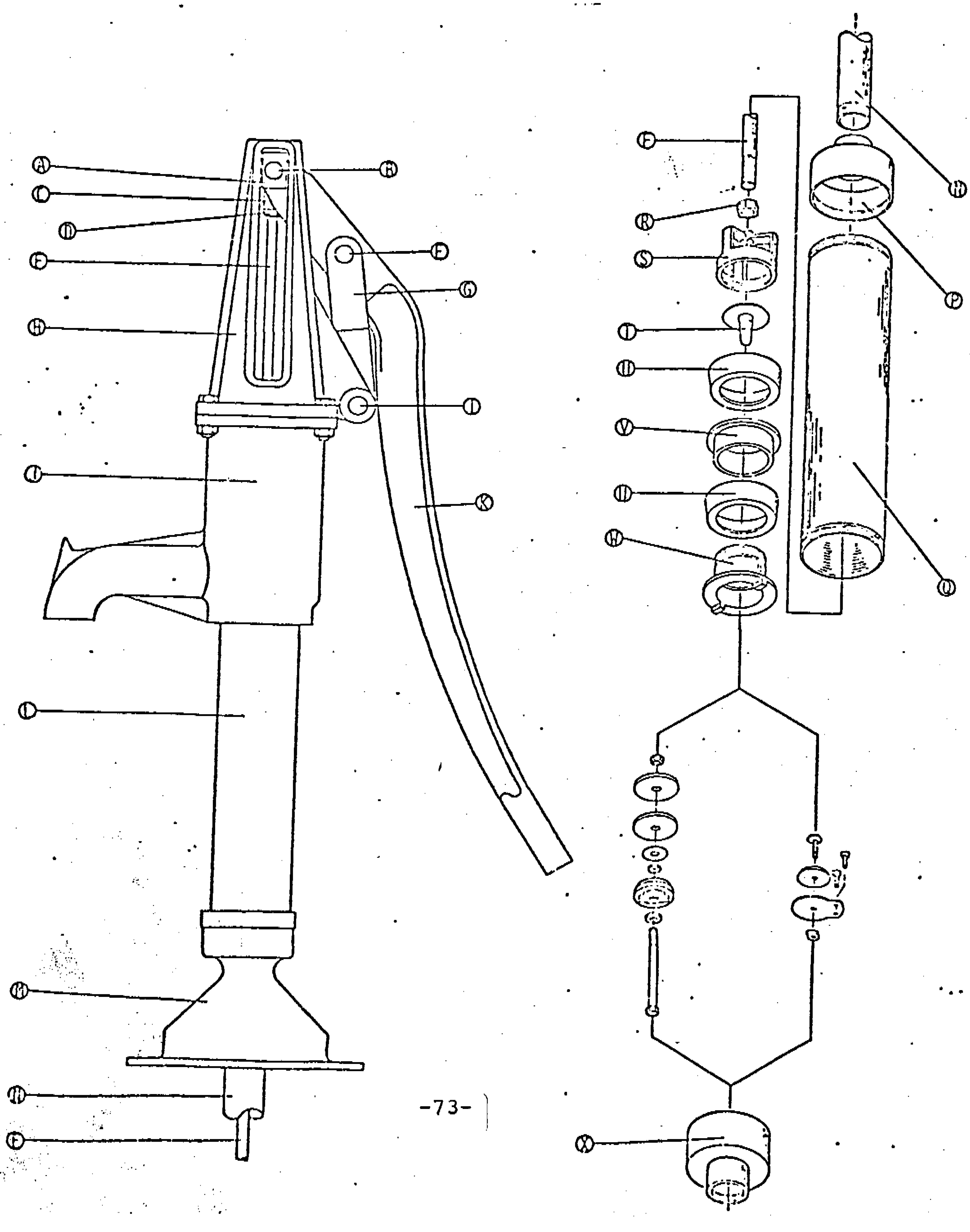
AMBATO - ECUADOR

DETALLE DEL COSTO DE VENTA DE [illegible]

COSTO DE PRODUCCION		
COSTO DIRECTO		
Materia Prima	S/ 653,67	
Mano de Obra Directa.	5223,40	
Materiales y Accesorios.	2705,00	
		S/ 8.582,07
COSTO INDIRECTO		
Materiales Indirectos.	S/.1797,00	
Otros (Mano de obra Indirecta).	35,56	
		S/ 1.832,56
GASTOS DE OPERACION		
Gastos de Administración.	S/ 229,50	
Energía Electrica, Combustible y Lubricantes.	271,75	
Gastos Financieros.	[illegible]	
		S/ 958,25
SUB-TOTAL		S/ 11372,88
UTILIDAD.	7,26%	826,12
COSTO TOTAL.		S/ 12[illegible]00,00

[illegible] 20% 11.372,88 / 2.274,57 / 13.[illegible]

NOMENCLATURA DE LA BOMBA



A. BLOQUES
B. PASADOR
C. ACOPLAMIENTO DE LA VARILLA
D. TUERCA
E. PASADOR
F. VARILLA
G. FULCRO
H. TAPA
I. PASADOR
J. CUERPO
K. PALANCA
L. SECCION DE TUBERIA
M. BASE
N. TUBERIA DE SUCCION
P TAPA SUPERIOR DEL CILINDRO
Q. CILINDRO
R. TUERCA
S. CAJUELA DEL PISTON
T. DISCO DE LA VALVULA
U. EMPAQUE
V. ESPACIADOR DEL PISTON
W. CUERPO DEL PISTON
X. TAPA INFERIOR DEL CILINDRO

Industrial Metal Mecánica «TIRADO» Hnos. Cia. Lta.

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AMBATO - ECUADOR

DETALLE DE PIEZAS FUNDIDAS QUE COMPONEN UNA BOMBA

PESO EN BRUTO - ANTES DE MAQUINADO

CABEZAL, Pieza Fundida en Hierro.	Peso	24	Lbs.	[illegible].XXX
CUERPO . " " " .	"	33	"	XXX
BASE , " " " .	"	34	"	XXX
PALANCA, " " " .	"	22	"	XXX
TAPA INFERIOR DE CILINDRO, Pieza fundida en H.	"	4	"	XXX
PESO DE LA LENGUETA, " " ".	"	0,50	"	XXX
CUERPO DE PISTON , " " Bronce.	"	1,00	"	XXX
ESPACIADOR , " " " .	"	0.50	"	XXX
DISCO DE LA VALVULA, " " " .	"	0.50	"	XXX
CAJUELA? " " " .	"	1	"	XXX
PULSOR OVIELA, " " Hierro.	"	9	"	XXX
ACOPLAMIENTO, " " " .	"	2	"	XXX
TAPA SUPERIOR DEL CILIDRO, " " " .	"	4	"	XXX
TAPA SUPERIOR DEL CIF, " " " .	"	3	"	XXX
ASIENTOS DE BRONCE DE LA VALVULA?		0,10	"	XXX
2 BLOQUES DESLIZANTES,		1,5	"	XXX
		140,10	Lbs.	XXX

COSTO DE LA BOMBA: 140,10 x 35,43 = $ 4963,21

TIEMPO EN MINUTOS DEL MAQUINADO DE LOS COMPONENTES PARA BOMBA A I D

O P E R A C I O N	CORTADO	ESMERILADO	TORNEADO	FRESADO	TALADRADO	ROSCADO	TOTAL	PRECIO	VALOR
B A S E	10'	15	40		15	10	90	6,70	603,0
TUBO DE ACERO	10		10			35	55	6,70	368,5
CUERPO	12	20	20		10	20	82	6,70	549,4
CABEZAL	12	30		20	20		82	6,70	549,4
VARILLA	3		10			10	23	6,70	154,1
ACOPLAMIENTO		20					20	6,70	134,0
BLOQUE	3	10			10		23	6,70	154,1
PIN DE ACOPLAMIENTO	3	2	10				15	6,70	100,5
PIN DE PALANCA	3	2	14		10		29	6,70	194,3
FULCRO	10	15			15		40	6,70	268,0
PIN DE CABEZAL	3	2	10		10		25	6,70	167,5
PALANCA	10	15			15		40	6,70	268,0
CAJUELA	5	5	12		3	5	40	6,70	268,0
DISCO DE LA VALVULA	5	2	15				22	6,70	147,4
ESPACIADOR	5	2	15				22	6,70	147,4
CUERPO DEL PISTON	5	5	15				25	6,70	167,5
PESO DE LA LENGUETA	5		5				10	6,70	67,0
TAPA INFERIOR CILINDRO	3	7	20				30	6,70	201,0

SON TOTAL S/ 4.509,1

COSTO DE MAQUINADO POR UNIDAD EN MANO DE OBRA .

Industrial Metal Mecánica «TIRADO» Hnos. Cia. Ltda.

CONSTRUCCION Y REPARACION DE MAQUINARIA AGRICOLA E INDUSTRIAL

DIRECCION OFICINA Y TALLERES: CONTROL NORTE Km. 4½ Teléfonos: 824230 - 820490

AMBATO - ECUADOR

RESUMEN DEL COSTO DE LA BOMBA

Preparación de Moldeo.	89.614,00
Preparación de Horno.	41.000,00
eyanas Preparadas.	13.155,50
Energía Quemada.	21.500,00
Combustible - Gasolina.	240,00
PREPARACION DE FUNDIDO.	165.509,50
MATERIALES DE FUNDICION.	52.294,00
MANO DE OBRA FUNDIDO 100	24.983,55
CARGA FABRIL 100 Unidades x 100	154.270,00
COSTO DE FUNDICION	397.057,05

Rendimiento de Unidades Fundidas al mes 90 x 100 piezas con un porcentaje de producción deficiente. del 20%.

$$\frac{397.057,05}{(100 - 40)\ 80} = 4.963,21$$

Costo Unitario Bomba en Fundido $ 4.963,4.

Peso Bruto de Fundición. 140,10 Lbs.

$$C.P. \quad \frac{4963,21}{140,10} = \$\ 35,43 \text{ cada libra.}$$

Industrial Metal Mecánica «TIRADO» Hnos. Cia. Ltda.

CONSTRUCCION Y REPARACION DE MAQUINARIA AGRICOLA E INDUSTRIAL

DIRECCION OFICINA Y TALLERES: CONTROL NORTE Km.4½ Teléfonos: 824230 - 820490

AMBATO - ECUADOR

COSTEADO PARA CIEN UNIDADES CON UN 20% DE DEFICIENCIA

MOLDEO			
ARENA DE MOLDEO 10.000 Kgs	5545 Kg	$ 7,60	$ 42.142,00
SILICATO DE SODIO/	305 "	28,00	8.540,00
BENTONITA.	11360 "	2,20	24,992,00
PLOMBAGINA O GRAFITO.	120 "	92,00	11.040,00
GAS CARBONICO.	116 "	25,00	2.900,00
			89.614,00
HORNO PREPARADO			
LADRILLOS REFRACTARIOS/	120 Un.	$150,00	18.000,00
TIERRAS O [illegible].	250 Kg.	92,00	23.000,00
			41.000,00
CUCHARAS PREPARADAS			
[illegible] PARA REVESTIMIENTO.	175 Kg	54,60	9.555,00
LADRILLOS V/33. [illegible] 24 ladrillos.		150.00	3.600,00
			13.155,50
[illegible]			
HIERRO/	5.180 Kg	8,36	43.054,00
[illegible] CALCIO	162 Kg	20,00	3.240,00
SILICIO.	50 Kg	120,00	6.000,00
			52.294,00
[illegible]			
[illegible]	30 Kg	700,00	21.000,00
[illegible]	1 m	500,00	500,00
			21.500,00
GASOLINA PARA [illegible] Y [illegible].	8 Galones	30,00	240,00

Industrial Metal Mecánica «TIRADO» Hnos. Cia. Lta.

CONSTRUCCION Y REPARACION DE MAQUINARIA AGRICOLA E INDUSTRIAL

DIRECCION OFICINA Y TALLERES: CONTROL NORTE Km. 4½ Teléfonos: 824230 - 820490

AMBATO - ECUADOR

DETALLES DE ACCESORIOS PARA ARMAR BOMBA

COMPRADOS DE COMERCIO

CANTIDAD	DETALLE		UNIDAD	TOTAL
3	PINES	2	200	400
		1	300	300
1	LENGUETA DE CUERO (Elavorado)		20	20
1	VARILLA		180	180
2	EMPAQUE DE CUERO (Elavorado).		60	120
6	CHAVETAS		4	24
4	Tornillos de 1/2 x 2		1	4
2	Tornillos de 3/4 x 1/4		1	2
1	Tornillos de 1/2 x 1/4		1	1
2	TUERCAS DE 7/16		2	4
1	TUBERIA DE ACERO 14½ X 3		700	700
1	CILINDRO DE ABS		125	125
9	BUSHING DE HIERRO DULCE 10-40 ENDURECIDO A 60Rc		83.33	750
1	DECIMO DE GALON DE PINTURA.		750	750
				S/ 2705

OTROS GASTOS EN MANO DE OBRA

TIEMPO DE ARMADO DE 1 BOMBA .	20'
INSPECCION Y PRUEBA	8'
TRASLADO DE BOMBA AL Dpto. DE PINTADO Y LIMPIEZA.	2'
PINTADO DE BOMBA.	15'
INSPECCION DE ACABADO.	15'
	60' x 6.70 = $ 402

Industrial Metal Mecánica«TIRADO»Hnos. Cia. Lta.

CONSTRUCCION Y REPARACION DE MAQUINARIA AGRICOLA E INDUSTRIAL
DIRECCION OFICINA Y TALLERES: CONTROL NORTE Km.4½ Teléfonos: 824230 - 820490
AMBATO - ECUADOR

Ambato, 24 de Mayo de 1.983

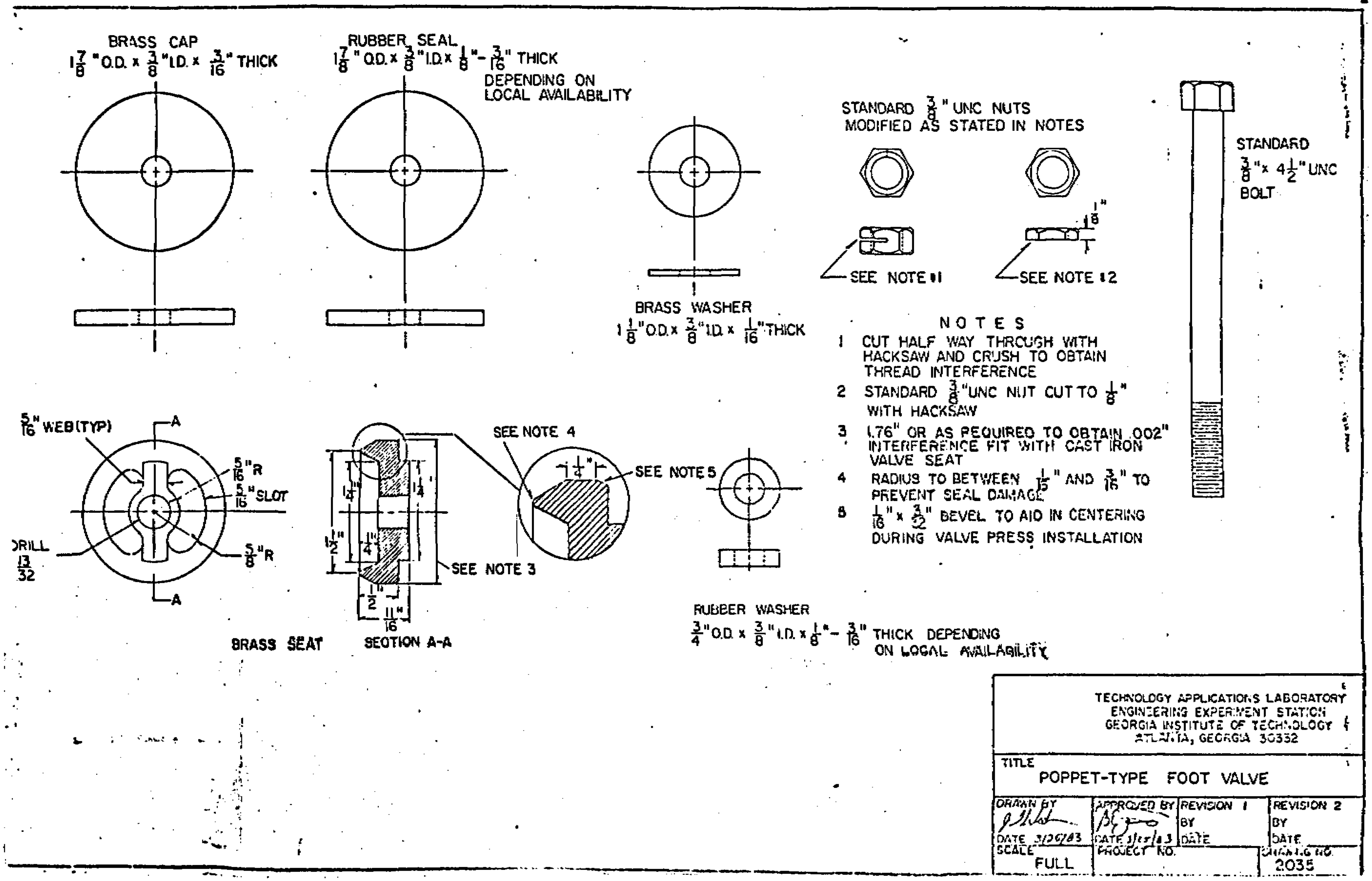
Sr.
Director del I.E.O.S
Quito

Señor Director:

Saludándolo, me es grato darle a conocer, la cotización de válvulas POPPET TYPE - DIBUJO Nº 2035 solicitada por ustedes, y cuyo precio de venta, lo hemos fijado en S/ 520,oo (QUINIENTOS VEINTE 00/100. SUCRES).

Esperamos que la presente cotización, este de acuerdo a las necesidades y presupuestos de vuestra entidad, por lo que agradecemos la atención que se dignarán dar a la presente.

JORGE EDUARDO TIRADO U
GERENTE GENERAL


BRASS CAP
1 7/8" O.D. x 3/8" I.D. x 3/16" THICK
RUBBER SEAL
1 7/8" O.D. x 3/8" I.D. x 1/8" - 3/16" THICK DEPENDING ON LOCAL AVAILABILITY
BRASS WASHER
1 1/8" O.D. x 3/8" I.D. x 1/16" THICK
STANDARD 3/8" UNC NUTS MODIFIED AS STATED IN NOTES
SEE NOTE #1
SEE NOTE #2
STANDARD 3/8" x 4 1/2" UNC BOLT
NOTES
1 CUT HALF WAY THROUGH WITH HACKSAW AND CRUSH TO OBTAIN THREAD INTERFERENCE
2 STANDARD 3/8" UNC NUT CUT TO 1/8" WITH HACKSAW
3 1.76" OR AS REQUIRED TO OBTAIN .002" INTERFERENCE FIT WITH CAST IRON VALVE SEAT
4 RADIUS TO BETWEEN 1/16" AND 3/16" TO PREVENT SEAL DAMAGE
5 1/16" x 3/32" BEVEL TO AID IN CENTERING DURING VALVE PRESS INSTALLATION
5/16" WEB (TYP)
5/16" R
5/16" SLOT
5/8" R
DRILL 13/32
BRASS SEAT
SECTION A-A
SEE NOTE 4
SEE NOTE 5
SEE NOTE 3
RUBBER WASHER
3/4" O.D. x 3/8" I.D. x 1/8" - 3/16" THICK DEPENDING ON LOCAL AVAILABILITY
TECHNOLOGY APPLICATIONS LABORATORY
ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332
TITLE
POPPET-TYPE FOOT VALVE
DRAWN BY
DATE 3/26/83
APPROVED BY
DATE 3/28/83
REVISION 1
BY
DATE
REVISION 2
BY
DATE
SCALE
FULL
PROJECT NO.
DRAWING NO.
2035

-82-

APPENDIX I

Final Report from National Polytechnic School on Foundry Assistance

ESCUELA POLITECNICA NACIONAL
Facultad de Ingeniería Mecánica
APARTADO Nº 2759
QUITO - ECUADOR

INFORME DEL ASESORAMIENTO EFECTUADO A LA FUNDICION TIRADO Hnos.

Se efectuaron cuatro visitas a la ciudad de Ambato a la Fundición TIRADO Hnos., las mismas que fueron en los siguientes días:

1a. VISITA	30 de Enero de 1984	Toma de datos y muestras
2da. VISITA	27, 28, 29 de Febrero, 1º de Marzo.	Trabajo de reparación del cubilote, medidores y mezcla de moldeo.
3era. VISITA	7-8-9 de Marzo	Moldeo y Fundición
4ta. VISITA	19 de Marzo	Evaluación de resultados.

Los aspectos fundamentales en los cuales se ha trabajado en la planta de fundición tiene que ver con lo siguiente:

DIMENSIONES REALES DEL HORNO

Sistema de carga del horno
Cantidad de material que se carga al cubilote
Muestras de las arenas de moldeo
Muestras del ladrillo refractario
Muestra de la caliza
Muestra de escoria
Muestra de metal fundido

Con las muestras tomadas se ha procedido a efectuar los análisis químicos correspondientes, así como el análisis metalográfico y la determinación de la calidad de arena de moldeo.

Con esto se establece un programa de trabajo que tiene los siguientes puntos:

- Reparar el cubilote
- Preparar arena de contacto con arena blanca tamizada por un tamiz fino inferior a 1 mm. y a efectivar con 10% Bentonita y 8% de agua.

- Hacer un mezclador de arena de moldeo
- Comprar arena blanca con tamaño AFS70
- Comprar ladrillo refractario
- Comprar bentonita
- Centrar los modelos metálicos
- Moldear con mayor fuerza y con pinzonadores neumáticos

Con este programa de trabajo se labora continuamente con la finalidad de acortar el tiempo de para la Fundición.
De este programa de trabajo se cumplen la mayoría de puntos, con excepción de la compra de ladrillo refractario, por no disponer la empresa vendedora al momento y la arena refractaria blanca que no se pudo comprar por estar las provincias del Oriente Ecuatoriano en paro de actividades.

En la visita tercera se procede a concluir con los puntos que quedaban pendientes del programa de trabajo previamente establecido y el día Jueves 8 de Marzo a las 20 horas se enciende la leña para realizar el calentamiento del horno.

Por otro lado, se ha enseñado las durezas que deben tener los moldes, y se han estado consiguiendo las operaciones de moldeo.

El día Viernes 8 de Marzo se inicia la operación de arranque de horno a las 12 horas, se finaliza la fusión a las 1/:20 y se ha efectuado la fusión de 4.0 Tons. de metal. La temperatura a la cual sale el metal es de 1380°C. Al observar la falta de silicio, se procede a corregir elmetal en cuchara con la adición de 2 Kg. por cada cuchara.

Las principales novedades en el procedimiento de colada es la excesiva oxidación con la que sale el metal, por lo cual es indispensable corregir en cuchara. Hay necesidad de balancear el peso de las cayanas de colado para que ambos grupos de trabajo tengan igual tiempo de trabajo y evitar se enfrie el material. También se observa que varias piezas se dañan por falta de cuidado sea al armar los moldes o porque posteriormente entra arena por los orificios de colada que impiden el ingreso de material.

Finalmente el 19 de Marzo se realiza la visita de evaluación de lo que se tiene lo siguiente:

TIPO DE PIEZA	MOLDEADAS	BUENAS	COMENTARIO
Cabezales	39	28	Falta de cuidado al armar
Cuerpos	50	46	Material frío
Bases	50	47	Falta cuidado al armar
Aros grandes	120	116	Material frío
Aros pequeños	80	76	Material frío
Tambores	2	2	-
Tapas reten	3	3	-
Piñón molino	1	1	-
Masas	3	3	-

El material hierro fundido ha disminuido considerablemente en porosidad. La metalografía refleja que es un hierro gris con grafito laminar con una distribución tipo A y con un tamaño Nº 7. La matriz es perlítica fina.

La composición química del material da un contenido en silicio de 1.4% y en carbón de 2.75%.

La escoria disminuye en contenido de Al_2O_3 a un 24.2% y en caliza CaO aumenta al 7.7%.

Con estos elementos de juicio se puede llegar a efectuar las siguientes recomendaciones con lo cua- se mejoraría la fundición:

- Arreglar las entradas en las placas modelo para mejorar el ingreso de material a los moldes. Se debe arreglar los modelos correspondientes a: la base, cabezal, cuerpo y accesorios.
- En las entradas de colada se debe hacer un sifón de manera que no haya arrastre de arena.
- En el cabezal hay que arreglar la inclinación de la placa superior para que haya más fácil extracción.
- En el cuerpo se debe ubicar una salida delgada.

En todos los casos, se ha suministrado al jefe de planta las indicaciones de como efectuar dichos cambios.

- Reparar el horno con cemento refractario universal super
- Al operar el horno disminuir la presión hasta que marque 34 cm. de diferencia.
- Las cargas del horno deben ser

./...

200 Kg. metal (hierro fundido)
20 Kg. coque
6 Kg. caliza

- La altura de cama de coque debe ser de 1.30 m. sobre toberas.
- Añadir en cuchara 2 Kg. de fenosilicio
- Limpiar la escoria en cuchara y escoriar el momento de colar con mayor cuidado.
- Balancear mejor el peso de las cajas moldeadas para evitar enfriamiento del material.
- Poner sumo cuidado al armar los moldes.

En lo que se refiere a la colaboración de la empresa debo indicar que si bien se prestó la ayuda necesaria para que el trabajo salga mejor, no fue suficiente por cuanto siempre hay una resistencia natural a introducir cambios en una planta de producción.

Adicionalmente debo mencionar que no es criterio el cambiar todos los procedimientos de una manera brusca, sino que los cambios vayan realizándose de forma consecutiva, de esta forma el personal de familiariza con un nuevo método de trabajo.

Así mismo los cambios introducidos son los que casi ninguna inversión requirieron.

Finalmente quiero indicar que en promedio se logró mejorar la producción de piezas fundidas hasta un nivel de 94% de piezas buenas.

Quito, Abril 12 de 1984

Ing. PATRICIO ESTUPIÑAN M.

ng.

(TRANSLATION)

Escuela Politecnica Nacional (School Name)
Mechanical Engineering Faculty
Quito, Ecuador

REPORT OF THE ASSISTANCE PROVIDED TO THE TIRADO HERMANOS FOUNDRY

Four visits were made to the Tirado Hermanos foundry in Ambato. The visits were made on the following days,

1st visit	Jan. 30, 1984	Take notes and samples
2nd visit	Feb. 27 thru March 1	Work on repairing cupola, measurement devices and casting mixture.
3rd visit	March 7 - 9	Casting and foundry
4th visit	March 19	Results evaluation

The fundamental aspects that have been worked on in the foundry are the following:

ACTUAL DIMENSIONS OF THE FURNACE

Loading System for the Furnace
Quantity of Material Loaded in Cupola
Samples of the Casting Sands
Samples of the Refractory Bricks
Sample of the Limestone
Sample of Slag
Sample of Casting

A chemical analysis, a metallographic analysis and a determination of sand casting quality were made from the samples taken.

From this a work program was established with the following aspects:

- Repair the cupola
- Prepare contact sand with a screened white sand thru a fine screen smaller than 1 mm with 10% bentonite and 8% water
- Make a casting sand mixer
- Buy white sand with size AFS70
- Buy refractory brick
- Buy bentonite
- Center metallic patterns
- Cast with major force and with pneumatic tongs.

By completing the work program the end result would be to cut foundry time. Most of the aspects of the work program were completed with the exception of buying refractory brick because a selling enterprise was not arranged, and the white refractory sand was not bought because of the halt of activities in the provinces of eastern Ecuadorian.

The pending aspects of the previously established work program are concluded on the third visit and on Thursday March 8 at 20.00 hours the firewood is lit to heat the furnace.

The hardness that the molds must have is taught and the casting operations followed.

On Friday, March 9, the operation of starting the furnace is started at 12:00 hours, the fusion is finalized at 1:20 and the fusion of 4.0 tons is carried out. The temperature at which the metal comes out is 1380°C. Observing the absence of ferro-silicate, the metal is corrected in the ladle with the addition of 2 kg per each ladle.

A new development in the melting procedure is the excessive oxidation that comes out with the metal which is essential to correct in the ladle. There is a necessity to balance the weight of the pour gates (Cayans de Colado) so that both work groups have equal work time to prevent the material from cooling. It is also observed that various pieces are ruined by lack of care in preparing molds or because previously sand has entered through the pour gate that impedes the entry of material.

Finally on March 19th an evaluation visit is made in which the following is observed:

Type of Piece	Cast	Pass Inspection	Comments
Caps	39	28	Lack of care in preparing mold
Bodies	50	46	Cold material
Bases	50	47	Lack of care in preparing mold
Big rings	120	116	Cold material
Small rings	80	76	Cold material
Wheel drums	2	2	
Retencion Caps	3	3	
Pinion Grinder	1	1	
Iron Bricks	3	3	

Porosity in the castings has diminished considerably. The metallography reflects that it is a grey iron with laminar graphite with a distribution type A and a size No. 7. The structure is a fine perlite.

The chemical composition of the material has a content of 1.4% silicon and 2.75% carbon.

The slag diminshes in Al_2O_3 content to 24.2% and increases in limestone CaO content to 7.7%.

By evaluating these elements the following recommendations are made that will improve casting:

- Improve the entrance of the mold plates to improve entry of material into the molds. The following molds should be improved: the base, cap, body and acessories.

- In the pour entries a siphon should be made in a manner that the sand does not drag.

- In the cap the inclination of the superior plate must be fixed for easier extraction.

- In the body a thin exit should be placed.

In all of the above cases an indication on how to effect such changes were provided to the head of the foundry.

- Repair the furnace with super universal refractory cement.

- While operating the furnace to diminish the pressure until the 34 cm mark of difference.

- The loads of the furnace should be

  200 kg metal (pig iron and steel)
  20 kg coke
  6 kg limestone

- The height of the coke bed should be 1.30 m above the nozzles.

- Add to ladle 2 kg of ferro-silicate.

- Clean the slag in the ladle and slag during the moment of pouring with more caution.

- Balance the weight of the mold boxes to prevent freezing of material.

- Assemble molds with extreme caution.

In what is referred to as colaboration by the plant I should indicate that the necessary help to improve the operations was not sufficient due to the natural resistance that is met when introducing changes in plant production.

Additionally I should mention that it is not critical to change all the procedures suddenly, but of a consecutive manner. This way the personnel can become familiar with the new work methods.

This way the introduced changes are such that hardly any loss of productivity will occur.

Finally I want to indicate that on the average the production of cast pieces improved to a level of 94% of good castings.

Quito, April 12, 1984

Ing. Patricio Estupinan M.