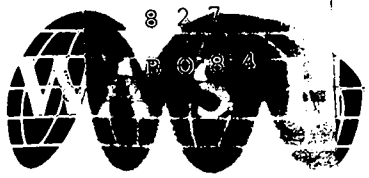

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EVALUATION OF WELL DRILLING EQUIPMENT FOR BOLIVIA RURAL WATER SUPPLY AND SANITATION PROGRAM

WASH FIELD REPORT NO. 116

MAY 1984

Prepared for:
USAID Mission to the Republic of Bolivia
Order of Technical Direction No. 173

WATER AND SANITATION FOR HEALTH PROJECT

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May 24, 1984

Henry Bassford, Director
USAID Mission
La Paz, Bolivia

Attention: Mr. Lee R. Hougen

Dear Mr. Bassford:

On behalf of the WASH Project I am pleased to provide you with ten (10) copies of a report on the Evaluation of Well Drilling Equipment for the Bolivia Rural Water Supply and Sanitation Program (Well Drilling).

This is the final report by William Turner and is based on his trip to Bolivia from January 28, 1984 to February 14, 1984.

This assistance is the result of a request by the Mission on November 18, 1983. The work was undertaken by the WASH Project on January 9, 1984 by means of Order of Technical Direction No. 173, 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 by:

William Turner

May 1984

Water and Sanitation for Health Project
Contract No. AID/DSPE-C-0080, Project No. 931-1176
is sponsored by the Office of Health, Bureau for Science and Technology
U.S. Agency for International Development
Washington, DC 20523

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Chapter 1

INTRODUCTION

The Bolivia Rural Water Supply and Sanitation Project (AID Loan 511-U-0458 and AID Grant 511-U-0458) was originally approved in 1977. The project was subsequently suspended in August 1980. It was reactivated in August, and the duration was extended to December 31, 1985. The original Project Paper called for the installation of 200 water supply systems in communities of 800 inhabitants or fewer. Of these systems it was anticipated that about one-half or 95 systems would be supplied by surface water and the remainder or 105 systems would be supplied by groundwater sources. The reactivated project calls for water supply systems to be extended to communities with 200 to 2,500 inhabitants. Furthermore, it is intended that the water supply systems be installed within the departments of Cochabamba and Chuquisaca.

Under the water supply project, the executing agency will be the Departamento y Saneamiento Ambiental (DSA), a department of the Ministerio de Prevision Social y Salud Publica (MPS/SP).

In May of 1982, the Water and Sanitation for Health Project (WASH) was requested to assist in the reprogramming of the Rural Sanitation Project in Bolivia. The resulting WASH Field Report 47 recommended the purchase of a combination rotary and percussion drilling rig capable of drilling holes up to 10 inches in diameter to depths of 500 feet. This equipment would be paid for by loan funds and would be supplied to the DSA as the executing agency.

Subsequent to the recommendations made in WASH Field Report 47, the USAID Mission in Bolivia received conflicting recommendations as to the type of equipment which should be purchased. As a result, in November 1983 the Mission requested the services of a consultant to advise on the type of well drilling equipment best suited for the objectives of the Rural Sanitation Project. On January 9, 1984 a WASH consultant arrived in Bolivia to carry out this request and this report is the result of his visit.

Chapter 2

GROUNDWATER OCCURRENCE AND DRILLING CONDITIONS AND REQUIREMENTS

2.1 Cochabamba

Most of the water supply projects within the Department of Cochabamba are planned within the upper and lower Cochabamba valleys. Several projects are foreseen in the Chapara area as well. Cochabamba is situated within the lower Cochabamba valley.

Both the upper and lower Cochabamba valleys are extensive and flat, and vehicular access to most parts of these valleys is unobstructed. Agriculture is widespread, and the inhabitants live in numerous small communities. Most communities are without sanitary drinking water supplies, and groundwater is the only easily accessible source of water.

Based upon the review of driller's logs prepared by Ing. Ricaldez of the DSA, the upper and lower valleys are comprised of interbedded alluvial and possibly lacustrine materials which have been derived from erosion of the surrounding mountainous areas. The quaternary alluvial materials within the lower Cochabamba valley is apparently much thicker than in the upper valley. In boths valleys, however, there are good thicknesses of coarse alluvial gravels which yield water easily to wells. Wells having yields of at least two litres per second should be easily obtained.

Because the alluvial materials in the upper and lower valleys were derived by erosion of surrounding mountainous areas and because of the torrential rainfall and runoff which occur from time to time, it is particularly common to encounter large clastic materials within the valley-fill material. The large clastic materials are, however, primarily confined to the circum-valley area bordering the mountains and along the paleo-drainage channels of major rivers and streams where they passed primarily into the upper valley. By the time water carrying clastic materials reached the lower valley it had lost most of its velocity and ability to transport large clastic materials. Most of the large clastic material is found, therefore, in the upper valley.

Groundwater is found within the alluvial materials of both the upper and lower valleys at a shallow depth. In the upper Cochabamba valley, groundwater is found at depths of up to 15 metres. In the lower Cochabamba valley, groundwater is reported to be virtually at the land surface. Ing. Ricaldez reports that nearly all wells in the project area have yields of at least two litres per second.

Water is recharged to the groundwater system annually by precipitation and rainfall runoff as mountain-front and line source recharge. Mountain-front recharge takes place as precipitation which falls on the mountains and hills which surround the upper and lower valleys runs off as sheet wash into the alluvial surface at the foot of the hills and mountains. Line-source recharge occurs as runoff collected by streams in mountain catchments debouches into the alluvial valley and percolates through the beds of the intermittent stream channels which drain mountain catchments.

The drilling conditions in the upper valley are slightly more difficult than in the lower valley because of the occurrence in the upper valley of larger clastic materials. In the case of both the upper and lower valleys, mud rotary drilling methods are quite suitable. Certainly percussion drilling methods may also be used, but there are no significant drilling conditions that would require percussion drilling methods on a regular basis.

It would be important to use at least five feet of continuous slot well screen in the wells in the Cochabamba area. In 1972, Boyles Engineering drilled nine wells for SEMAPA in the Cochabamba area. The wells were gravel packed. Boyles determined that 100-slot screen was too large and variously used 60-, 40-, and 30-slot wells screens. It is suggested that 40-slot well screen is the most appropriate but it is recommended that this be determined by DSA personnel prior to ordering screen. New screen designs are available which increase the amount of the open area for a 40-slot screen from 30 percent to 38 percent.

The Chapara area is characterized by mountainous areas comprised of Paleozoic rocks and narrow valleys containing thin zones of alluvial material. Percussion drilling methods will be best suited to this area. Because of the characteristics of the area, well depths and depths to water cannot easily be foreseen.

There are 50 wells planned for the Cochabamba and Chapara areas. Depths to water in the Cochabamba area are likely to be no more than 15 metres (45 ft.) and well depths will probably not exceed 50 metres (150 ft.). The wells should be cased with 6-inch black steel or casing grade PVC pipe. It is understood that rural electrification has reached all areas which will be served. Therefore, electrosubmersible pumps should be utilized in the 50 wells.

2.2 Chuquisaca

The Department of Chuquisaca is comprised of mountainous terrain with generally narrow valleys. Unlike the area between LaPaz and Cochabamba, the terrain in the Department of Chuquisaca which was visited seems to exhibit less relief although valleys are still quite narrow along all but the largest rivers.

Throughout the limited part of the Department of Chuquisaca which was visited communities were primarily located on Paleozoic bedrock. In the eastern part of Chuquisaca, where the relief seems to be greater, communities are located along the wider river valleys.

Where communities are located along alluvium-filled river valleys, the alluvium is commonly thin because the rivers are at an active stage of downcutting their bed. Also, the alluvial material which occurs along these swiftly flowing streams is commonly large in size and completely unconsolidated. Groundwater usually occurs within several feet of the surface. Drilling through this material is often exceedingly difficult because of the rocks and boulders of variable size and distribution which obstruct mud rotary drills. The material does not present a uniform, stable and immovable drilling surface to the drill bit. In addition, the rocks and boulders are not fixed in place and they tend to dislodge and move about when the drilling tools are removed from the borehole which makes it difficult to case the hole because it is no

longer unobstructed. Under these types of drilling conditions percussion methods are preferred and particularly those which allow the casing to be installed as the drilling continues. This insures that unconsolidated materials once drilled do not move into the borehole. If air percussion methods are used, it also ensures that air, which is required to evacuate cuttings from the hole, does not escape into the air spaces between the unconsolidated clastic material. If air were to escape, it would be more difficult to remove the cuttings without resorting to the use of foaming agents which add to the cost of the well.

Many communities in the Department of Chuquisaca are on the tops of broad hills and within broad topographic swales developed within the Paleozoic basement rock. The bedrock is invariably highly deformed and folded into anticlinal and synclinal structures. Faults are common throughout the area. The rocks in the area are generally extremely thick sequences of thinly bedded argillites (clays and shales) and thicker beds of arenites (sandstones). In many places the intensity of deformation has resulted in very low grade metamorphism of these rocks into phyllites (meta-arenites) and metaquartzites (meta-arenites). Groundwater occurs primarily in the highly fractured and fissured sandstone and metaquartzite beds. Where these rocks are encountered beneath the water table, they should yield satisfactory quantities of water to properly constructed wells. Because the rocks are steeply dipping and because the depth of the water table is almost completely unknown throughout these areas, it will be difficult to locate well sites such that the sandstone units are penetrated beneath the water table. It is necessary to be able to drill down the dip of these sandstone beds to locate water no matter at what depth it occurs. This will entail drilling slanted holes which severely limits the choice in selecting drilling equipment.

As far as drilling conditions are concerned, mud rotary drilling methods may be suitable for drilling the softer argillites and phyllites but they will encounter difficulty in the highly indurated and fractured sandstones and quartzites because they are indurated and because the highly fractured character of the rock may lead to significant problems of lost circulation. These problems develop when the drilling mud or air which fills the borehole and removes drill cuttings suddenly begins to flow into an underground opening such as an open fracture in the rock. Where fractured rocks occur above the water table, this can be a particularly bothersome, time consuming, and costly problem. In drilling the Paleozoic rocks in the Chuquisaca Department, percussion methods should be preferred because they are suited to drilling the highly indurated sandstones and quartzites. Fractures in these rocks above the water table will pose the same problem that they pose for mud rotary methods. Air used for removing drill cuttings may be bled off by the fractures and it may become difficult to remove the cuttings. If tubing can be set as drilling progresses this problem can be solved because the tubing seals the boreface and contains the air.

There are 20 wells planned under the project for the Chuquisaca Department. The area is not completely electrified. DSA staff in Sucre estimate that most of the systems will require line-shaft turbine pumps powered by gasoline engines and the remainder should be powered by electrosubmersible pumps with capacities of two litres per second. The WASH consultant disagrees and believes that all wells should be equipped with electrosubmersible pumps. In areas where electric power does not exist, gasoline-powered generator sets

should be used to supply electric power. In general, gasoline-powered generator sets are only available with gasoline engines up to 16 horsepower. If more than 16 horsepower engines are required, then diesel engines must be used. A side benefit of using electric generating sets is that surplus power may be available for other community uses.

Chapter 3

EQUIPMENT

3.1 Present Drilling Equipment Utilization

The consultant has visited both sites at which the DSA is currently drilling wells, one in the upper Cochabamba valley and the other near Sucre. Both sites share some of the same technical problems such as lack of casing, drill bits, slips, pipe-joint grease, and on-site welding equipment. Lack of spare parts for the two Portadrill rigs certainly results in down time. Both rigs require new Kelly bushings, and the poor state of the present Kelly bushings greatly slows down drilling. Despite the lack of equipment and spare parts, the DSA drillers are to be commended for the care they have given the equipment over the years. It is the understanding of the consultant that title to this equipment is still held by UNICEF.

In the Cochabamba area, the average drilling time for a well is probably about one month. In some cases, when particularly soft and easily drilled materials have been encountered, several tens of metres have been drilled in several hours.

Other non-technical problems may retard project progress and add to the overall cost of wells. One such major problem appears to be lack of per diem funds with which to pay field costs of DSA personnel. If this lack of funds prevents drilling operations while salaries continue, then these salary costs incurred while not drilling must be added to the overall cost of the wells drilled.

An additional problem which may lead to underutilization is the work which must take place prior to moving on to a new drilling site. This may involve preparation of access roads, clearing a well site, and clearing legal title to the well site itself. If engineering studies for a water distribution network were to be carried out preparatory to any title work and/or site preparation and access work, this may lead to additional delays in drilling particularly in cases where the equipment is capable of drilling one well per day.

3.2 Drilling Equipment Recommendations

The Rural Sanitation Program has budgeted $676,000 for the acquisition of drilling equipment and vehicles. It was anticipated under the project agreement that two new drilling units be purchased. In the acquisition of any equipment it is desirable to standardize equipment owned or operated within any particular agency to facilitate operator training and maintenance. It is also necessary that any equipment purchased have good local representation and service available.

3.2.1 Cochabamba

In the Cochabamba area mud rotary drilling equipment appears perfectly able to cope with the drilling conditions found there. The low rate of well construction is caused by lack of spare parts for the Portadrill 1500 and lack of drilling and well construction materials and other equipment necessary to develop and test pump the wells once they are constructed. However, in the area of Chapara, mud rotary methods are not particularly applicable and percussion methods will be more suitable.

3.2.2 Chuquisaca

The drilling conditions in the Chiuquisaca area call for a drilling machine which is capable of:

1. Drilling in unconsolidated fanglomerate and alluvial material containing rocks, cobble and boulders;

2. Drilling in highly indurated and fractured sandstones and quartzites with relative ease;

3. Driving casing as the hole is drilled to prevent lost circulation and hole collapse problems;

4. Drilling slanted holes;

5. Moving into poorly accessible location;

6. Drilling 6- and 8-inch holes which can be cased with 6-inch casing;

7. Ease of maintenance.

Given the above constraints, it is likely that the Rotamec 50 equipment manufactured by Atlas Copco of Sweden and the B-80 manufactured in the United States by Mobil Drill International under license from Atlas Copco are the only equipment which satisfy the above conditions. The Rotamec 50 and Mobile B-80 equipment are capable of drilling one well a day and similar equipment in Potosi has achieved this drilling rate. At this rate all communities within the project may be served in at least a year by one rig alone. The rig should be capable of both DTH, ODEX, and air rotary drilling. Specifications for the Rotamec 50 and Mobile B-80 related equipment are given in Appendix C. Any procurement of the Mobile B-80 equipment will also require purchase of some Atlas Copco equipment because of the patents held by Atlas Copco on the ODEX drilling method.

Several other alternatives have been considered. The other alternatives involved the purchase of at least one Rotamec 50 and the rehabilitation of the Portadrill 1500 and Portadrill 2500 equipment and the removal of the Portadrill 2500 from Chuquisaca to Cochabamba. All alternatives involving the Portadrill equipment, which is owned by UNICEF, would involve rehabilitating the equipment. It is felt that because the Portadrill equipment does not belong to the DSA no funds should be spent in its rehabilitation under the present program. Discussions with Dr. Martin Beyer, Director of UNICEF water

programs, suggest that UNICEF would be willing to transfer title to the equipment to an appropriate Bolivian Government agency upon receipt of a written request addressed to:

Mr. Guentas Zavallac
UNICEF
Casilla De Correo #20527
La Paz, Bolivia

with a copy to:

Mr. Javier Toro
UNICEF
Box 5317
Lima, Peru

If the equipment could be transferred to an interested Private Volunteer Organization (PVO), USAID might provide rehabilitation funds for training private sector individuals through an Operational Program Grant (OPG).

3.3 Pumps and Generators

In the Department of Cochabamba, the depth to water is more or less uniform and in most cases, past experience is that wells will produce at least two litres per second. In this case, the specifications for pumps are not likely to vary widely even though it is possible.

In the Department of Chuquisaca, where the depth to water may vary from near the surface to more than 100 metres and the yield may also vary considerably, it will be necessary to conduct pumping tests in order to specify pumping equipment and electric generator sets. The tests should be carried out as follows.

Conduct three pumping tests of one hour duration each followed by two hours of recovery. The pumping rates for each test should be different--say one, two, and three litres per second. Water-level drawdown and water-level recovery data should be analysed using the standard Theis drawdown and recovery methods and the Horner method to determine well efficiency and undamaged aquifer transmissivity. Based upon this information, a pumping rate should be selected such that pumping water levels will not reach pump intakes in less than 40 years. The determined yield and the determined maximum drawdown are used to size the pump. Required pump horsepower must be known to size the generator set. It is recommended that pumps and generator sets for the Chuquisaca area not be purchased until the tests have been completed.

3.4 Additional Recommendations

3.4.1 Well Service Rigs

The terms of reference for the present assignment only called for the consultant to recommend and specify drilling equipment. After review of the project, it was evident to the consultant that there are no proper well

service rigs in the Departments of Cochabamba and Chuquisaca. The lack of this equipment means that drilling equipment must be used to set test pumps, carry out the test pumping, and pull test pumps. Also, the drilling equipment must be used to set production pumps and pull pumps when problems occur.

The utilization of drilling equipment for the above tasks represents an improper use of the equipment and will result in delays in reaching the well construction goals of the project. Therefore, it is recommended that two well service rigs be purchased. Specifications for a small Smeal well service rig is included in Appendix D. Smeal well service rigs are probably the most popular well service rigs used in the United States.

3.4.2 Additional Equipment

Though not within the consultants scope of work, it is evident that certain additional equipment will need to be procured for wells in both the Cochabamba and Chuquisaca areas. Materials which will be necessary in the Cochabamba area are:

1. One 230V x 50Hz x 3-phase x 1HP electrosubmersible test pump capable of producing 40 gpm against a total dynamic head of about 90 feet together with 150 feet of two-inch drop pipe and couplings, 1 x 2-inch x 90-degree elbow, 1 x 2-inch x 3-feet pipe nipple, 1 x 2-inch to 3/4-inch bell reducer, 1 x 3/4-inch x 3-feet pipe nipple, 1 x 2-inch gate valve, 1 x 3/4-inch water meter, one electrical water-level measurement device, and one trailer-mounted gasoline-powered generator producing a nominal 4.5KW. General specifications for continuous duty, low-maintenance generator sets are given in Appendix E.

2. 50 pumps x 230V x 50Hz x single phase or three-phase electrosubmersible pumps with current surge suppressors and lightning arrestors capable of producing 2 1/s (32 gpm) against a total dynamic head of about 30 metres (90 ft.), 2500 feet of wire, control panels, water-level control switches and miscellaneous related supplies such as rubber tape, stacons, electrical tape, pipe joint compound, and well seals. Appendix F contains information on a typical electrosubmersible pump manufactured in the United States which has a very good record of performance in the United States and abroad.

3. Miscellaneous tools including 14- and 16-inch pipe wrenches, wire brushes, screwdrivers, crescent wrenches, hammers, combination wrenches, socket wrenches, electrical wire stripper and other hand tools which DSA may require.

4. At least 2500 feet of 2-inch galvanized drop pipe on which to set pumps as well as couplings, bell reducers, bushings, T's and crosses, pipe nipple of various lengths up to three feet, 3/4-inch water meters, gate valves, unions, water meter gaskets, teflon tape check valves, and centralizers.

5. At least 250 feet of Johnson-type stainless steel well screen of appropriate slot size.

Additional equipment which should be purchased for the Chuquisaca program is listed below.

1. One 230V x 50Hz x 3-phase 5HP electrosubmersible test pump capable of producing two litres per second from 300 feet plus one trailer-mounted diesel-powered generator set producing a nominal 10KW. Additional equipment such as that listed above for Cochabamba will also be necessary including 400 feet of 2-inch drop pipe and coupling.

2. At least 4,500 feet of 6-inch black steel well casing.

3. At least 320 feet of stainless steel Johnson well screen of appropriate slot size which includes 100 feet of ODEX compatible screen.

4. 4500 ft. of 2-inch galvanized steel drop pipe with couplings.

5. Miscellaneous hand tools as required by the DSA.

Chapter 4

CONCLUSIONS

It is concluded from the field drilling conditions that Rotamec 50 or Mobile B-80 drilling equipment is most appropriate to the drilling conditions encountered throughout Bolivia and in particular throughout the Departments of Cochabamba and Chuquisaca. It is particularly important to note that the Rotamec equipment and Mobile equipment are the only water well equipment known which are capable of drilling inclined water wells as may be required in drilling steeply dipping fractured sandstone and metaquartzite beds where the depth to groundwater is unknown.

Furthermore, Atlas Copco has a Bolivian subsidiary company which primarily serves the very large Bolivian mining industry. It is recommended that two Rotamec 50s or two Mobile B-80s be purchased as a sole source procurement. The Atlas Copco factory in Bolivia will provide full service for the Rotamec or Mobile B-80 equipment. It is important to note that any procurement of the Mobile B-80 will require purchase of some Swedish manufactured Atlas Copco parts and equipment because of the patents held by Atlas Copco on the ODEX drilling method. Furthermore, it is recommended that Atlas Copco button-bit dressing equipment be purchased. This equipment is utilized even by U.S. manufacturers of button bits and is generally recognized as the best available for the job.

The United Nations Development Program together with the Swedish International Development Agency has recently provided the Corporation para el Desarollo de Potosi (CORDEPO) with a Rotamec 50. This equipment was provided with a Swedish drilling expert who is now in country. It is expected that this same individual would be available from Atlas Copco to train DSA personnel. It is also possible that the DSA driller may be able to take instruction in the use of the equipment under the UNDP program and that the additional cost of an expatriate expert may not be needed.

Finally, it will be unwise to try to purchase electrosubmersible pumps and electrical generator sets until the wells have been completed and test pumped. Well yields, pumping water levels and system head are likely to be highly variable in the Department of Chuquisaca particularly. If equipment is purchased in advance, it is likely to be unsuited to the individual situations. This may lead to excess pump wear and high operating costs. In some cases, the pumps may not work at all. It is recommended that pump and generator sets be ordered either individually or, say, five at a time. If the drilling equipment is utilized effectively, there should be only a short lag between the completion of a well and the delivery of equipment.

To standardize the slot size of Johnson well screens, a standard gravel pack should be used. Ing. Ricaldez should be consulted regarding the slot size required for the gravel pack they use. In purchasing well screen for the Department of Chuquisaca some of the screen must be manufactured to be compatible with the ODEX method. This screen is non-standard screen. Suggested specifications for the screen are given in Appendix C.

REFERENCES

Budo, Shora
1972 Mejores del systema de agua potable de Cochabamba, SEMAPA, Boyles Engineering, April 1972, funded by Interamerican Development Bank.

Project Paper
1977 Proposal and Recommendations for the review of the Development Loan Committee, Bolivia - Rural Sanitation AID-DLC/P-2220, March 18, 1977.

Stevens, C.S.
1982 Reprogramming of the rural sanitation project in Bolivia, WASH Field Report No. 47, Water and Sanitation for Health, Washington, D.C.

APPENDIX A

DAILY LOG OF CONSULTANT

January 9, 1984

Arrived in La Paz in evening went to Sheraton Hotel.

January 10, 1984

Arrived USAID office 0930. Had meeting with Dr. Lee Hougen and spent remainder of day reviewing project documents and discussing project with USAID senior project engineer Rene Pena y Lillo.

January 11, 1984

Spent day at USAID office reviewing documents. Held meeting with Rene Pena y Lillo and DSA Ings Jose Antonio Zuleta and Enrique Torrico. Made arrangements for field trip to Cochabamba and Chuquisaca. Bought copies of geological maps of Bolivia from GEOBOL. Visited local agent of Atlas Copco, manufacturers of ODEX method drilling equipment.

January 12, 1984

Departed LaPaz at 0700 together with Ing. Torrico for Cochabamba. Arrived Cochabamba about 1500 hours and proceeded directly to the office of DSA in Cochabamba. Met with Ing. Juan Carlos Ricaldez, Director of the DSA office in Cochabamba. Ing. Ricaldez explained drilling conditions in the lower and upper valleys of Cochabamba where all 50 wells anticipated for the Department of Cochabamba are planned. He provided files on wells already constructed under his supervision. These files were of good professional quality with accurate descriptions of material encountered and with professional quality well construction details. Subsequent to our meeting with Ing. Ricaldez, Ing. Ricaldez led us on a field trip into the Upper Cochabamba Valley. We visited the Portadrill 1500 which is operated by the DSA office in Cochabamba. The rig is operated by Sr. Alcibiadez Andia. The rig is about 18 years old and is operated in a highly competent manner by Sr. Andia. The rig is well maintained by Sr. Andia despite a lack of spare parts for the rig. However, it is evident that the rig requires new cables; a compressor for well development; test pumping equipment including an electrosubmersible pump and a trailer mounted generator; drill bits; and electrical arc welding equipment.

January 13, 1984

Proceeded to Sucre by road. Arrived in Sucre about 1900 and registered at the Hotel Sucre.

January 14, 1984

In proceeding to Sucre, gasoline tank of our vehicle was punctured in fording the Rio Chuquichuqui. Repairs required most of the morning. In the afternoon together with Tecd. Nestor Perez of the OSA office in Chuquisaca, we travelled to Yotalilla on the road to Potosi to view the Portadrill 2500 used by the OSA office in Chuquisaca. The rig is operated by Sr. Rafael Escobar. Sr. Escobar had been trained by a UNICEF program on the Portadrill when it was acquired about 10 years ago. Sr. Escobar is extremely competent and has maintained his equipment in excellent condition despite the need for spare parts. In going over his equipment, he pointed out the need for gaskets, bearings, clutch plates, transfer case chains, air compressor, complete replacement of mud pump pistons, cylinder linings and valves; cables; kelly bushing; drill bits; welding equipment; and tools for carrying out repairs. Sr. Escobar has also worked on other types of equipment in Bolivia including the Ingersoll Rand TH-60 which is operated by GEOBOL. In the past 10 years, Sr. Escobar has developed a fine understanding of the occurrence of ground water in the areas of Bolivia he has worked in. Sr. Escobar is also responsible for preparing drillers logs of the rock materials encountered and in preparing the well construction drawings. These materials were reviewed and found to be of excellect quality. Following the visit to the drill site at Yotalilla, we proceeded on to Tambo Cachila to view the drilling conditions at this community. The village is situated on a thin agglomerate overburden overlying steeply tilted beds of thinly bedded argillite and medium bedded sandstone. A well located in this community of about 60 people will not produce large quantities of water but should be capable of producing sufficient water for the community by means of a hand pump. Following visit to Tambo Cachila we returned to Sucre. Return was delayed by a large bus which had slipped from the road.

January 15, 1984

In company of Ing. Edgar Caviedes Salinas, District Director of the Chuquisaca OSA office, and Tpec. Nestor Perez, District Supervisor, we traveled to Tarabuco about 70 kilometers east of Sucre.

January 16, 1984

Held meeting in office of DSA in Sucre. Gave geological maps purchased earlier in La Paz to the DSA office. They reviewed other areas of the Department of Chuquisaca with us. The eastern part of the Department of Chuquisaca consists of narrow elongate intermountain valleys with deposits of Tertiary material. They are difficult of access. Returned to La Paz by air in company of Ing. Torrico about 1830.

January 17, 18, 19, 1984

Returned to USAID office to begin preparation of report. Left for U.S. January 19, 1984.

January 20, 1984

Returned to home office.

APPENDIX B

Individuals Contacted

USAID/BOLIVIA

Mr. Henry Bassford, Mission Director

Dr. Lee Hougen, Chief of Health and Human Resources Division

Ing. Rene Pena y Lillo U, Engineer

Sr. Oscar Sarmiento, Procurement Officer

Mr. Michael Lofstrom, Procurement Officer

DEPARTAMIENTO SANAMIENTO Y AMBIENTAL

Ing. Jose Antonio Zuleta, National Director of DSA

Ing. Enrique Torrico

Ing. Edgar Caviedas Salinas, Chief of DSA office in Chuquisaca

UNITED NATIONS DEVELOPMENT PROGRAM

Ing. Fernando Mujica

District

Tpec. Nestor Perez, Chuquisaca District Supervisor of projects

Ing. Juan Carlos Ricaldez, Chief of DSA office in Cochabamba District

Sr. Alcibiadez Andia, Chief driller in Cochabamba Department

Sr. Rafael Escobar, Chief driller in Chuquisaci Department

APPENDIX C

SPECIFICATIONS FOR DRILLING EQUIPMENT, PARTS,
AND MISCELLANEOUS SUPPLIES

Atlas Copco Roctec
Mining and Construction Equipment

February 2, 1984

Mr. Turner
American Ground Water Consultants
2300 Candelaria Road, N.E.
Albuquerque, NM 87107

Subject: Rotamec Quote

Dear Mr. Turner:

Attached is our quotation and specifications for Rotamec 50-DH. I hope you'll find the information complete. The prices quoted are F.O.B. Swedish Port.

Approximate Freight: (Ocean Freight Sweden - Arica Chile)

(1) XRS-35 Gross 6200 KGS @

	USD	USD
Basic Rate	234.50 W/M	$ 5,904.71
Currency Reduc.	4%	236.19
BAF	19.00 W/M	478.42
Surcharge	2.30 W/M	57.91
Total - Just Freight		$ 6,677.23

(1) Rotamec 50-DH Gross Net 11,000 KGS @

	USD	USD
Basic Rate	234.50 W/M	$ 15,305.82
Currency Reduc.	4%	612.23
H.L. Add	33.90 W	372.90
BAF	19 W/M	1,240.13
Surcharge	2.30 W/M	150.12
Total - Just Freight		$ 17,681.20

70 Demarest Drive, Wayne, New Jersey 07470
Telephone (201) 696-0554 Telex 130492

Additional Information:

20% customs duty on C.I.F. value
20% tax on C.I.F. plus customs duty
3% stamp tax on C.I.F. value

The above freight figures are net per drill package.

If I can be of further assistance, please feel free to contact me.

Sincerely,

ATLAS COPCO ROCTEC

Richard W. Stasyshan
Product Manager

RWS/pp
Attachments
S1/e2

cc: Curt Ove Wendelin - AC MCT Sweden
Lennart Lager - AC MCT Sweden
Kaare Engstroem - AC Bolivia

American Ground Water Consultants
R. Stasyshan - February 2, 1984

Hydraulic Water Well Drilling Rig - Rotamec 50-DH complete as speced out on Attachment #1 and per leaflet #E11324:

Net Price (F.O.B. Sweden Port) U.S.D. - $ 115,630.00

Atlas Copco XRH-350 compressor per leaflet #E14159b:

Net Price (F.O.B. Sweden Port) U.S.D. - $ 78,880.00

Miscellaneous Drilling Accessories per Attachment #2:

Net Price (F.O.B. Sweden Port) U.S.D. - $ 85,472.00

TOTAL $ 279,712.00

RS/pp
S1/e4

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ATTACHMENT #1

Rig is a basic Rotamec 50-DH, mounted on a Magirius Deutz 130 DTZAK, 4 x 4 truck.* The hydraulic system of the rig is driven by the truck engine. The rotation head is fitted with double rotation motors and equipped with a switch-over valve giving 2 torque ranges:

High Torque Range - 7437Nm at 0-19 rpm
Low Torque Range - 3727Nm at 0-37 rpm

The following options are included in the price of the rig:

- Hydraulic Foam Pump
- Water tank (300 liter) with rack for 25 liter foam concentrate
- Floating Sub
- Front Hydraulic Jack
- Front Frame Assy.
- Middle Frame Assy.
- Tool Box
- Break-out table guides for COP 62 & 4" drill tubes
- Break-out plates for DTH bits - 6", 6-1/2", 8-1/2", and 7-7/8" tricome
- Work Lites 3 x 100W
- Hold back gauge
- Chain tongs
- Break-out spanner for 102mm drill tubes and subs
- Dust deflector on break-out table
- Rigid 60" pipe wrench
- Hydraulic welding unit
- Accessory kit for welder
- Set of electrodes for welder
- Pilot bit holder for break-out of ODEX 115

*Magirius Deutz - delivery 6 weeks to Stockholm port after order.

Alternative

Volvo N7, 4 x 2, 4.2 chassis - delivery 14 weeks ARO.

Same price, irregardless of carrier.

RS/pp
S1/d

American Ground Water Consultants
R. Stasyshan - February 2, 1984

ATTACHMENT #2

		Part Number	Qty.	Net Price Each	Total
1.	Down-the-Hole Hammer Atlas Copco COP62 for drilling 6" -8½" diameter holes	8311-0902-22	2	4,500.00	9,000.00
2.	Drill Tubes 114mm x 3000mm for 3½ API connection, double wrench flats in both ends. Wall thickness: 6mm. Weight: 62Kg	8393-0708-03	33	450.00	14,850.00
3.	Drill Tube as per #2 but length - 1500mm	8393-0709-02	1	400.00	400.00
4.	Button Drill Bit 6" for COP62	7755-7656-40	2	819.00	1,638.00
5.	Button Drill Bit 6½" for COP62	7755-7665-40	2	846.00	1,692.00
6.	Button Drill Bit 8½" for COP62	7755-7616-40	1	1,726.00	1,726.00
7.	Pilot Bit for ODEX 165 for 6" dia.	7588-0752-40	3	1,819.00	5,457.00
8.	Reamer Bit for ODEX 165 for 8-11/32 dia.	7588-0712-40	6	952.00	5,712.00
9.	Guide Device for ODEX 165 - COP62	7989-1766-62	1	1,803.00	1,803.00
10.	Casing Tube Bit	7989-1703-00	25	247.00	6,175.00
11.	Guide Sleeve 177mm dia.	7989-1777-00	1	1,483.00	1,483.00
12.	Flushing head complete	7989-1725-00	1	844.00	844.00
13.	Steel casing tubes 193.7 x 5.4mm; length 3000mm, bevelled 45° in one end, weight approx. 75Kg.		200	124.00	24,800.00

S1/d2

American Ground Water Consultants
R. Stasyshan - February 2, 1984

		Part Number	Qty.	Net Price Each	Total
14.	Sub API Reg. 2-3/8" pin x 3-1/2" box	8092-0180-95	2	456.00	912.00
15.	Sub API Reg. 3-1/2" pin x 4-1/2" box	8092-0198-04	2	547.00	1,094.00
16.	Sub API Reg. 2-3/8" box x 3-1/2" box	8092-0184-59	2	456.00	912.00
17.	Slide Calipher Max. operating 250mm Luna	6876-0107-00	1	98.00	98.00
18.	Drilling Foam DFA51 25Kg. Can.	3176-5697-00	8	279.00	2,232.00
19.	Thread grease for tool joints. 4.5Kg Can.	0795-1960	5	65.00	325.00
20.	Drilling Foam Additive Stabilizer 25Kg Can.	3176-7001	4	105.00	420.00
21.	Coupling	9000-0032	2	34.00	68.00
22.	Hose Nipple	9000-0374	2	48.30	96.60
23.	Seal Ring	9000-0026	4	1.00	4.00
24.	Wing Nut	9000-0159	2	29.00	58.00
25.	Hose Clamp	9000-0199	4	5.00	20.00
26.	Air Hose - 2" ID for 20 bar pressure 20M		1	680.00	680.00
27.	Atlas Copco LSR26 S-120-30 straight grinder for button bits	8423-1320-57	1	400.00	400.00
28.	Air Hose Set	8202-1180-25	1	23.00	23.00
29.	Air Hose Set	9030-0096-00	1	15.00	15.00
30.	Grinding Wheels for Carbide 50 x 19 x 10m	9760-1050-81	40	12.00	480.00

S1/d3

American Ground Water Consultants
R. Stasyshan - February 2, 1984

		Part Number	Qty.	Net Price Each	Total
31.	Holder	4150-0212-00	1	16.00	16.00
32.	Washer	4106-5938-00	1	4.00	4.00
33.	Nut	0266-1111-00	2	1.00	2.00
34.	Guard	4150-0705-80	1	16.00	16.00
35.	Vertical Grinding Machines LSS64S085	8423-2640-38	1	370.00	370.00
36.	Attachment Set	4170-0758-83	1	34.00	34.00
37.	Cut off Wheel	9760-1180-40	10	7.00	70.00
38.	Grinding Wheel Depressed Center	9760-1180-30	10	10.20	102.00
39.	Claw Coupling 5/8"	9000-0311-00	1	7.00	7.00
40.	Rubber Air Hose 5/8"	9000-0400-00	10	7.00	70.00
41.	Quick Coupling Hose Nipple	8202-1152-29	1	136.00	136.00
42.	Quick Coupling Thread	8202-1251-86	1	7.00	7.00
43.	Hose Clips	0347-6106-00	2	10.20	20.40
44.	7-7/8" Steel Tooth Tricone Roller Bit for Hard Formation Connection API Reg. 4-1/2"	8092-0174-51	1	1,200.00	1,200.00
TOTAL:					$ 85,472.00

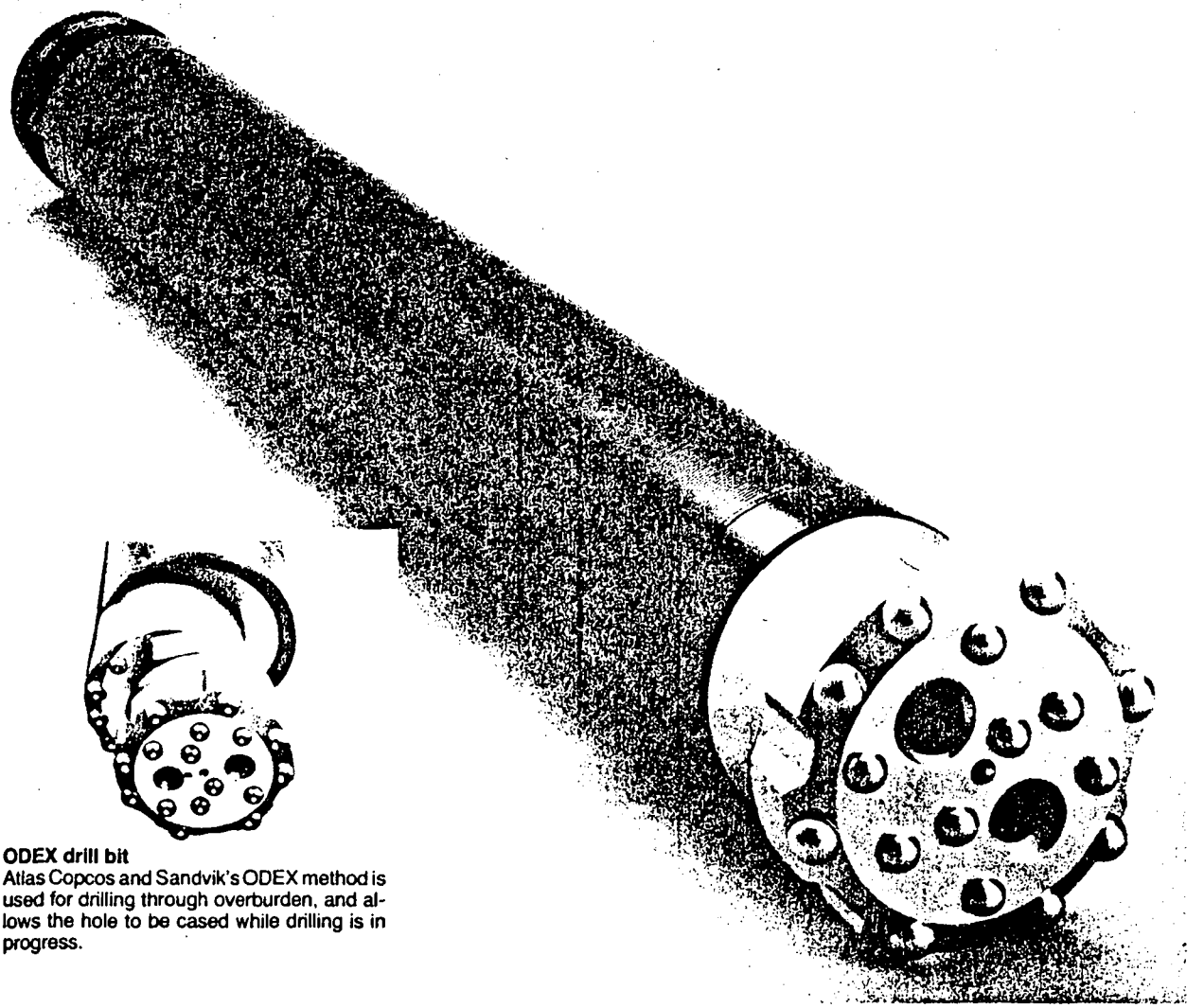
RS/pp
S1/d4

Down-the-hole drills

COP 42 and COP 62

Atlas Copco

New, valveless high-pressure rock drills for blast hole drilling and water well drilling.



ODEX drill bit
Atlas Copcos and Sandvik's ODEX method is used for drilling through overburden, and allows the hole to be cased while drilling is in progress.

COP 42 and COP 62 are two new down-the-hole drills from Atlas Copco, which replace the earlier variants COP 4 and COP 6. The new machines offer higher rates of penetration and increased operational reliability, thus contributing to lower costs per drill footage and a high percentage of availability, even under difficult drilling conditions.

Higher outputs Low energy consumption More effective drill bits	**Lower drilling costs**
Uncomplex design Easy to service Wide range of accessories	**Higher dependability**

Higher outputs
Improved impact parameters, such as a higher impact rate, larger piston area and heavier impact piston, raise the output and capacity potential of both machines over an entire pressure range extending from 6–18 bar.

Low energy consumption
A higher drilling rate, but unchanged air consumption, offers low air requirements per drill metre.

Uncomplex design
The valveless design of the rock drill, lacking a lining or welded outer casing, but fitted with a centre tube instead of special foot valves in the drill bit, make COP 42 and COP 62 uncomplex machines containing a minimum of internal components.

Easy to service
Through simplicity in design and few internal components, both rock drills are simple to dismantle and reassemble. No special tools are required either.

More effective drill bits
New design Sandvik Coromant drill bits, incorporating better rock penetration characteristics and increased service life, have been developed in parallel with the new rock drills.

Optional Equipment
- Flush subs and adapters for more effective flushing, e.g. when drilling in fractured or non-consolidated rock.
- Guide adapters for precision drilling of straight holes.
- ODEX drill bits for simultaneous drilling and casing of holes through soil, boulders and gravel strata, down to solid rock.
- Drill tubes and threaded adapters suitable for drilling with Atlas Copco drill rigs as well as rigs of other manufacture.

ATLAS COPCO CAN ALSO OFFER A WIDE RANGE OF DRILL RIGS ADAPTED FOR DOWN-THE-HOLE EQUIPMENT, AND COMPRESSORS FOR DRILLING AT EITHER LOW OR HIGH PRESSURE.

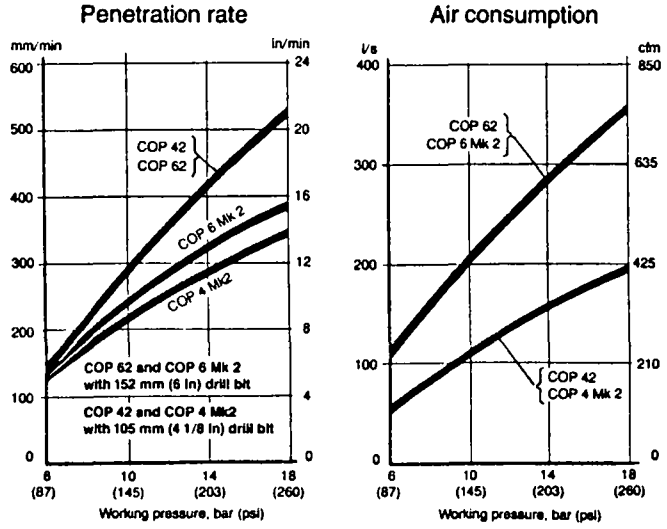
COP 42 and COP 62, Technical data

	COP 42		COP 62	
Standard hole dimensions	105 mm 110 mm 115 mm 127 mm 140 mm ODEX 115	4 1/8 in 4 5/16 in 4 1/2 in 5 in 5 1/2 in ODEX 115	152 mm 156 mm 165 mm 216 mm ODEX 165	6 in 6 1/8 in 6 1/2 in 8 1/2 in ODEX 165
Air consumption at				
6 bar (87 psi)	min. 56 l/s	118 cfm	min. 115 l/s	243 cfm
	max. 85 l/s	180 cfm	max. 198 l/s	420 cfm
10,5 bar (150 psi)	min. 110 l/s	233 cfm	min. 213 l/s	451 cfm
	max. 149 l/s	315 cfm	max. 363 l/s	769 cfm
18 bar (260 psi)	min. 200 l/s	423 cfm	min. 360 l/s	762 cfm
	max. 280 l/s	593 cfm	max. 576 l/s	1220 cfm
Weight excl. drill bit	35 kg	77 lb	93 kg	205 lb
Length excl. drill bit	960 mm	38 in	1280 mm	50 in

Min. = Without flushing through choke plug
Max. = With flushing through the choke plug

Extra flushing
The need for extra flushing is greater at low working pressures. On COP 42 and 62 this can be achieved by replacing the flow-through plug in the centre tube with a so-called choke plug. The latter channels an increase in the flow of air directly to the flush ducts of the drill bit.

Examples of penetration rate and air consumption with COP 42 and COP 62 as compared with COP 4 and COP 6, when drilling in granit.



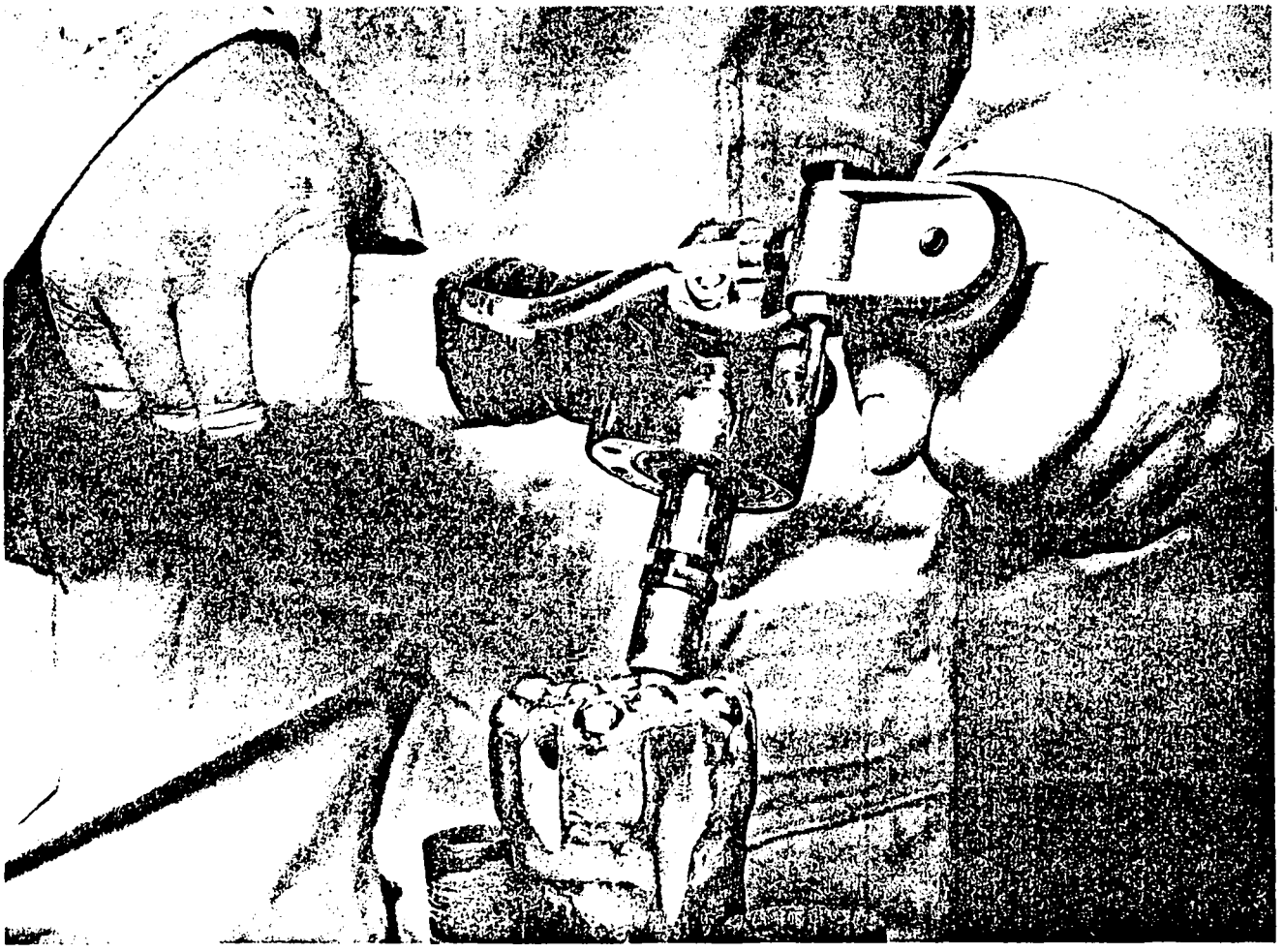
Atlas Copco

Sweden/Larserics Offset AB, Nacka 1980

Button bit attendance

The DIAROC method

Atlas Copco

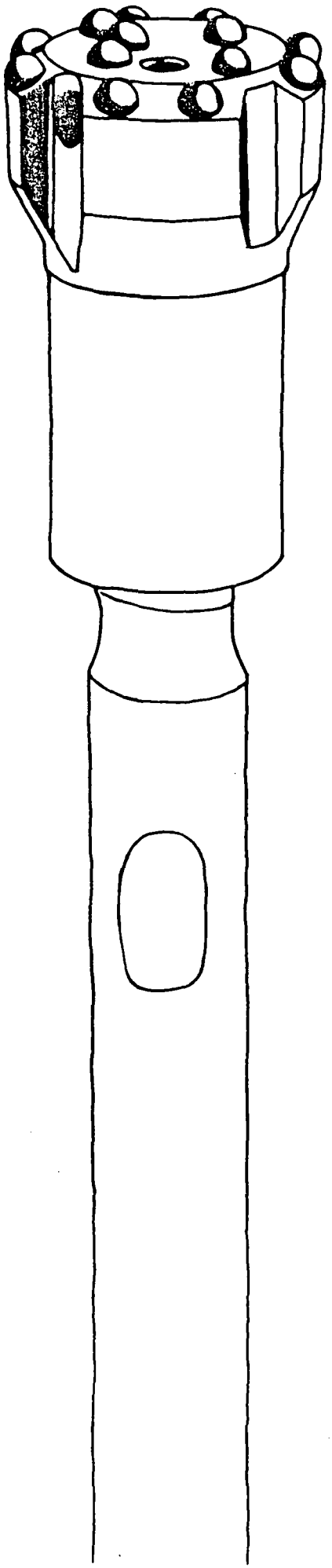


Give your bits a better bite!

Working with button bits in sizes from 64 mm and upwards, you can usually improve the drilling economy substantially by regular trimming and re-shaping of the cemented carbide buttons.

Under unfavourable conditions, heavily worn buttons could cause a decrease in penetration rate with as much as 25% and reduce the working life of the bit with nearly 30%.

Using the Atlas Copco DIAROC method you can quickly and easily recondition the buttons and give them the correct spherical shape. You use cupped diamond grinding pins and a special Atlas Copco grinder. The latest model has increased speed and improved capacity which greatly contributes to a faster job.



The DIAROC method gives button bits better penetration rates and longer working life

Button bits work most effectively when the cemented carbide buttons have the right, spherical shape. The DIAROC method is based on regular inspection and trimming of the buttons. Result: Unsurpassed drilling economy.

When should the buttons be trimmed?

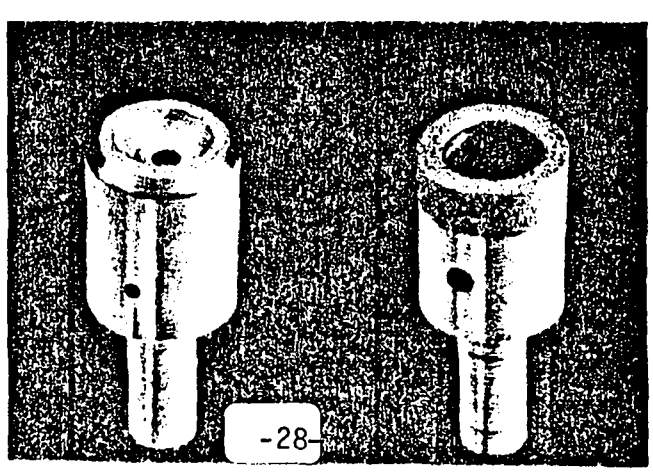
Practice has shown that it pays to trim the buttons more frequently than previously considered. The rule of thumb was to trim when the diameter of the flat-worn area was half that of the button. Obviously, you should not wait that long, but redress the buttons already when the flat area has grown to one third of the button width. In this way you extend the bit's working life and avoid decrease in penetration rate.
In addition the diamond grinding pin will last longer.

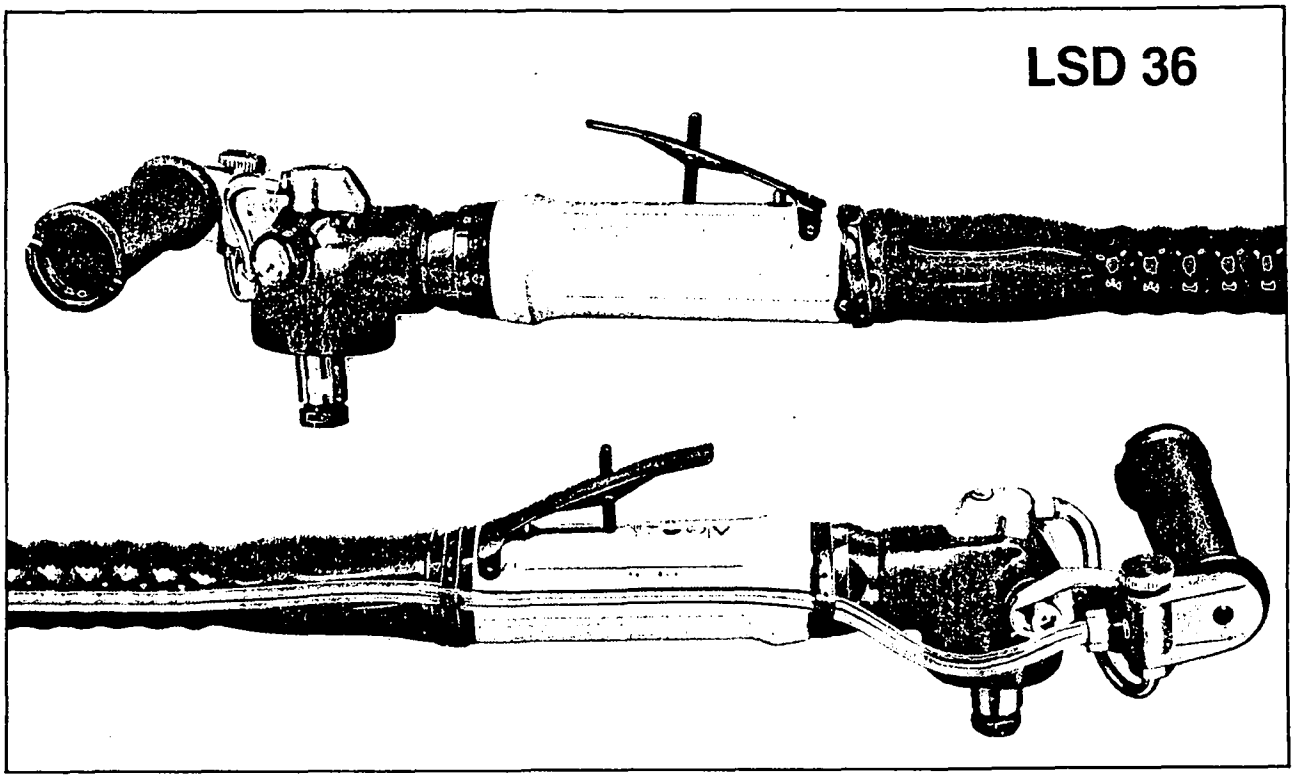
Special machine and diamond grinding pins

Compared to the old method using flat grinding discs, the DIAROC method is very fast and simple. A special angle grinder is used together with cupped diamond pins.
After a short instruction, anyone can do the job. The final result will always be correct spherical shape of the buttons and following good drilling economy. The trimming of a button does not take more than 30 seconds.
The DIAROC pins come in five dimensions to fit the different sizes of cemented carbide buttons.

BORROC pins

In certain formations, the steel around the cemented carbide buttons does not wear off at the same rate, which prevents the DIAROC point to be used directly. In this case a special, hollow grinding pin, BORROC, is used to remove the steel around the buttons. Preparatory grinding with BORROC pins makes the DIAROC pins last longer. The BORROC pins match the DIAROC series for size.



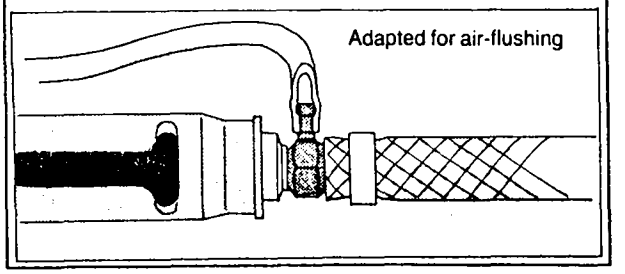


Increased machine capacity – faster job

The new model of the Atlas Copco angle grinder, type LSD 36, is provided with a more powerful vane motor, redesigned angle gear and improved sealings. These measures have increased the capacity greatly – 0.7 kW compared to 0.4 kW earlier – and the speed has been raised from 16,000 r/min to 20,000 r/min.
Through its improved performance, the new machine model offers considerable savings in time at the bit trimming work.
For work with diamond grinding pins waterflushing is strongly recommended. If water is not available, or in the case of extreme cold, air-flushing can still be used. For this purpose a T-nipple is delivered with the machine. This is screwed into the air intake and allows a short flushing hose to be connected.
When air-flushing is applied, approved protective breathing masks must be used.
The machine is delivered with hoses and fittings for connection to air and water.

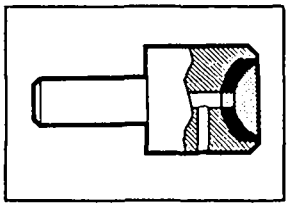
Angle grinder type LSD 36 – main data

Part No.	8423-0324-27
Working pressure, air	6–7 bar (87–102 psig)
Air consumption	17 l/s (36 ft³/min)
Flushing water pressure	max 4.5 bar (65.3 psig)
Free speed	20,000 r/min
Weight, excl. hoses	1.5 kg (3.3 lb)
Hose dimensions, air	13 mm (½")
water	6.3 mm (¼")



- Preferably, the cemented carbide buttons should be reshapened already when the diameter of the flat-worn surface is approx. one third of that of the button itself.
- Water-flushing is recommended for grinding with diamond pins. Connect water at a pressure of 2–4 bar (30–60 psig). Work with air-flushing requires the use of approved protective breathing mask.
- When grinding with DIAROC pins, the machine is kept in circular motion without letting the pin touch the steel surrounding the button. The contact pressure must be light. When steel is removed using BORROC pins, the grinder is kept still.

Choose the right grinding pin

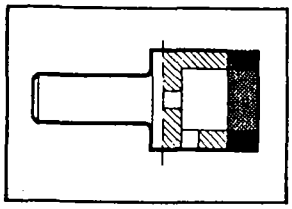


DIAROC

diamond cup grinding pin

for trimming of cemented carbide buttons

For button size mm	Designation	Part No.	Colour of package
8–9	Diaroc 8	0444-1800-80	yellow
10–11	Diaroc 10	0444-1800-81	green
12–13	Diaroc 12	0444-1800-82	red
14–15	Diaroc 14	0444-1800-83	blue
16–17	Diaroc 16	0444-1800-84	white



BORROC

boron nitride grinding pins

for removal of steel

For button size mm	Designation	Part No.	Colour of package
8–9	Borroc 8	0444-1800-90	yellow
10–11	Borroc 10	0444-1800-91	green
12–13	Borroc 12	0444-1800-92	red
14–15	Borroc 14	0444-1800-93	blue
16–17	Borroc 16	0444-1800-94	vhite

Sandvik Coromant button bits – button sizes

Button sizes can be subject to alterations without notice.

Threaded button bits

Dim mm	Bit type The figures in the head of the columns refer to middle group of the part number			 -02xx-	 -03xx-	 -04xx-	 -05xx-	 -66xx- -86xx-
35				7 & 9		7 & 9		
38				8 & 9	8 & 10	7 & 9		
41				9 & 9		8 & 9	8 & 10	
43					9 & 11	8 & 10		
45				9 & 10		8 & 10	8 & 11	8 & 9
48				9 & 10				8 & 9
51				9 & 12		10 & 11	9 & 12	9 & 10
Dim mm	 -66xx- -67xx-	 -86xx-	 -66xx-	 -66xx-	 -67xx-	 -67xx-	 -67xx-	 -66xx-
57	10							
64	10 & 12	10	10					
70		10			10 & 12			
76		10				10 & 12		
89		12				12 & 14		
102				12			12 & 14	
110								12 & 14
115				12				

Tunnelling reaming bits

64 mm	8 & 9
76–89 mm	10
89 mm	10 & 12
102–127 mm	12
152 mm	16

Down-the-hole-bits

Normal

105–127 mm	10 & 12
140 mm	12 & 14
152–305 mm	16

Heavy Duty

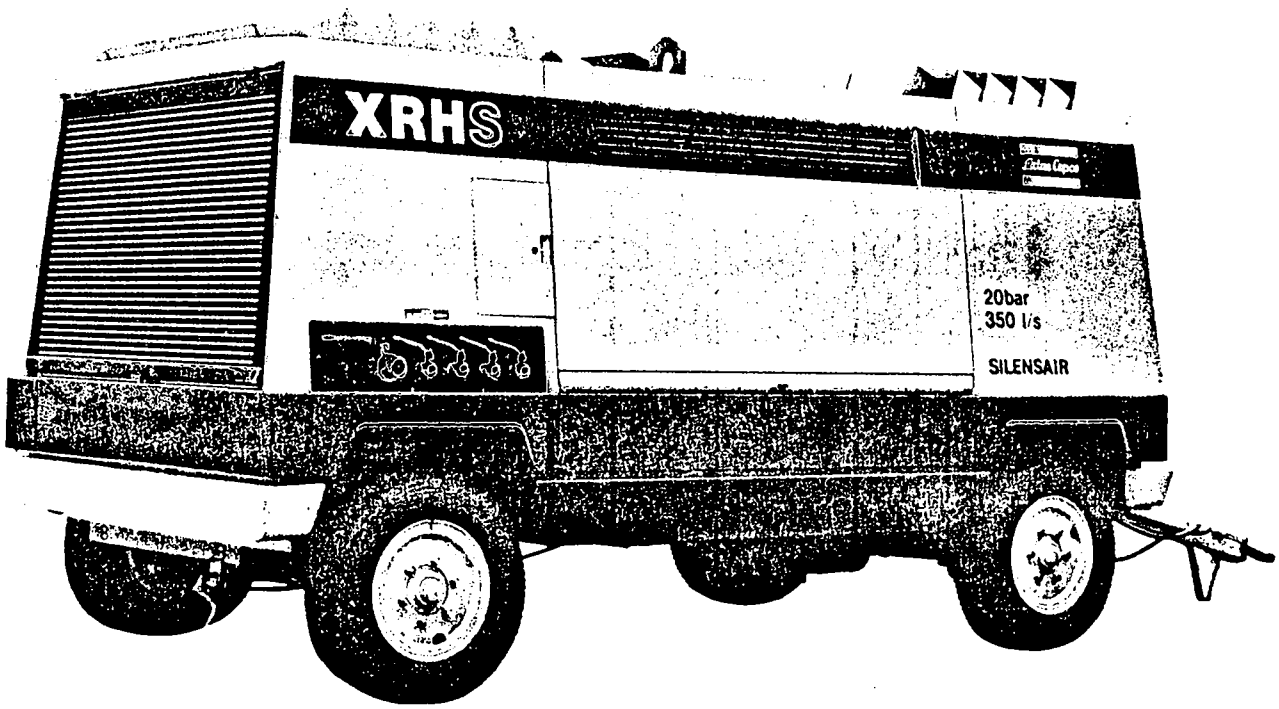
105–140 mm	12 & 14
Reaming bits	16

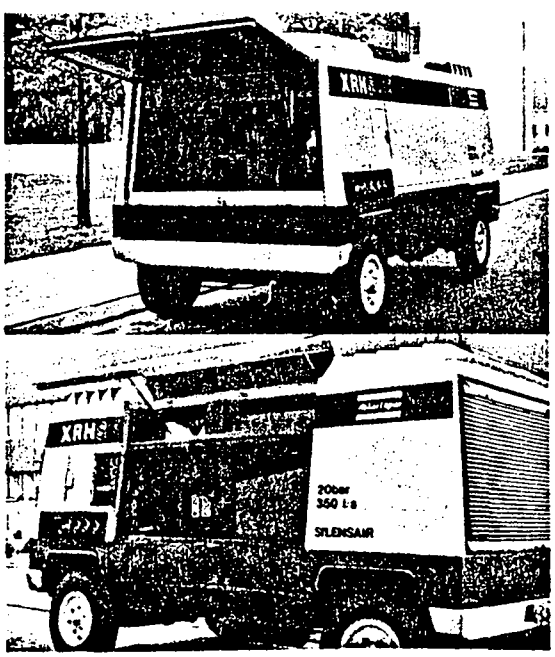
ODEX-bits

ODEX 76	10 & 12
ODEX 115	12 & 14
ODEX 140	12 & 14
ODEX 165	16

Trycken AB, Växjö

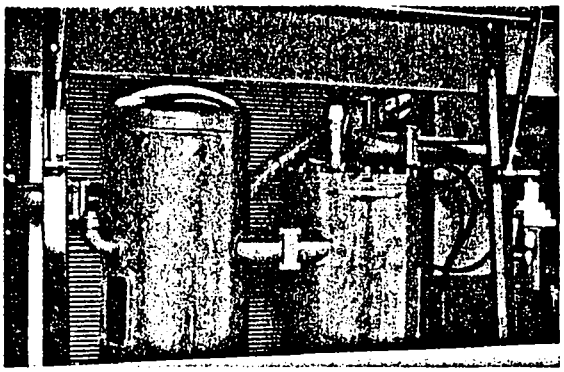
XRHS-350 Dd
(with Deutz diesel)
290-PSI



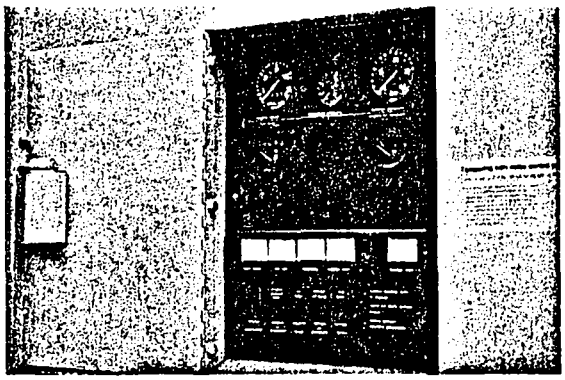


QUIET, HIGH PRESSURE — 290 PSI (742CFM) — OIL FLOODED SCREW COMPRESSOR

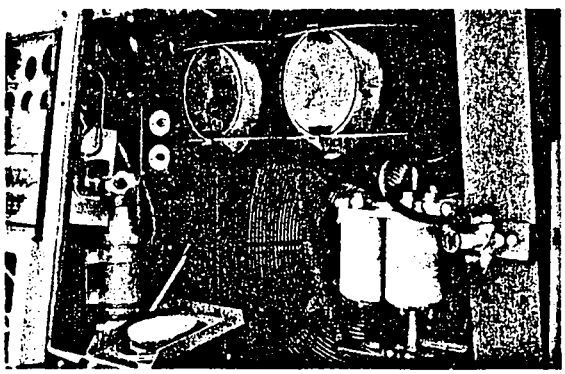
- Two year warranty on compressor elements, drive gear, and Deutz engine.
- Operates under widely varying climatic conditions — air cooled engine, large capacity oil cooling system, high efficiency heavy-duty two-stage intake filters (with cartridge replacement indicator).
- New continuous compressor throttling and engine speed regulation system, governing output in accordance with air demand for maximum economy.
- Highly efficient oil extraction system means low oil consumption.
- Big fuel tank capacity for eight hours operation: placed low for good roadholding and easy filling.
- Roof lifting eye for easy hoisting.
- Absence of vibration: smooth, pulsation-free compressed air flow.
- Few moving parts: minimum mechanical wear. Rugged and reliable, needing little maintenance.



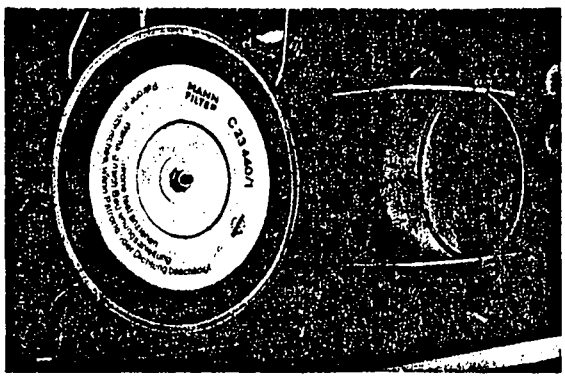
Air/Oil Reservoir: The first air reservoir acts as an oil storage sump and oil separator. In the second one, final oil separation takes place.



Instrument Panel: The instruments are recessed into a matt-black panel to cut down surface reflections making for easy reading. Displays include: engine revolutions, air delivery pressure, fuel level, and engine oil pressure.



Fuel Filter: The fuel filter is located at a convenient height with an adjacent hand-pump for use when normal pumping is not available.



Air Filters: The two-stage air filters ensure that the air entering the compressor is clean and dust-free.

Principal Data/XRHS-350 Dd

COMPRESSOR

Max. effective working pressure (conditioned by altitude and ambient temperature)	bar	20
	psi	290
Normal effective working pressure	bar	20
	psi	290
Min. effective working pressure	bar	9
	psi	130.5
Speed, normal and max. during load	r/min	2300.
Min. load speed	r/min	1300
Actual free air delivery at full load at max. speed and at normal effective working pressure.*	l/s	350
	cfm	742
Number of compression stages		2
Capacity of oil system, approx.	l	105
	gal (US)	27.7
Cooling system		oil

ENGINE

Make		Deutz diesel
Type		F12L413F
Cooling system		air
Number of cylinders		12
Bore	mm	125
	in	4.92
Stroke	mm	130
	in	5.12
Swept volume	l	19.14
	cu. in	1168
Output acc. DIN 6270B (at 2300 r/min)	kgW	247
	Bhp	331
Fuel consumption at full load, at max. speed and at normal effective working pressure (approx.)	kg/h	49.4
	gal (US)/h	17.9
Capacity of oil sump, approx.	l	41
	gal (US)	10.8
Capacity of fuel tank, approx.	l	600
	gal (US)	159

UNIT

Capacity of air receiver, approx.	l	185
	cu. ft.	6.5
Overall length	mm	4650
	in	183
Overall width	mm	2120
	in	84
Overall height	mm	2345
	in	92
Mass (unit in operating condition) (approx.)	kg	6030
	lb	13367

* at following inlet conditions:
- absolute inlet air pressure = 1 bar (1.02 kp/cm², 14.5 psi)
- inlet air temperature and inlet coolant temperature = 15°C (60° F)

Atlas Copco Mining and Construction Equipment
70 Demarest Drive, Wayne, NJ 07470 • (201) 696-0554

CONTACT YOUR ATLAS COPCO DISTRIBUTOR:

AAL-034

SPECIFICATIONS

MOBILE B-50 DRILLING EQUIPMENT

ITEM	QUANTITY	DESCRIPTION
		DRILLING EQUIPMENT
1	1	Mobile Drill Model B-80 (equipped w 0-54 rom heavy duty rotary table and cradle in lieu of standard 5-speed rotary table & SLIDRAMATIC), 3-1/2" API reg. floating spindle, heavy duty air swivel, 6000# main hoist, 14' feed stroke, crown block assembly, hydraulic breakout wrench, breakout table, 2-1/2" mast standpipe, LIFELINE safety shutdown system, 20-bar air system, adapted for PYO drive from carrier.
2	1	Custom steel deck with tool boxes and racks.
3.	1	Rear mounted hydraulic stabilizer
4	1	Front mounted hydraulic stabilizer
5	1	250-gallon capacity all steel water tank
6	1	Foam flushing system
7	1	1.25 l/s rated reciprocal water pump.
8	1	Guide bushing size 3-1/2" O.D.
9	1	1984 I.H. Series 1654 4 x 4 powered by 210 HP turbo diesel
10	1	Hydraulic welding unit
11	1	Accessory kit for welder
12	1	Electrodes for welder
13	1	Chain tongs
14	1	60" pipe wrench
15	1	Pilot bit holder for breakout of ODEX 165
16	1	Atlas Copco XRH-350 compressor or equivalent

DRILLING TOOLS

17	2	6"-8.5" down-the-hole air hammer with 3/.5" APE box connection
18	6	6" button bits
19	6	6.5" button bits
20	6	8" or 8-5/8" button bits
21	33	Drill pipe, 3-1/2" API with wrench flats both ends, 114mm O.D. x 6mm wall thickness x 3000mm long
22	3	Pilot bit for ODEX 165 for 6" diameter
23	6	Reamer bit for ODEX 165 for 8-11/32" diameter
24	1	Guide device for ODEX 165 for appropriate air hammer
25	25	casing tube bits
26	1	Guide sleeve, 177mm diameter
27	1	Flushing head complete
28	2	Sub API Reg., 2-3/8" pin x 3-1/2" box
29	2	Sub API Reg., 3-1/2" pin x 4-1/2" box
30	2	Sub API Reg., 2-3/8" box x 3-1/2" box
31	1	Slide caliper max operating 250mm luna
32	1	7-7/8" steel tooth tricone roller bit for hard formation connection API Reg. 4-1/2"

BUTTON DRESSING EQUIPMENT

33	2	Couplings
34	2	Hose nipples
35	4	Seal rings
36	2	Wing nuts
37	4	Hose clamps

38	1	Air hose - 2" I.D. for 20 bar pressure 20M
39	1	Claw coupling 5/8"
40	10	Rubber air hose 5/8"
41	1	Quick coupling hose nipples
42	1	Quick coupling thread
43	2	Hose clips
44	1	Atlas Copco LSR26 S-120-30 straight grinder for button bits
45	10	Grinding wheel depressed center
46	10	Cut off wheel
47	1	Attachment set
48	2	Air hose sets
49	40	Grinding wheel for carbide 50 x 19 x 10M
50	1	Holder
51	1	Guard
52	1	Washer
53	2	Nut
54	1	Vertical grinding machine

MISCELLANEOUS CASING AND SCREEN

55	100	Special steel casing for ODEX system 193.7 x 5.4mm; 3000mm, bevelled 45 degrees on one end or equivalent
56	20	ODEX compatible Continuous wire wound V-slot well screen x 7.3" I.D. x 7.9" O.D. x 5'; collapse resistance 200 psi for 40 slot screen; open area 30%; tensile strength under working load 45,000# with internally reinforced connection to weld rings which does not interfere with I.D. specs.; weld rings 8.0" O.D.; weld rings to be of same metal as screen; 304 stainless steel

57	45	6" continuous slot wire wound type 304 stainless steel x 40 slot x 135 psi collapse strength; 30,000# tensile strength x 38% open area.
		MISCELLANEOUS DRILLING SUPPLIES
58	8	Drilling foam x 25kg cans
59	5	Thread grease x 4.5kg cans
60	4	Drilling foam additive stabilizer, 25kg cans

APPENDIX D

SPECIFICATIONS FOR WELL SERVICE EQUIPMENT

THE BIG THREE

3T

6000 lbs. capacity
32 ft. mast

4T

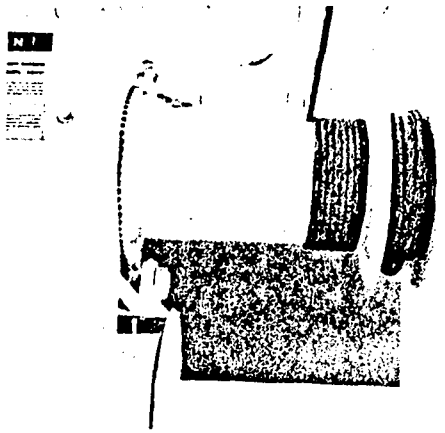
6000 lbs. capacity
35 ft. mast

5T

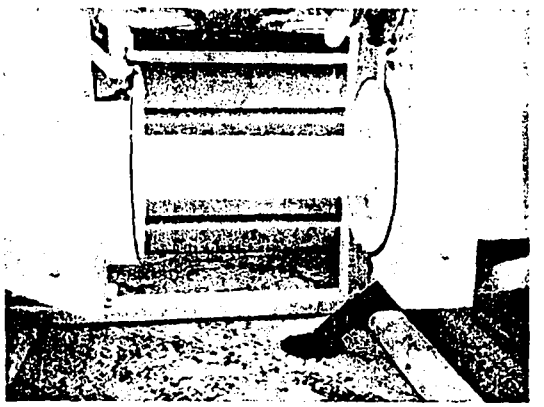
12,000 lbs. capacity
36 ft. mast

smeal

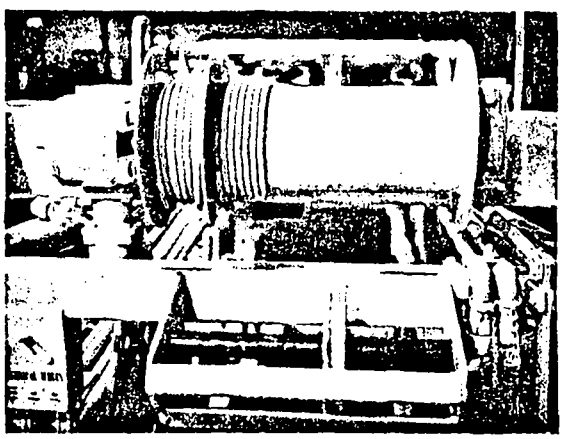
Optional Equipment a



The 5T and 4T all hydraulic winch with the original engineered Smeal automatic fail safe brake has a 120 feet per minute line speed with a 3000 lb. single line lifting capacity on the 5T, and a 150 ft. per minute line speed with a 2000 lb. single line lifting capacity on the 4T. The hydraulic motor is direct coupled to the heavy duty pinion gear.

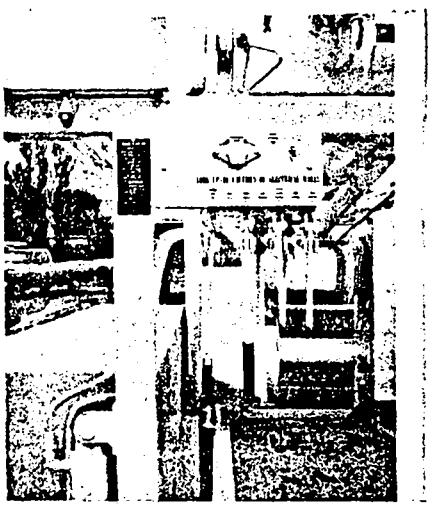


The sandreel attachment has a 1000 lb. bare spool lifting capacity with a 350 ft. per minute line speed. Power up-power down plus a 100% freefall for deep well work. Another feature of the sand-reel is a level wind mounted on the back frame to allow equal distribution of the cable to the drum. 350 ft. per minute line speed with a spool capacity of 1650 ft. of ¼" cable, 1050 ft. of 5/16 cable, and 740 ft. of 3/8 cable.

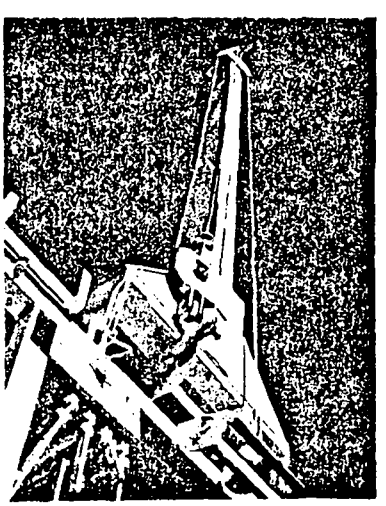


The 3T main winch assembly is a hydraulic worm driven gear box to drum assembly. The worm driven drum requires no brake because the winch cannot be raised or lowered unless the input shaft is rotated by the hydraulic motor.

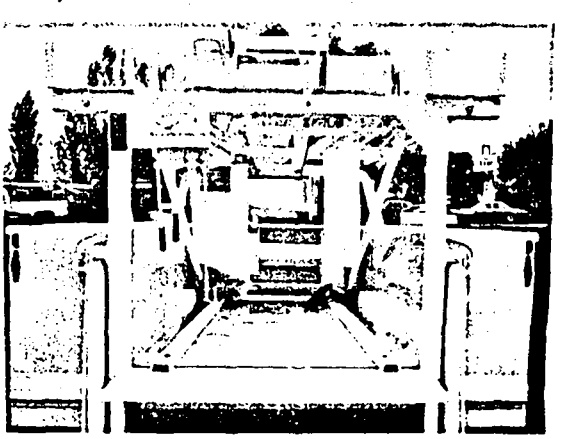
The 3T has a single line pull of 2000 lbs. at 45 ft. per minute. Any overload or misuse is prevented by the by-pass or relief valve incorporated in the hydraulic system. The 3T winch is totally a fail safe winch.



The operating controls on 3T-4T-5T derricks are conveniently positioned at the left rear corner of the rig and easy accessible from ground level. The machine is protected from any type of overloading or misuse by a special hydraulic by-pass valve incorporated into the hydraulic system.



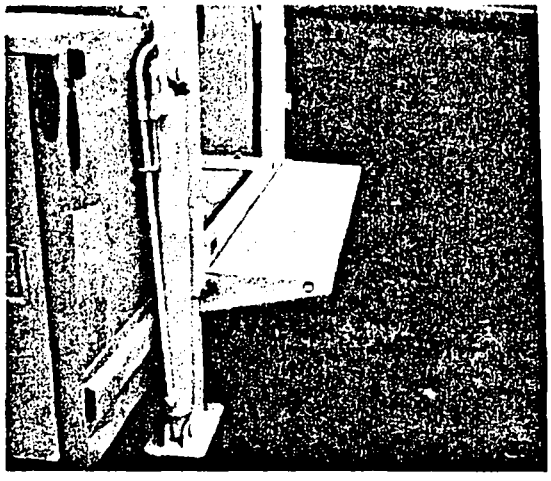
All Smeal Derricks are equipped as standard equipment with the unique method of reeving a one-two or three part line without the problem or time consuming delay of lowering the tower to reeve



The main frame assembly on the 3T-4T-5T allows full use of the interframe for material hauling or any other use the customer may require.

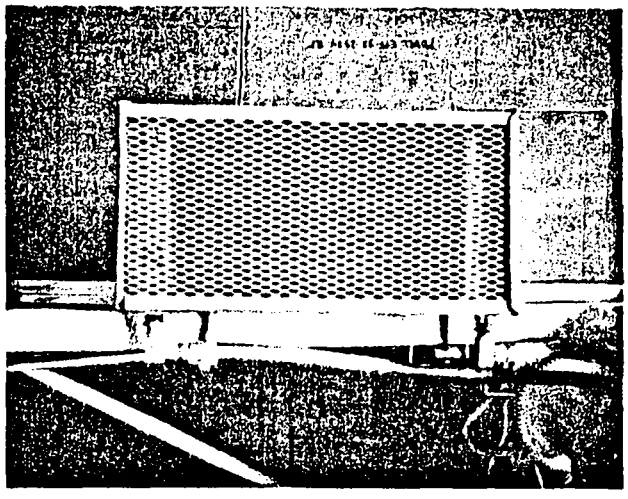
The 3T-4T-5T will mount inside a utility type body with a minimum 48" width and 100" length. The lower frame assembly is modified to accommodate the wheel wells on dual wheel type

nd Features on the 3T —

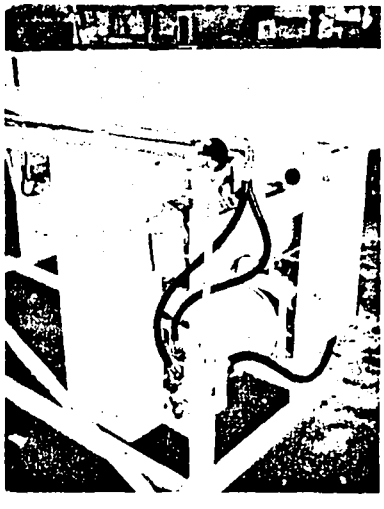


Dual rear hydraulic outriggers are standard equipment and are independently controlled to afford easy leveling on uneven terrain.

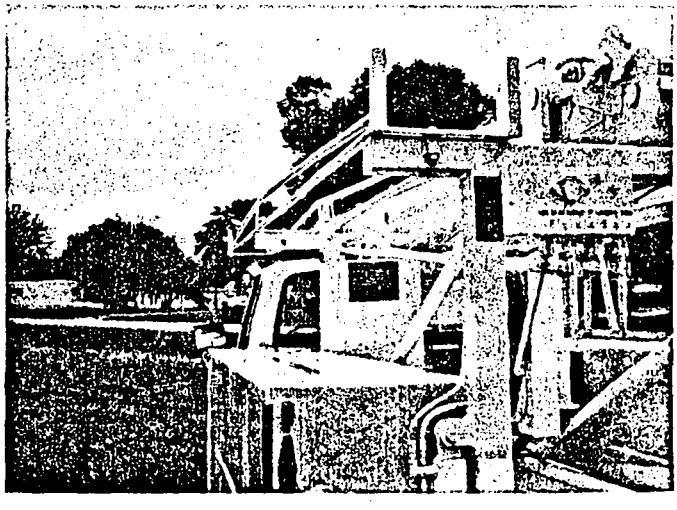
The heavy duty tailgate is designed for extreme strength and long life.



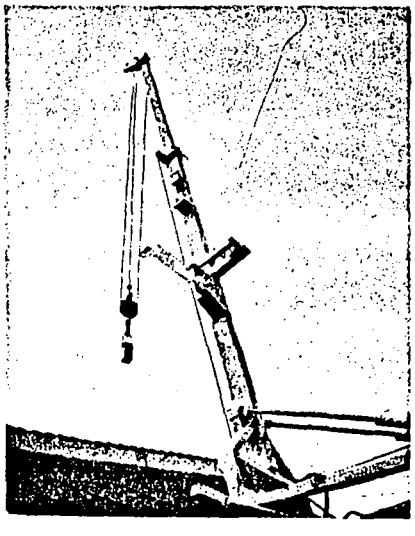
The oil cooler is a Hayden heavy duty hydraulic cooling coil with a 12 volt D.C. fan which in most operating conditions allows for continuous operation normally curtailed by overheated hydraulic oil.



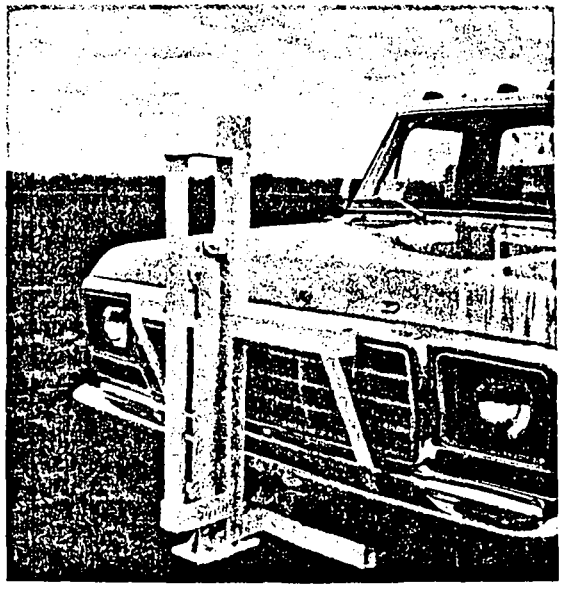
The Power To Rear attachments operates the Cathead, Plastic Pipe Reel, Walking Beam, or other hydraulic equipment.



The Pipe Racks mount independently on right or left side of the derrick and will carry approximately 700 ft. of 1" pipe on each side.

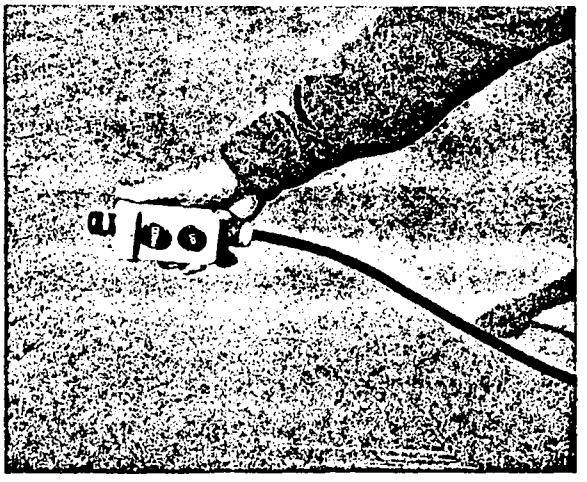


The Walking Beam is a new concept in the line of jarring or cleaning and pumping wells. The unit consists of a mast mounted beam powered by a 2½" D.A. Cylinder with capacity in excess of 1000 lbs., maximum 18" stroke, and up to 60 cycles per minute. An electric valve automatically changes cycles with micro switches that

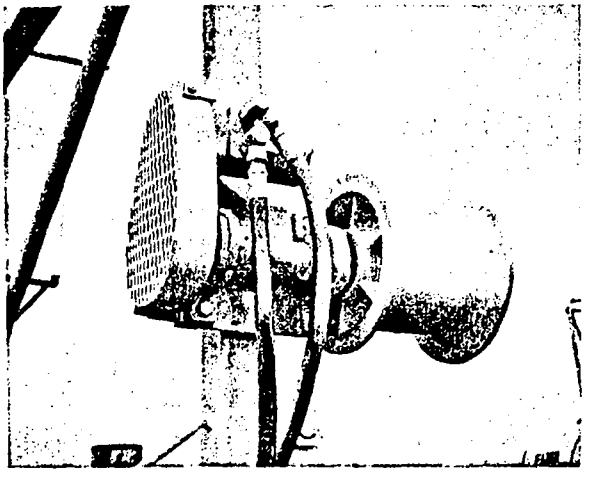


The front hydraulic outrigger is designed to eliminate the truck spring reaction when the load is lifted or set back down plus it also

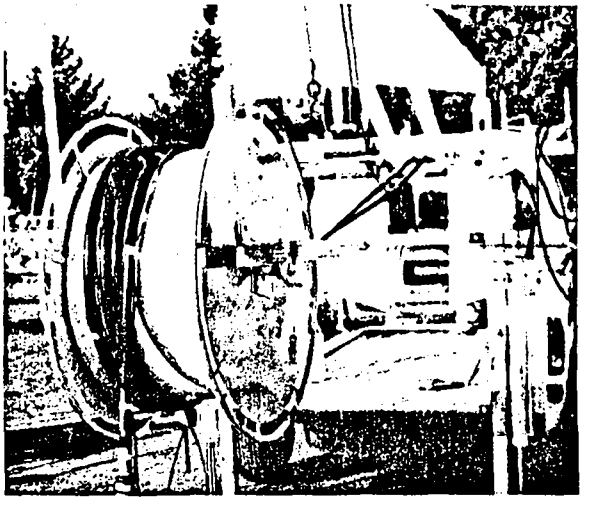
4T and 5T Derricks



The Remote Control attachment controls the main winch or sandreel plus the engine speed and can be used to the rig's maximum winch capacity within a 30 ft. range of the machine. Eliminates the need for two men on most jobs.

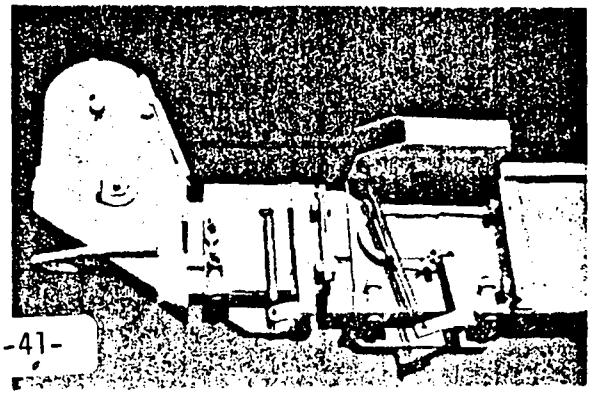


The cathead attachment is a hydraulic driven 7" capstan; right rear mounted which develops approximately 1000 lbs. pull.



The Plastic Pipe Reel solves at long last the problem of pulling and servicing submersible pumps hung on plastic pipe. The Plastic Pipe Reel has a 700 lb. working load with a 100 ft. per minute line speed and a spool capacity of 300 ft. of 1¼" pipe.

The E3 attachment which adapts to all Smeal Rigs is designed for light work in hard to get places or windmill work. It allows 10 ft. additional mast height and 4½ ft. additional lay back. Capacities on the different models are 1500 lbs. on 5T and 800 lbs. on 4T and 3T.



3T Hydraulic Derrick

The 3T is the most economical all around rig on the market today. Low in cost and simple in construction makes it one of the best small machines available. The 3T has 6000 lb. capacity. The 3T is designed to fit on a ¾" ton truck or larger. The 3T has a self supporting mast which eliminates need for a guy cable affording fast and easy setup. The 3T Basic Rig consists of a 32 ft. telescoping mast, 125 ft. of 3/8 NSNR cable, 2 and 3 part line blocks, open spelter socket with a 3 ton safety hook, hydraulic outriggers, automatic engine speed control and power-take-off for a 4 speed transmission. Shipping weight is approximately 1760 lbs.

NOTE: 5 speed transmissions may require a special double gear P.T.O.

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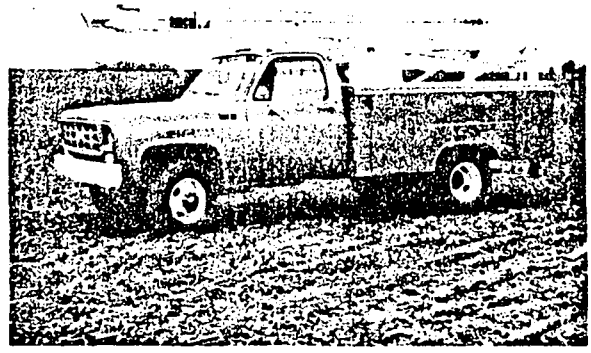
4T Hydraulic Derrick

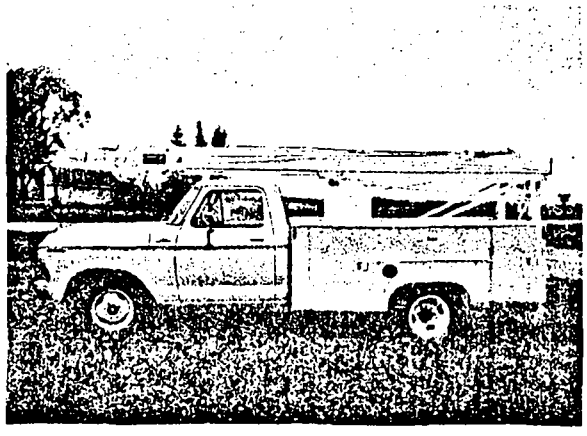


The Smeal 4T is the newest addition to the complete line Smeal pump hoists. The 4T is designed for the pump man who requires speed in his operation. The 4T is designed with a self-supporting mast which eliminates the need for guy cables. The load is supported by two 3½" x 48" double acting cylinders. Maximum layback on the 4T is 10 ft. back of the truck to allow easy access to hard to get pumps or pump houses. The 4T Basic Rig consists of a 35 ft. telescoping mast, 6000 lb. capacity, 150' of 3/8" NSNR cable with a swaged socket, 3 ton swivel safety hook, blocks for a 2 or 3 part line reeving, hydraulic outriggers, automatic engine speed control, and a single gear P.T.O. for 4 speed transmission. The 4T will adapt to ¾" ton truck or larger. Shipping weight is approximately 2300 lbs.

NOTE: 5 speed transmissions may require a special double gear P.T.O.

The P
Pipe Reel,

5T Hydraulic Derrick



The 5T is the most popular all around pump hoist on the market today. Its extreme versatility ranges from small submersible pumps all the way to line shaft turbines. The 5T is designed with a self-supporting mast which eliminates the need for guy cables. The load is supported by two 3½" x 48" double acting cylinders. Maximum layback on the 5T is 11 ft. back of the truck to allow easy access to hard to get pumps or pump houses. The 5T Basic Rig consists of a 36 ft. telescoping mast, 12,000 lb. capacity, 220 ft. of 7/16" NSNS cable with an open spelt-ered socket, 4½ ton swivel safety hook, blocks for 2-3 or 4 part line reeving, hydraulic outriggers, automatic engine speed control, and a single gear P.T.O. for 4 speed transmission. The 5T will adapt to a 1 ton truck or larger. Approximate shipping weight is 2600 lbs.

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MANUFACTURING COMPANY—SNYDER, NEBRASKA 68664—PHONE 402-568-2221

January 25, 1984

American Ground Water Consultants
2300 Candelairia Road NE
Albuquerque, N.M. 87107

ATTN.: Mr. Bill Turner

Dear Sir:

Thank you for your inquiry regarding two Smeal units for export to Bolivia. Also enclosed please find a 5T brochure.

Some of the features of the 5T are:

- 36' telescopic mast
- Free standing mast no guy cables required
- 11' layback
- 4 part mainline reeving
- 12000# maximum mainwinch capacity
- Independently controlled rear outriggers
- Automatic engine speed
- Automatic failsafe brake on winch
- Main winch has ring gear attached to one side and is driven by a pinion gear
- 120 FPM mainline single line speed

All of the above is standard equipment on a 5T basic unit. Please see the brochure for specifications on the optional equipment.

5T hydraulic derrick	$7490.00	
Sandreel less cable	1500.00	
Remote control	655.00	
2--Pipe racks	220.00	
Tailgate	90.00	
Oil cooler	750.00	
Mounting	600.00	
TOTAL		$11,305.00
Standard utility body	$2200.00	
Aux. tank modification	150.00	
TOTAL		$ 2,350.00

1 ton Chevrolet 4x4 chassis 60" cab to axle
H.D. rear springs 5000#
750x16 8 ply rear dual all mud and snow tires
Spare tire and wheel
350 V-8 engine
4 speed
4:56 rear axle ratio
West coast mirrors

H.D. Battery
H.D. Cooling
Gauges
H.D. stabilizer
Power steering
Power brakes
Auxilliary gas
Hydraulic jack
TOTAL OF TRUCK.....$11,915.00

Ramsey 200 front winch with 150' 5/16 cable
6000# pull installed with bumper kit..... 1,171.00

Delivery to port at Houston, Texas (per unit).... 1,000.00

Price per unit F.O.B. Houston, Texas.....$27,741.00
Price per 2 units F.O.B. Houston, Texas.....$55,482.00

The dimensions and weight of the unit are:
Approximately 8' wide
10½' high
20' long
9200 lbs.
The length could possibly be under 20' depending on the front winch dimensions.

If the cable is desired for the sandreel you need 5/16 6x19 which is 58¢ per foot. If you need the cable please state the length up to 1200' and add the amount to the quoted price.

Below is listed the suggested spare parts list for the 5T unit.

TC pump seal kit.....		$ 44.22
2--F410 mast cylinder seal kits	29.70	59.40
2--F406 out. cylinder seal kits	21.80	43.60
2--R1440 brake cyl. seal kits	11.50	23.00
1--brake cylinder.....		70.80
1--7/16x220' mainline cable.....		259.80
1--cooler fan motor.....		18.90
2--filter elements.....	6.75..	13.50
1--AM mainwinch or sandline hyd.motor		227.00
4--safety latches for mainline hook	3.50.....	14.00
1--12 volt solenoid.....		55.50
1--4x203 switch.....		5.00
1--2x464 switch.....		4.00
TOTAL OF SPARE PARTS.....		$838.72

Hoping the enclosed is sufficient and please contact me for any further information.

SMEAL MANUFACTURING COMPANY

Gerald Kassmeier

Gerald Kassmeier
Sales Representative

GK/mb

APPENDIX E

SPECIFICATIONS FOR ELECTRICAL GENERATOR SETS

GENERAL GENERATOR SET SPECIFICATIONS

Engine

Continuous duty heavy duty gasoline engine up to 16HP

above 16HP diesel power may be used
Externally located ignition points
Separate carburator and fuel tank
Overhead valves above 14HP
Ball bearing main bearings for Crankshaft
Needle connecting rod bearings for 14HP and above
Engine elapsed operating time meter
Engine blocks reboreable to three oversizes for engine rebuilding
Cast iron cylinder sleeves or removeable sleeves
Crankshaft can be reground to three undersizes
Crankshaft of nodular cast iron
Fittings for external fuel tank

Generator

230V x 50Hz
Sustain at least 80 degree Centigrade temperature rise w/o loss of power
Sufficient net continuous power for pump operation
Class H rotor insulation
Class F stator insulation
Varnish impregnated windings
Epoxy impregnated rotor
Transient voltage drop at full load <10%
Nominal voltage return <0.10 second
300% motor starting ability with less than 25% voltage drop
Voltage regulation plus or minus 5%
No brushes or slip rings

Note: time between piston ring replacement should be at least 2000 hours. Engine oil should be changed every 50 hours of operation. A Series I motor oil similar to Chevron DELO 100 should be used during the first 200 hours of operation. Following break-in of the engine, a Series III oil such as Chevron DELO 400 or Phillips HDS-2 oil should be used. This

should result in an increase of operation of up to 50% between piston changes.

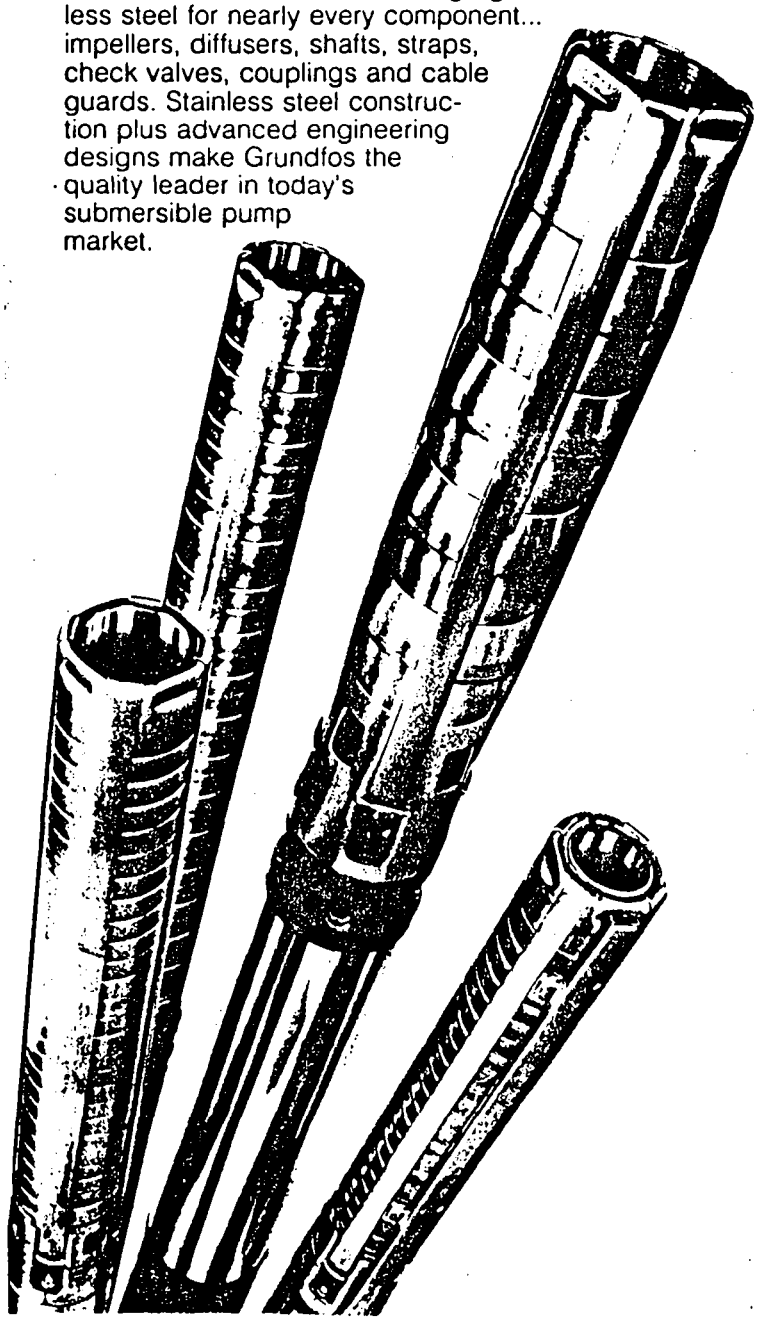
APPENDIX F

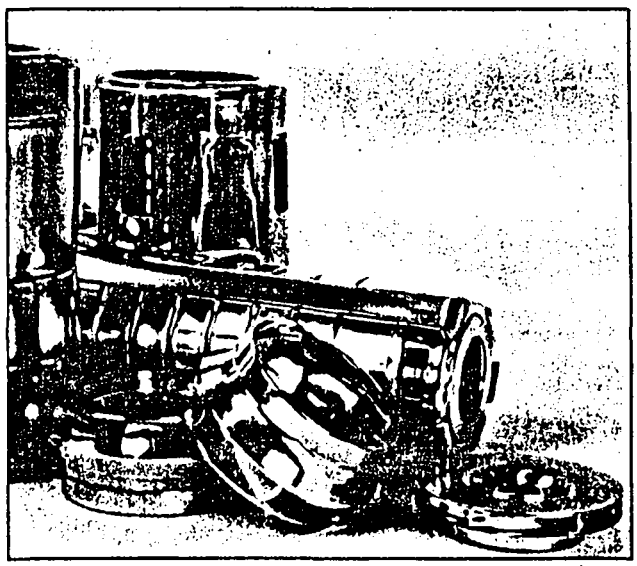
INFORMATION ON ELECTROSUBMERSIBLE PUMPS

Grundfos Stainless Steel Submersible Pumps

Stainless Steel Quality

In the pump industry, stainless steel has come to mean Grundfos Pumps. Unlike any other pump manufacturer, Grundfos uses high grade stainless steel for nearly every component... impellers, diffusers, shafts, straps, check valves, couplings and cable guards. Stainless steel construction plus advanced engineering designs make Grundfos the quality leader in today's submersible pump market.





Resistant to Wear, Corrosion and Abrasion

Stainless steel has long been recognized as the best material for pump construction. Its resistance to wear, corrosion and abrasion ranks far above the ratings for commonly used plastic, bronze and cast iron materials.

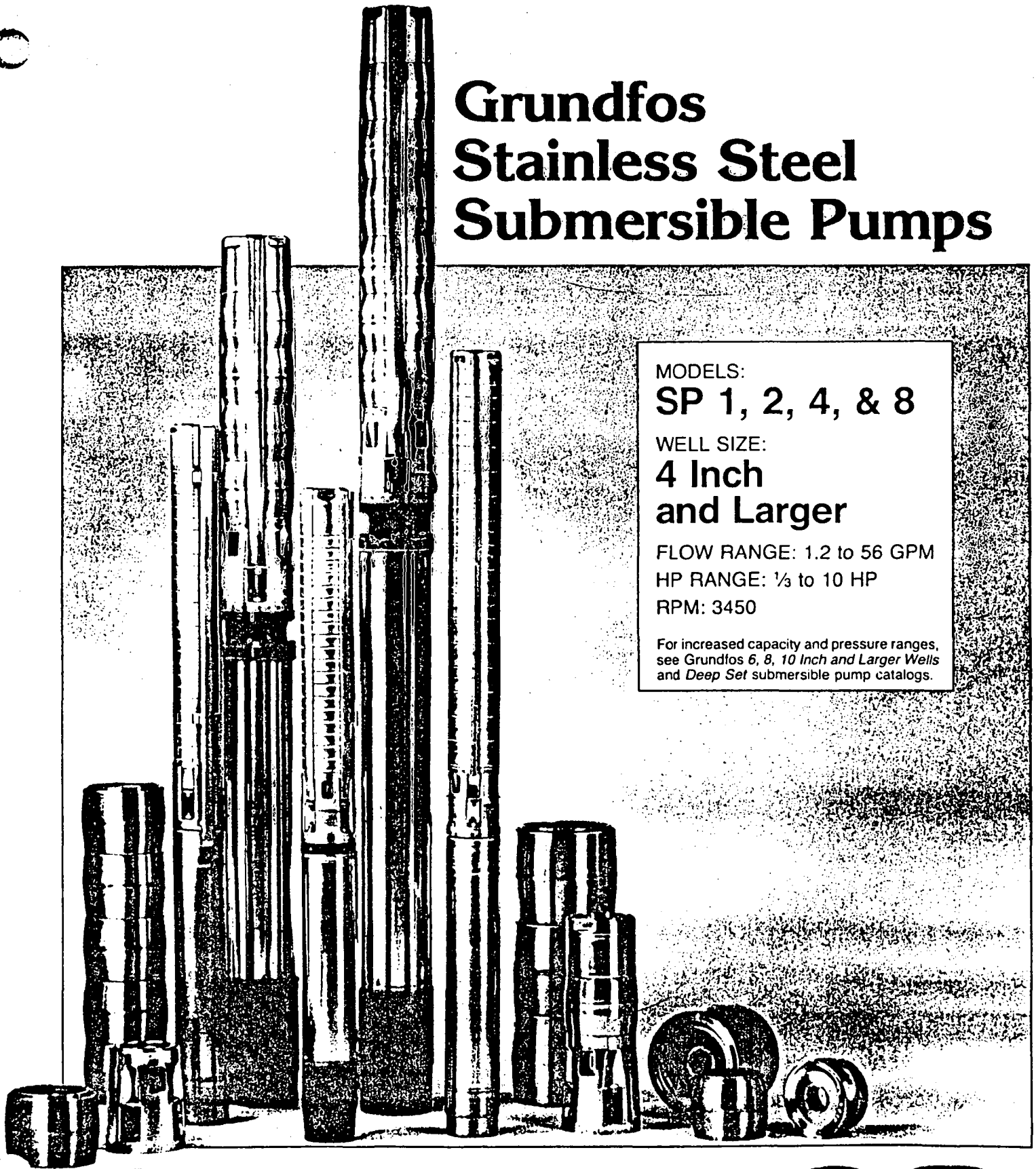
Competitively Priced

Only Grundfos has combined the superiority of stainless steel with advanced production and design techniques to produce stainless steel submersible pumps. Mass production and standardized parts have yielded a superior product at a competitive price.

Wide Operating Ranges Available

Grundfos stainless steel submersibles range in size from 4" to 10" well diameters and from ⅓ to 100 HP with capacities up to 800 GPM and to depths exceeding 1900 feet. See the Grundfos catalog for the complete line of Grundfos stainless steel submersibles for 4 inch and larger, 6, 8, 10 inch and larger, and deep set water well applications.

Grundfos Stainless Steel Submersible Pumps



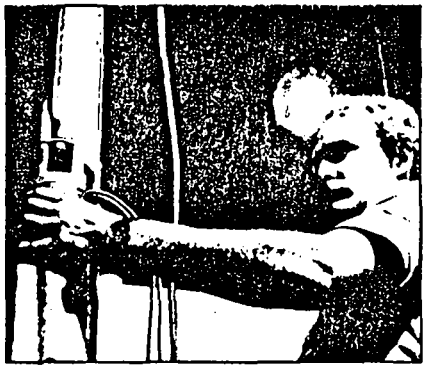
MODELS:
SP 1, 2, 4, & 8

WELL SIZE:
4 Inch and Larger

FLOW RANGE: 1.2 to 56 GPM
HP RANGE: ⅓ to 10 HP
RPM: 3450

For increased capacity and pressure ranges, see Grundfos *6, 8, 10 Inch and Larger Wells* and *Deep Set* submersible pump catalogs.

GRUNDFOS



Stainless Steel Construction

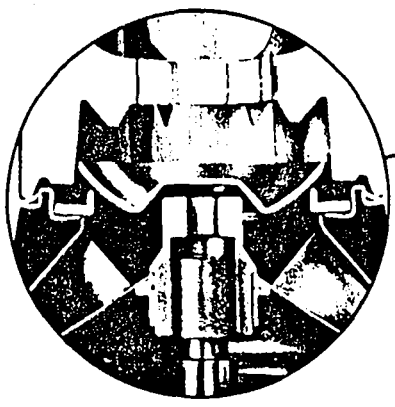
Grundfos uses high grade stainless steel (primarily 304 and 316) for nearly every component in their submersibles. Stainless steel insures Grundfos quality with its strong, but lightweight properties, its resistance to corrosion and abrasion, and its ability to be precisely shaped and fabricated.

Alternate construction pumps are also available for brackish, seawater and other harsh and corrosive environments. For oil field applications, the Grundfos "SPO" units are especially designed to handle the rigors of shallow well oil field pumping.

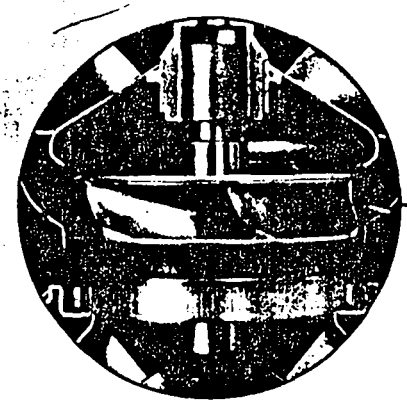
Pump Selection Guide

MODEL	MIN. WELL SIZE	FLOW RANGE (GPM)	MAX. HEAD (FEET)	MAX. HEAD (PSI)
4 Inch & Larger Wells				
SP 1	4"	1.2-7	1055	457
SP 2	4"	5-14	930	403
SP 4	4"	11-28	900	390
SP 8	4" & 6"	22-56	765	331
6, 8, 10 Inch & Larger Wells				
SP 16	6"	48-110	845	366
SP 27	6"	75-200	835	361
SP 45	6"	150-290	680	294
SP 75	8"	230-500	310	134
SP 120	10"	350-800	420	182
Deep Set				
SP 1-DS	4" & 5"	1.2-7	1695	734
SP 2-DS	4" & 5"	5-14	1620	701
SP 4-DS	6"	11-28	1720	745
SP 8-DS	6"	22-56	1450	628
SP 16-DS	6" & 8"	48-110	1745	777
SP 27-DS	8"	75-200	1910	827
SP 45-DS	8"	150-290	1220	528
SP 75-DS	8"	230-500	1080	467
SP 120-DS	10"	350-800	590	255

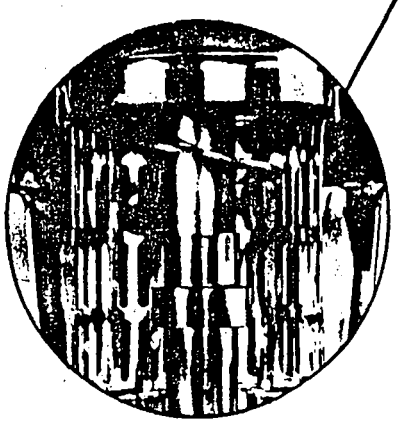
Exclusive Grundfos Designs



PATENTED, FAIL-SAFE CHECK VALVE DESIGN: Grundfos stainless steel check valves are built into the top pump chamber to prevent loss of head and backflow. These positive, non-clogging, non-slamming valves are sized to meet the maximum pressures for each model.



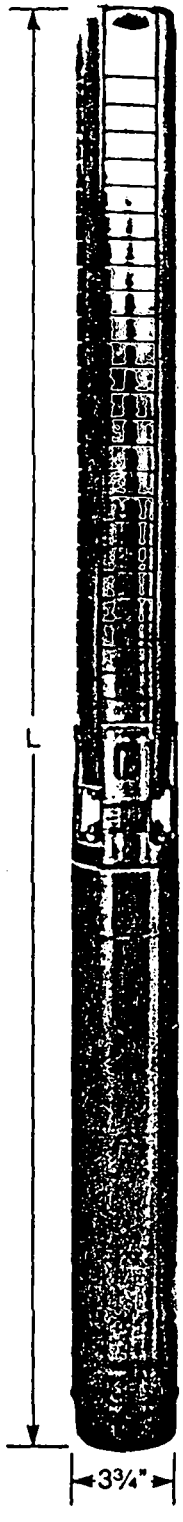
STAINLESS STEEL FABRICATION YIELDS MAXIMUM HYDRAULIC PERFORMANCE: Grundfos fabrication techniques for stainless steel permit ideal shaping of impeller and diffuser vanes to maximize hydraulic design. Combined with the inherent smoothness of stainless steel, the Grundfos design provides optimum performance and high operating efficiencies.



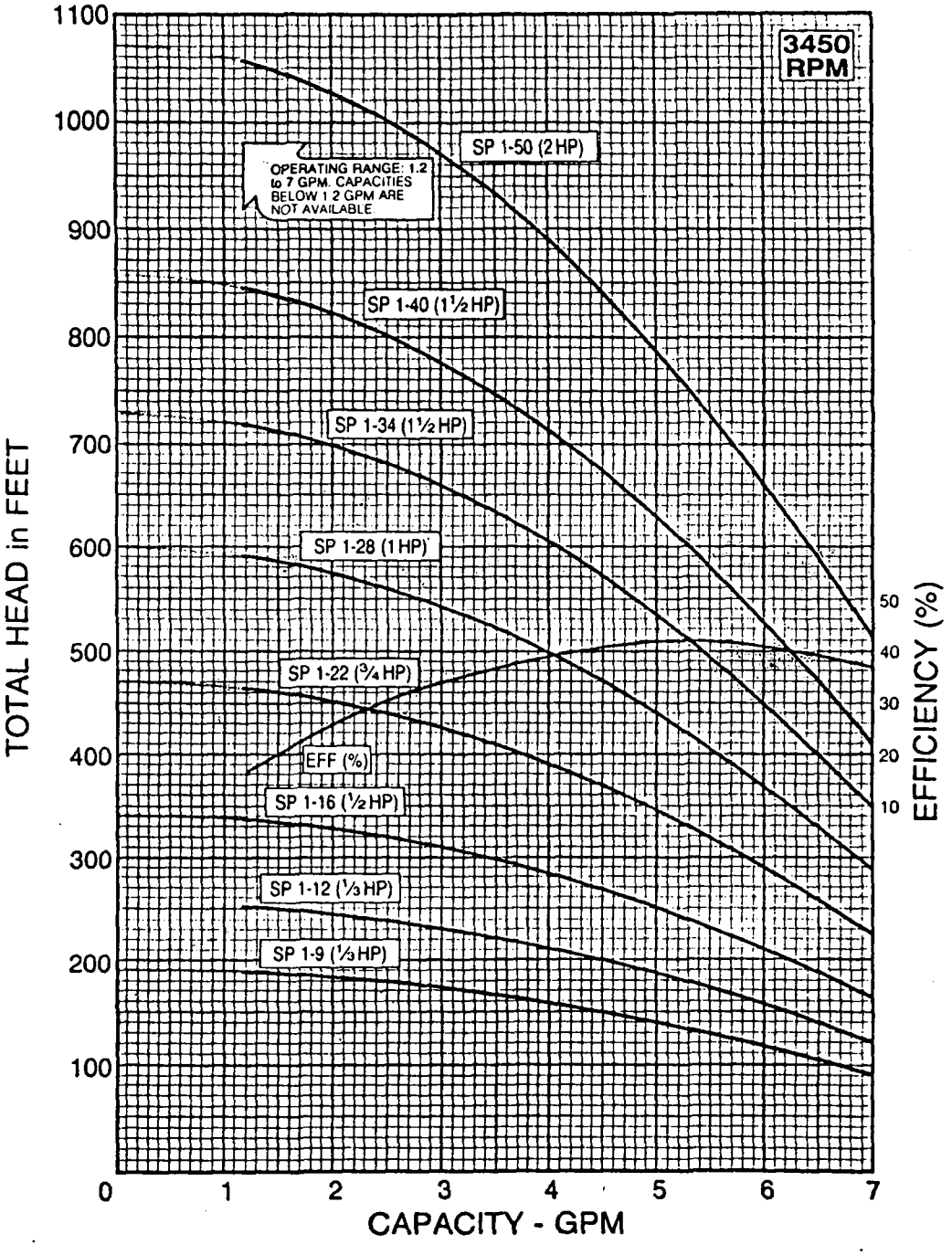
EXCLUSIVE PRIMING INDUCER PROTECTS AGAINST DRY RUNNING: The exclusive Grundfos priming inducer protects against damage due to dry running should water levels drop unexpectedly in the well. Located inside the suction interconnector at pump intake, this small, axial flow screw provides enough water to lubricate the pump until the well has time to recover.

MODEL
SP 1

NOM. FLOW RATE
5 GPM
FLOW RANGE
1.2 to 7 GPM
PUMP OUTLET
1" NPT



Performance Curves



DIMENSIONS AND WEIGHTS

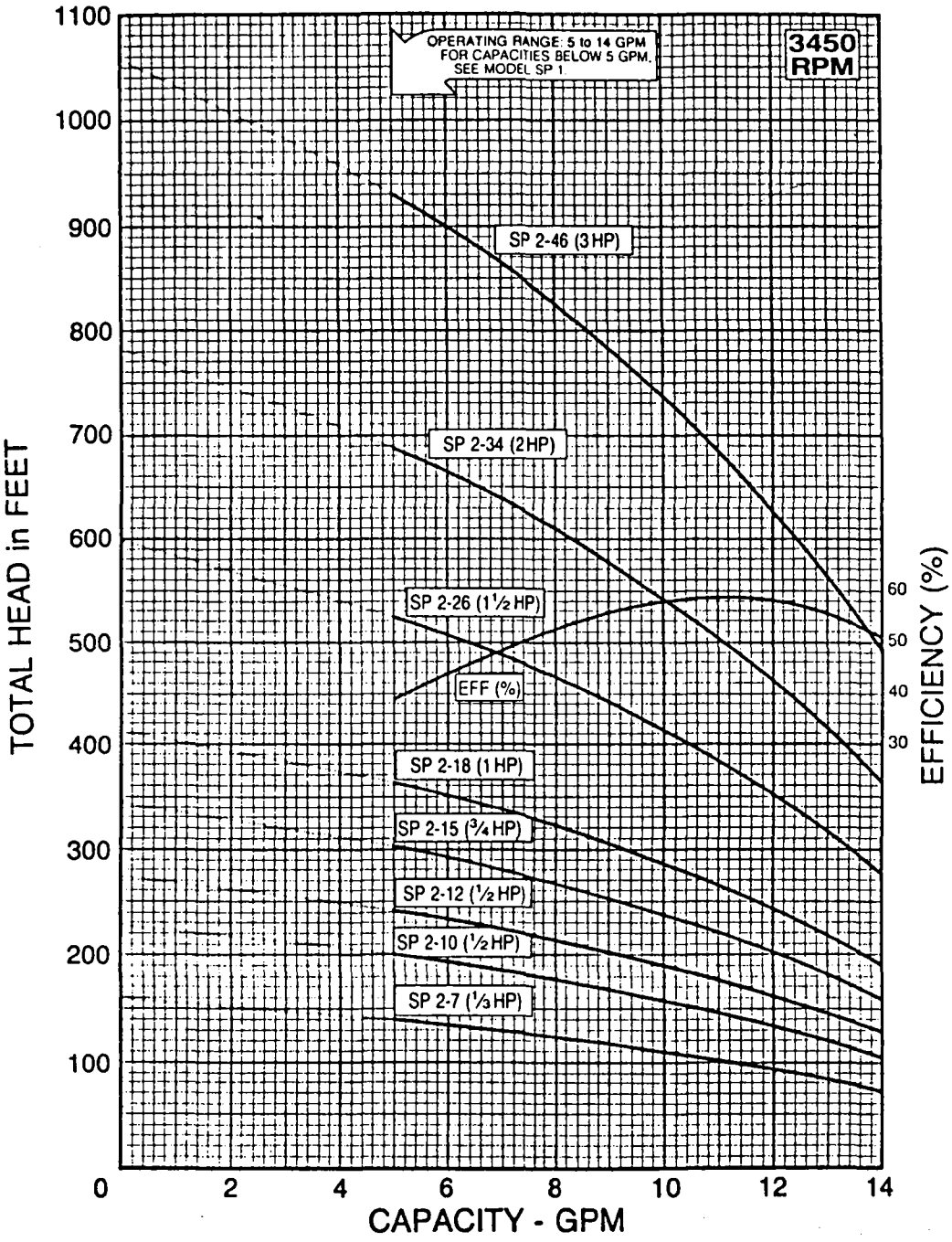
MODEL NO.	HP	LENGTH (L)	APPROX. UNIT SHIPPING WT. (LBS.)
SP 1-9	⅓	24½"	27
SP 1-12	⅓	27"	30
SP 1-16	½	31⅛"	36
SP 1-22	¾	37¼"	44
SP 1-28	1	43½"	51
SP 1-34	1½	51"	62
SP 1-40	1½	58"	68
SP 1-50	2	69¼"	83

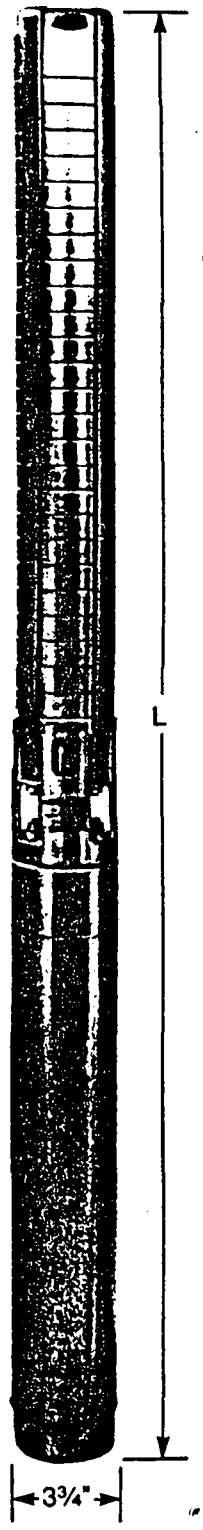
Specifications are subject to change without notice.

Performance Curves

MODEL
SP 2

NOM. FLOW RATE
10 GPM
FLOW RANGE
5 to 14 GPM
PUMP OUTLET
1" NPT





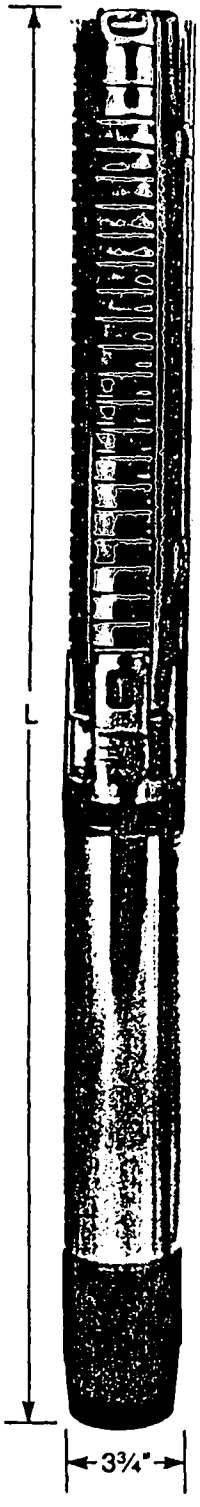
DIMENSIONS AND WEIGHTS

MODEL NO.	HP	LENGTH (L)	APPROX. UNIT SHIPPING WT. (LBS.)
SP 2-7	⅓	22⅞"	27
SP 2-10	½	26⅛"	31
SP 2-12	½	27¾"	32
SP 2-15	¾	31½"	38
SP 2-18	1	32¾"	43
SP 2-26	1½	44½"	55
SP 2-34	2	55⅞"	70
SP 2-46	3	68⅜"	92

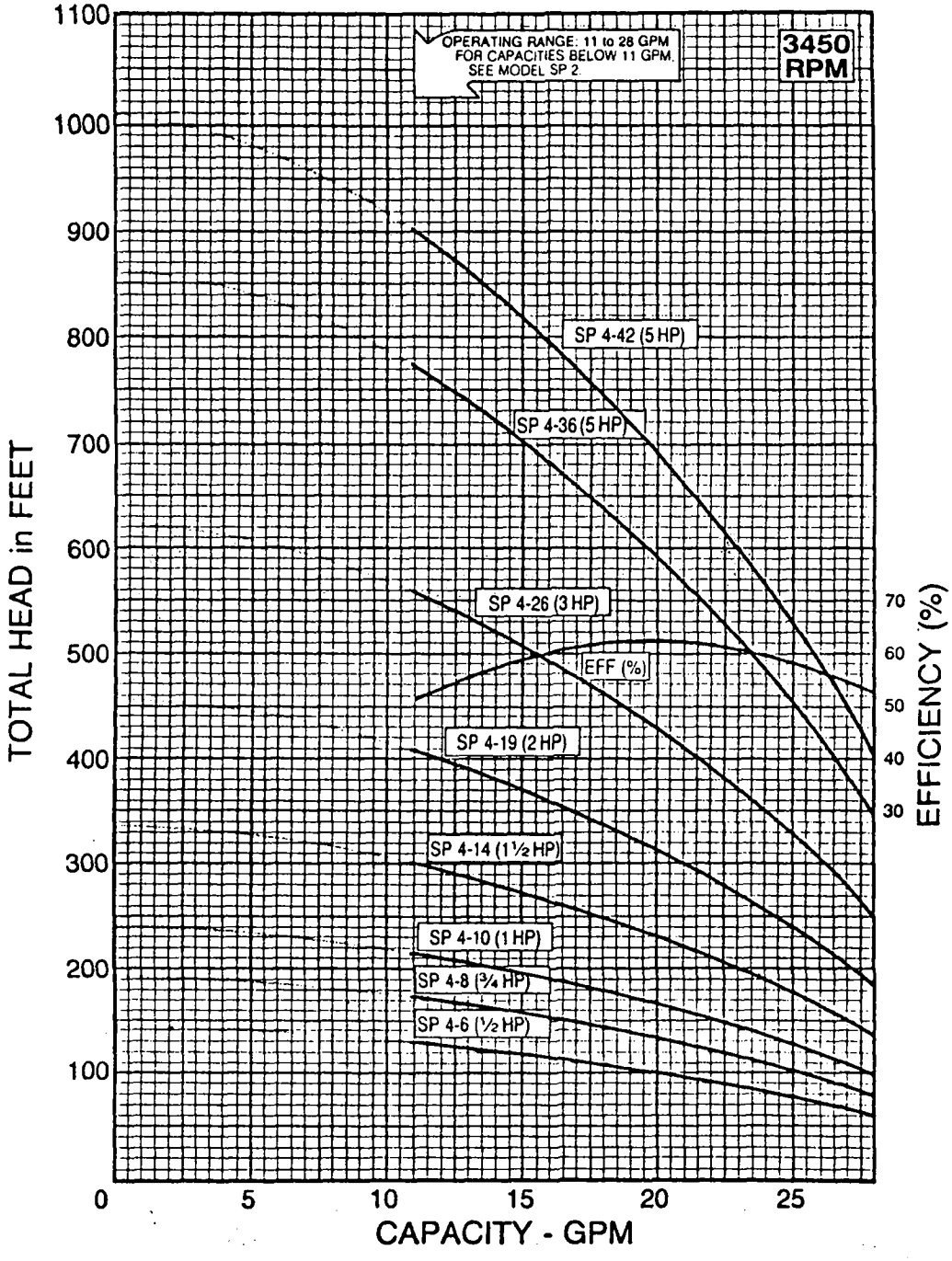
Specifications are subject to change without notice.

MODEL
SP 4

NOM. FLOW RATE
20 GPM
FLOW RANGE
11 to 28 GPM
PUMP OUTLET
1½" NPT



Performance Curves



DIMENSIONS AND WEIGHTS

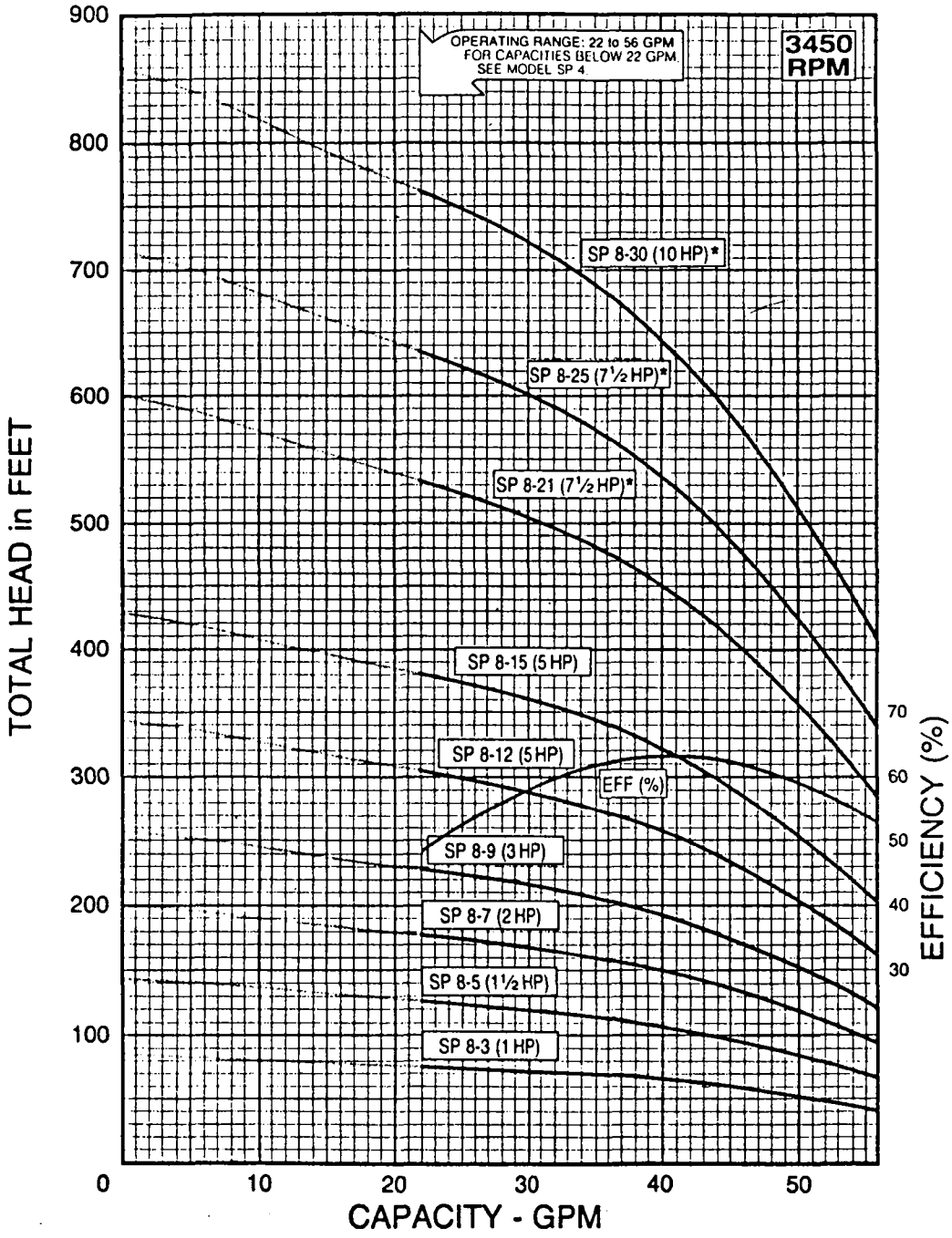
MODEL NO.	HP	LENGTH (L)	APPROX. UNIT SHIPPING WT. (LBS.)
SP 4-6	½	22⅞"	28
SP 4-8	¾	25¾"	33
SP 4-10	1	28⅝"	38
SP 4-14	1½	34⅝"	47
SP 4-19	2	43½"	59
SP 4-26	3	51¾"	78
SP 4-36	5	66⅛"	104
SP 4-42	5	71"	110

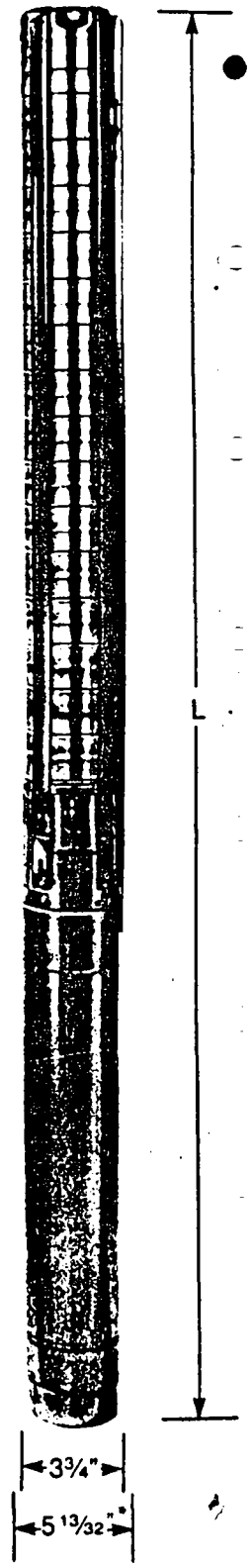
Specifications are subject to change without notice.

Performance Curves

MODEL
SP 8

NOM. FLOW RATE
40 GPM
FLOW RANGE
22 to 56 GPM
PUMP OUTLET
2" NPT





DIMENSIONS AND WEIGHTS

MODEL NO.	HP	LENGTH (L)	APPROX. UNIT SHIPPING WT. (LBS.)
SP 8-3	1	27⅞"	35
SP 8-5	1½	33¾"	43
SP 8-7	2	41⅞"	54
SP 8-9	3	47⅝"	70
SP 8-12	5	58⅝"	91
SP 8-15	5	63⅝"	97
SP 8-21	7½*	75¾"	164
SP 8-25	7½*	82⅜"	172
SP 8-30	10*	94⅜"	201

* A 6" minimum well diameter is required for the SP 8-21 (7½ HP), SP 8-25 (7½ HP) and SP 8-30 (10 HP) models.

Specifications are subject to change without notice.