LIMA DISASTER PREPAREDNESS REPORT

VOLUME IV:

Water and Sewerage

by

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FOREWORD

This is one section of a fifteen volume report concerning disaster preparedness in Lima, Peru. It was researched in Lima by a team of disaster specialists during the period July - November, 1981, for the Agency for International Development's Office of U. S. Foreign Disaster Assistance and USAID Mission in Peru. The report is supplemented by a considerable number of maps, charts and resource documents which are located in the USAID/ Peru Disaster Preparedness Resource Library in Lima.

June 1982

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The Lima Disaster Preparedness Report has 15 sections:

Volume I:	Methodology Employed
Volume II:	Port of Callao Infrastructure Security and Emergency Evacuation Needs
Volume III:	Electricity
Volume IV:	Water and Sewerage
Volume V:	Heavy Equipment Rehabilitation and Maintenance
Volume VI:	Airport and Aircraft Resources
Volume VII:	Education
Volume VIII:	Food
Volume IX:	Housing
Volume X:	Health
Volume XI:	International Donor Coordination
Volume XII:	Critical Abstracts from the Literature: A field perspective on major earthquakes: Peru, 5-31-70 Nicaragua, 12-23-72 Guatemala, 2-4-76
Volume XIII:	Review of Earthquake Prediction by Brian Brady
Volume XIV:	Other Issues
Volume XV:	Summary

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NOTE

This section of the disaster preparedness report focuses on Lima's water and sewerage system. It contains:

One principal volume

One supplementary volume, referred to as the "supplementary volume" in the text of the principal volume

Ten Maps (listed on the previous pages)

Three Books of Data (listed on the previous page)

USEFUL DATA FOR ANALYZING WATER/SEWERAGE SECTOR

1 cubic meter	=	1,000 liters (= 220 gallons)
1 cubic meter	=	1,000 liters (= 2,200 pounds)
1 gallon	=	10 pounds
1 cubic meter	=	1,000 kilograms
1 liter	=	1 kilogram
1 hectare	=	2.47 acres

EXAMPLES

15 cubic meters ($15m^3$)	=	15,000 liters
	=	3,300 gallons
	=	33,000 pounds
	=	15 kilograms

Very often, reference is made to a rate of production of water, and is expressed in cubic meters per second = m^3/s.

INTRODUCTION/EXECUTIVE SUMMARY

Lima's water supply and sewerage systems are its most vital lifelines. As water is relatively scarce in Lima in the best of times, it is of great concern to disaster preparedness planners in the City. This report describes the two systems, which are managed by a State-owned and managed public utility known by its acronym, ESAL. It provides a glimpse of post-disaster experiences after earthquakes in Peru (1970), Managua (1972) and Guatemala (1976). Some of the system's principal vulnerabilities in an earthquake are presented, and proposed disaster preparedness and response actions are recommended. Lima's post-disaster water requirements are estimated at about 50,000 cubic meters per day — 10 liters per person.

Nearly 60% of Lima's water is drawn from the surface of the Rimac River. Before it reaches the captation point, the river has served as a depository for three other sewerage systems and considerable industrial waste. About 40% of Lima's water is produced by a series of approximately 200 ESAL-managed water wells in Lima.

Rimac River water is processed at the La Atarjea Water Treatment Plant located within the City, designed to purify water coming in with a rate of up to 3,500 parts per million impurities (PPM) down to about two PPM. But during landslide periods, the intake level sometimes reaches up to 90,000 PPM. The plant's gravity-flow system relies principally on natural sedimentation for purification, but also uses coagulants and chlorine. The plant relies principally on the power authority, ELECTRO-LIMA, for its energy and has its own secondary substation nearby. It has an 80 horsepower generator, which is inadequate to efficiently substitute for normal power.

Nearly 30% of all water well-production is generated by only 24 of the City's 229 active wells. These 24 produce 130,000 cubic meters of water per day, about 9% of the City's daily consumption. All wells are powered by ELECTRO-LIMA high-tension wires, which are stepped down at each well by transformers to appropriate levels. In the past, before ELECTRO-LIMA's service was completely reliable, many wells had generators or gear head drives as auxiliary power sources; today, none have standby power.

ESAL's distribution network (4,800 kilometers of water piping; 4,000 kilometers of sewerage piping), serve about 400,000 homes; about 3,400,000 people; about 75% of the City's population. In the water pipe distribution network, new major trunklines -- steel-reinforced concrete pipes -- are considered highly seismic resistant; while some of the newer but somewhat smaller trunk lines are not as reliable. A considerable proportion of the distribution lines are asbestos cement with rubber joints between them. The sewerage network tends to rely almost entirely on concrete joints between pipes and is considerably more vulnerable.

For the parts of the City without pipe distribution, a group of about 180 private tanktrucks (2,000 gallon capacity per truck) distribute water. Tanktrucks are filled by ESAL at very low prices and distribute directly from truck to individual family. It is reported that there are 100 additional trucks being used for other purposes which can be rapidly refitted to carrying water in an emergency; and the municipal authorities have about 50 trucks used for watering parks.

For emergency fire-fighting, there is a network of 4,500 hydrants. But water pressure is erratic.

In addition to the ESAL water system, there is an underground irrigation system which consumes about five cubic meters per second from the Rimac River and without decontamination is used for some agriculture but mostly for watering parks.

In the Chillón Valley north of Lima, there are numerous wells used for irrigating agricultural lands. Five of these provide 25,000 cubic meters of water per day in normal times; they are powered by diesel generators and are completely independent of the ELECTRO-LIMA system.

Finally, there are about fifteen substantial privately-operated wells in Lima, many of which have their own generators. There are also some shallow wells where water can be tapped at a depth of only six to eight meters, permitting their operation with small [10KVA] generators.

Sewerage tends to be conducted through the piping system by gravity, with the exception of about ten critical spots around the city where power -- supplied by ELECTRO-LIMA -- is required for operation. About 65% of the City's waste is pumped into the Pacific at the northern side of the City, in El Callao; the balance is discharged in the south.

The vulnerabilities of the water and sewerage systems in Lima are multiple: the Atarjea water treatment plant has poor standby power resources; its 500,000 cubic meter storage reservoir broke down because of structural collapse in 1970 without earthquake provocation, flooding downtown Lima -- at that time the reservoir was only about 30% full.

Hydrogeologists do not anticipate substantial permanent change in the underground water table. But the water wells are completely dependent on ELECTRO-LIMA's power. Thus, even though the majority of wells would structurally survive an earthquake, they could not function. The water pipe distribution system would be expected to fare erratically: the main new

trunk lines may survive; the secondary trunk lines cannot be relied upon; and much of the asbestos-cement distribution piping would fracture. The sewerage system is more vulnerable than the water system, because more than 90% of it has unreinforced cement joints. Because the sewerage system is generally constructed under the water pipes; and because there is a layer of about 30 meters of earth between the sewerage lines and the underground water supply, contamination of the underground water supply is not anticipated. But if sewerage waste rose to the surface in some places, it could flow into water wells. ESAL does not have the magnitude of equipment or trained staff to conduct emergency water quality tests on a large scale.

The City's valve control system for water is not in reliable working order. Thus, manipulation of available water pressure would be difficult after an earthquake, as it is in daily emergencies (for example, for firefighting).

Lima could upgrade its level of preparedness for a major earthquake if some of the following suggestions were considered:

- Raising the priority for the purchase of a 300 KVA generator for the Atarjea water plant;

- Identification, in advance, of water wells to which ELECTRO-LIMA should give immediate priority after an earthquake;

- Placement now of available gear-head drives on the 24 key water producing wells;

- Fitting the 24 principal wells with dispenser units, permitting their use in conjunction with tanktrunks or water bladders;

- Considering revisions in the construction specifications for some types of water storage tanks;

- Planning for post-disaster operations with increased specificity and including the potential use for back-up purposes of the Chillon Valley wells, the underground irrigation system, the industrial and "shallow" wells; and, as a worst-case back-up, the use of Chillon or Lurin surface river water.

- Increasing ESAL's capacity to monitor water quality after a disaster, through provision now of emergency testing equipment and staff training;

- Equipping major new wells to be constructed with both standby power (gear head drives) and dispenser units, features which can be incorporated from design stage at costs considerably lower than those of retrofitting the units;

- Finalizing contingency plans for providing water to hospitals.

In the event of a disaster, AID/Peru through its Office of Engineering should establish contact with ESAL. In addition, USAID could consider:

- Provision of experienced water engineers for liaison and technical purposes;

- Provision of full-circle clamp couplings via emergency airshipment. These couplings, which require no special equipment for use, could greatly accelerate immediate, permanent repair of fractures in the pipe system.

- Emergency provision of gear-head drives, available from a local producer in Lima;

- Provision of water purification units after the disaster. However, a warning: OFDA's seven units can provide only 600 cubic meters per day, about 1% of the City's minimum need. Still, in a worst-case emergency, these units could be used at selected critical facilities, perhaps drawing on the underground irrigation system.

- Provision of rubberized canvas water bladders, with about 2,000 gallon capacity, to permit decentralized tanktruck distribution of emergency water supplies, and permitting tanktrucks to be used for delivery (not storage or distribution) of water;

- Provision of emergency sanitation expertise and resources.

The provision of enough generators to provide significant standby power for water wells would be impossible. One large standby generator for La Atarjea, if provisions have not been made before then, might be useful only in the unlikely case that ELECTRO-LIMA is unable to provide emergency power.

ESAL currently possesses two mobile electronic leak detectors, recently acquired from the HYDROTRONICS/Miami group, and trained operators for them.

A list of contacts in the water/sewerage public and private sectors appears at the conclusion of the report.

LIMA'S WATER AND SEWERAGE SYSTEMS

Introduction

Lima's water supply and sewerage systems are its most vital lifelines. Discussions concerning the City's ability to sustain and recover from a major earthquake inevitably focus on the water supply system, as water, even in the best of times, has been scarce and the size of the population demands that this service continue virtually uninterrupted after an earthquake.

One international organization has suggested that the minimum daily requirement for water — for very short initial periods after disasters -- is ten liters per person. Thus, Lima requires 50,000,000 liters, equal to 50,000 cubic meters per day to "survive".

This report describes the City's current water and sewerage systems, which are managed by a State-owned and managed public utility called the Empresa de Saniamiento de Lima - commonly known by its acronym, ESAL.* It reviews some problems in this sector which arose after earthquakes in Guatemala (1976) and Managua (1972), as well as the major national experience — Peru (1970). Some of the vulnerable components of the water system will be described, together with a synopsis of the state of ESAL's planning and capacity to deal with such an emergency.

Finally, a number of fairly modest steps which could be taken to prepare for and accelerate post-disaster operations, and some areas where USAID might assist ESAL in its post-disaster recovery efforts, are suggested.

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* After the drafting of this report, ESAL's name was changed to SEDAPAL, Servicio Departamental de Agua Potable y Alcantarillado de Lima.

Institutional and Technical Planning

At the moment, there are two important initiatives which are well underway which will affect the management and future of ESAL and the Lima water system:

1. Reorganization of Water Sector The Ministry of Housing has the overall responsibility for water distribution in Lima. It has established a new unit within the Ministry, the Servicio Nacional de Agua Potable y Alcantarillado (SENAPA), which will join together under one office all of the local municipal water authorities which currently operate in less coordinated fashion. In addition, a number of responsibilities for water wells will pass from the jurisdiction of the Ministry of Agriculture's Underground Water Division to SENAPA. Of special interest to disaster preparedness, SENAPA (and ESAL) will gain control of all water wells within Lima.

2. Master Plan for Lima Water System

Under a World Bank loan, a long-term planning project has been undertaken for the Lima water system. This plan includes three components:

(a) Diagnosis of Water Leakage The U.S. (Miami) based firm HYDROTRONICS Corporation of America was contracted to undertake a diagnosis of leaks in the current water system. This study was completed several months ago, and a final report has been filed with ESAL.

At the end of the contract, HYDROTRONICS encountered problems with Peruvian Customs Authorities in shipping their mobile electronic equipment back to their home-base. Exhausted by the effort, HYDROTRONICS finally offered ESAL two such fully-equipped units at a cost of US$15,000 each, which was probably the value of the vehicles alone. ESAL has accepted the offer

and now possesses two fully equipped mobile units for leak detection. They plan to integrate these units into their normal maintenance programs. During their work in Peru, HYDROTRONICS trained several Peruvian technicians in the use of their equipment. These technicians have now been hired by ESAL on a full-time basis.

(b) The U.S. based firm of ENGINEERING SCIENCE is conducting the second major component of the World Bank planning project. This is the development of a Master Plan for Lima's water supply system. The plan is studying the City's well network (detailed information concerning their methodology is presented later); the river supply and distribution system, and the ambitious project to construct aqueducts to conduct Mantaro River water to the City via the Rimac River.

(c) A final activity under the loan is an analysis of the institutional management structure of ESAL, rates of remuneration, and other organizational issues.

The ESAL Water System

This brief description of the ESAL water system will be divided into three parts: production of water, distribution through the pipe network and via tanktruck delivery; and consumption. Finally, a brief description of the City's sewage system is provided.

In addition to extensive interviews with ESAL officials, much of the data presented in this section is drawn from the following sources:

- ESAL Memoria - 79 (Booh A)
- ESAL Boletin Estadistico - Primer Semestre 1980 (Booh B)
- ESAL - El Agua Potable - Planta de Tratamiento de las Aguas del Rio Rimac
- Informes Mensuales - Enero, 1981, Marzo, 1981 - Gerencia de Operaciónes
- Monthly Reports on Well Production for Lima and El Callao (see items A and B in supplement) and other documentation provided by ESAL.

Production

Lima relies principally on two sources of water:

— Nearly 60% is surface water drawn from the Rimac River and processed at the Atarjea Water Treatment Plant. Before the river reaches Lima, it receives sewerage from three systems up-river and considerable industrial waste discharge.

— Almost 40% is well water, drawn from a series of about 200 wells operated in the City by ESAL.

A small percentage, not exceeding 2%, is drawn from natural springs located at the Atarjea Water Treatment Plant. Because of the proportionately small share of total production from this source, it receives little attention in this report.

Through the ESAL system, Lima consumes just over sixteen cubic meters per second ($16m^3/s$) of water (= 16,000 liters per second), which is the equivalent of about 1.4 million cubic meters or 1,400 million liters of water each day. Based on these figures, the per capita consumption of water in Lima is about 0.3 cubic meters, or about 300 liters, per day.

In general, the production level in the most recent officially reported period (January through June, 1980) was:

Production Source	Cubic Meters Per Second	Cubic Meters Per month (000's)	Percentage of Total
La Atarjea Water Treatment Plant	9.46	24,800	58.5%
Water Wells in Lima and El Callao	6.33	16,600	39.0%
Springs	0.39	1,000	2.5%
TOTAL	16.18	42,400	100.0%

Chart I, at the following page, traces the evolution from 1956 through 1979 of gross ESAL water production, indicating also the proportion of water attributable to each of the above sources. Chart II provides similar statistics for 1977, 1978 and 1979.

The first quarter of 1981, for which statistics are also available, was an unusual one because of landslides and mass failures in the Rimac Valley which disrupted plant production. During March, the most disrupted month, figures from unpublished documents were as follows:

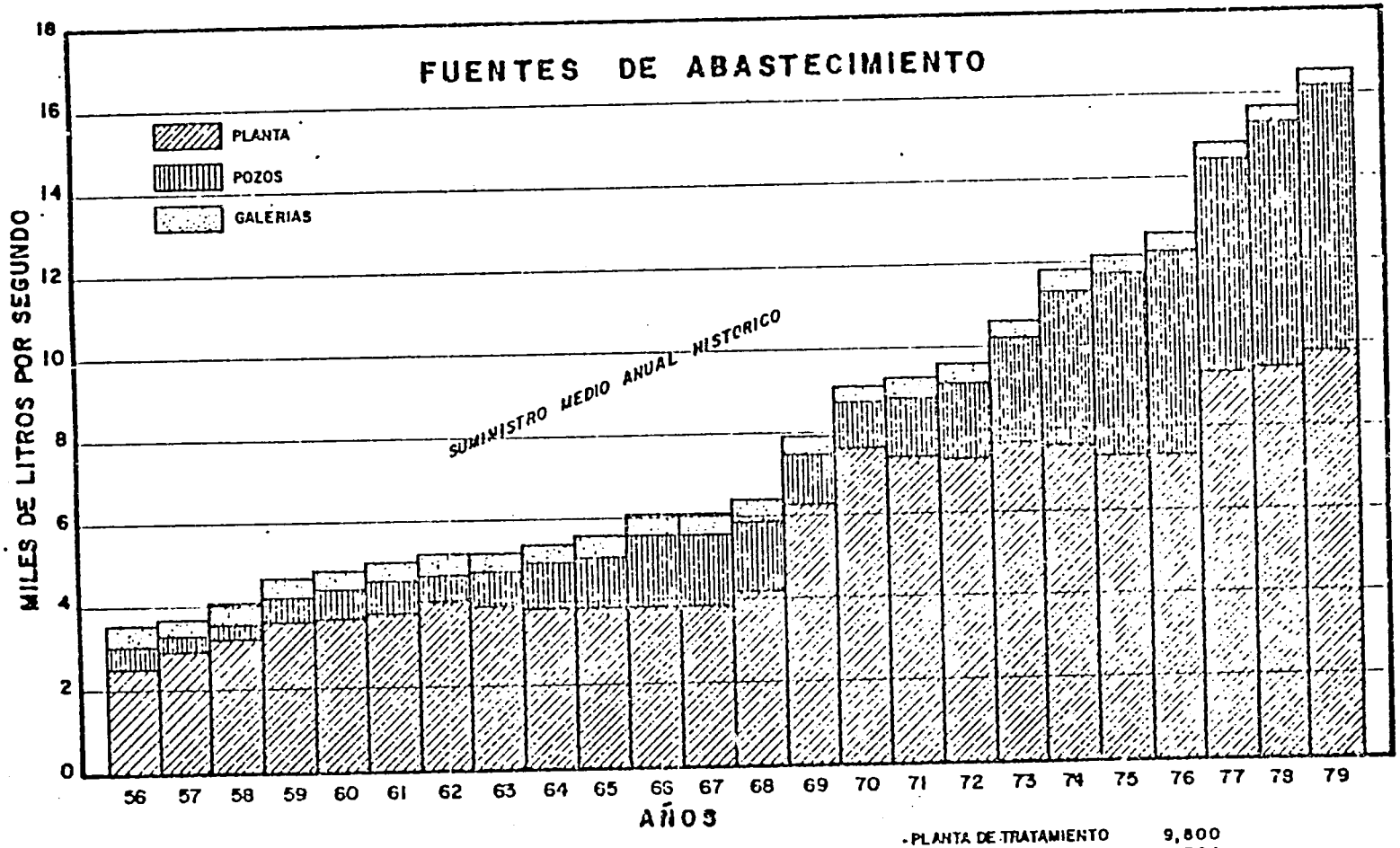
	Cubic Meters Per Month (in 000's)	Percentage of Total
La Atarjea Water Treatment Plant	19,000	54%
Wells in Lima and Callao	15,500	44%
Springs	1,000	2%
TOTAL	35,500	100%

March production was lower than previous averages by about 16%, attributable almost entirely to lower production at La Atarjea Water Treatment Plant, which fell 23% because of river turbulence problems described later in this report.

In general, however, water production for Lima could be summarized as follows:

La Atarjea Water Treatment Plant	nearly 60%
Water Wells in Lima and El Callao	nearly 40%
Springs	about 2%
TOTAL	100%

Chart I



EN 1979 LA PRODUCCION DE LAS FUENTES DE ABASTECIMIENTO FUE COMO SIGUE :

-PLANTA DE TRATAMIENTO	9,800	
-POZOS	6,304	
-GALERIAS	389	
TOTAL	16,493	L.P.S.

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Chart II

VOLUMEN DE AGUA PRODUCIDO

FUENTES \ AÑOS	1979		1978		1977	
	m3	%	m3	%	m3	%
PLANTA DE TRATAMIENTO LA ATARJEA	309'052,800	59.4	296'438,400 (*)	59.7	293'284,800 (*)	60.9
GALERIAS FILTRANTES	12'259,800	2.4	12'259,800	2.5	12'261,000	2.5
POZOS	198'813,433	38.2	187'770,839	37.8	176'267,930	36.6
— LIMA	171'301,743	32.9	158'787,695	32.0	150'443,456	31.2
— CALLAO	27'511,690	5.3	28'983,144	5.8	25'824,474	5.4
TOTAL	520'126,033	100.0	496'469,039	100.0	481'813,730	100.0

(*) VOLUMENES CORREGIDOS POR ERROR EN APRECIACION DE LECTURA EN INSTRUMENTOS DE PRECISION.

La Atarjea

Lima has throughout its history relied principally on surface water from the Rimac River and the City has grown up on the river's banks. The first tax imposed on the City, in 1575, was used for the Atarjea captation facility and for the construction of an aqueduct to the Plaza de Armas. At the time the Atarjea was constructed, it was located outside the City, about eight kilometers from its center.* Today, it is located inside the City, just above the densely populated neighbourhood of Barrios Altos, formally a part of the Cercado de Lima District and close to the City Cemetery (see aerial photographic MAP A and the Plant) and continues to provide nearly 60% of the City's water supply.

The water system really begins with a series of highland lakes which are regulated by the hydro-electric authority, ELECTRO-LIMA. Chart III at the following page illustrates the amount of water actually stored in these lakes (total capacity is 170 million cubic meters) and the manner in which they are regulated to insure a steady flow of water, especially during the drier or summer months of the year (January - March).

La Atarjea's role begins at its captation point on the river, which is regulated by seven concrete and steel locks. These locks permit the Atarjea to repress the flow of water in the river, raising its level almost as if it were a reservoir, and forcing the flow of water into its pipe systems for conduct into the plant. Its captation capacity is fifteen cubic

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* For a historical summary of the evolution of the City's water system from the 16th Century, see excerpts from Estudio del Mejoramiento de la Red de Distribucion de Agua Potable de Lima, 1956, included in the accompanying "Water Supplement" volume.

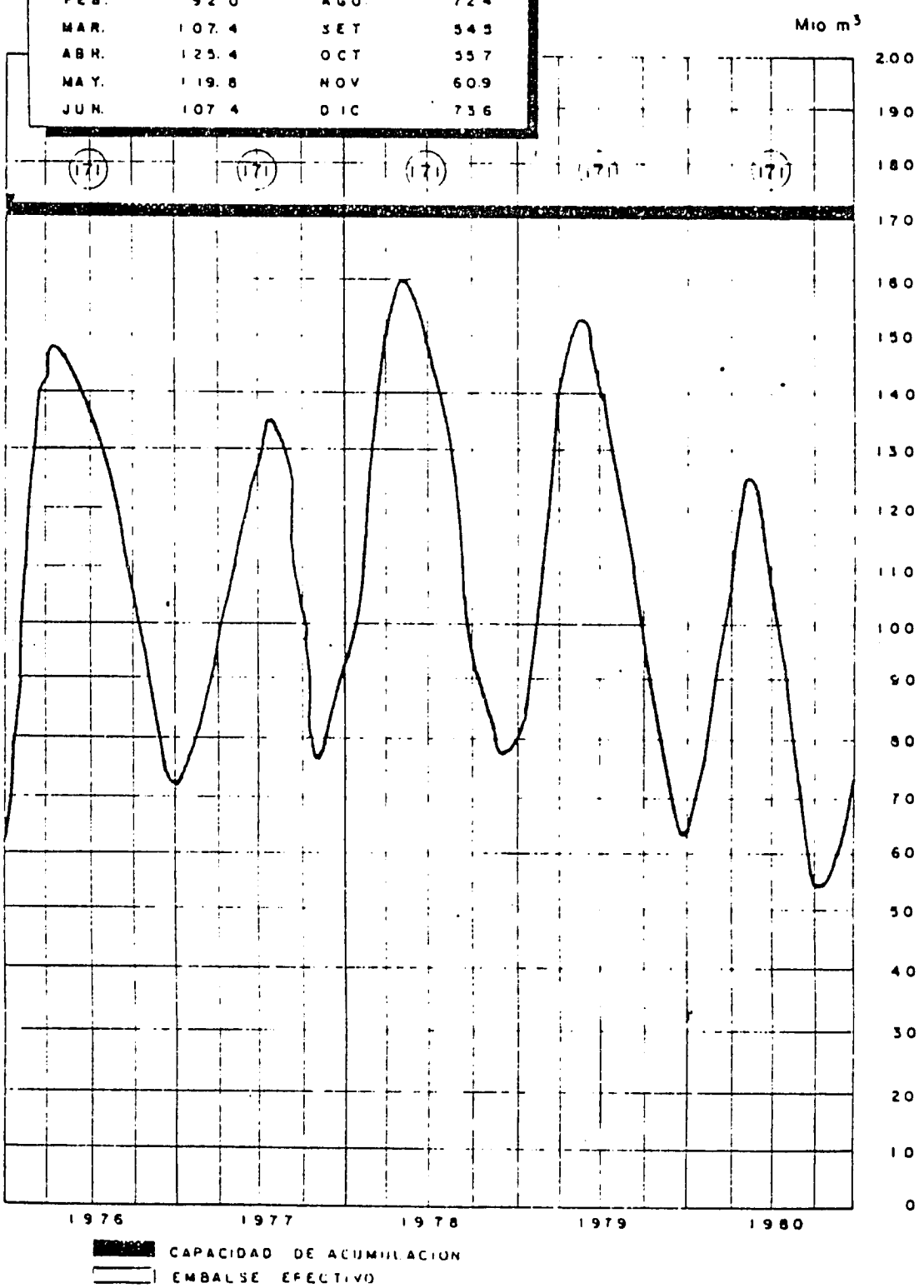
CAPACIDAD DE ACUMULACION Y EMBALSE EFECTIVO DE LAS LAGUNAS DE REGULACION

(En millones de m^3 a fin de mes)

1980

EMBALSE EFECTIVO A FIN DE MES

	Mio m^3		Mio m^3
ENE.	78.8	JUL	91.2
FEB.	92.0	AGO.	72.4
MAR.	107.4	SET	54.5
ABR.	125.4	OCT	55.7
MAY.	119.8	NOV	60.9
JUN.	107.4	DIC	73.6



metres per second, greater than the plant's processing capacity by 50%. Large pieces of debris are excluded from captation. The locks require energy for their operation. In an emergency, they can be manually raised or lowered. Each such manual operation requires 20,000 turns. It takes one worker about 2 - 3 hours to open or close each one (of seven) locks.

During the April/December period, the plant normally handles water which, at the captation point, has about 30 parts per million of impurities. Through sedimentation this is reduced to 10 parts per million; and through filtration to no more than two parts per million.

However, during the January - March 1981, the rate of impurities reached "incalculable" levels. During those times the plant reduced production by up to 75%. According to ESAL's Director of Operations, the plant was designed to handle a maximum of impurities of 3,500 parts per million.

The locks are especially important because there have been numerous landslides and collapses of cliffs into the River at higher mountain points. Ten to twelve hours later the mudslides reach La Atarjea. The lock system enables the plant to insure that such mud flows do not enter the plant.

For example, during a particularly difficult period, March, 1981, there were 11 major landslides in 10 separate days. The captation process had to be interrupted for an average of five hours each time (interruptions usually ranged from about 1.5 to 6 hours.) In seven of these cases, the captation process had to be suspended beginning between 9 p.m. and 1 a.m.; in the other four, the problems arose during normal working hours.

Maximum turbiedad (level of impurities) was experienced during a 15-hour interruption when it reached 90,000 parts per million. Two of the cases ranged from 40,000 - 60,000 PPM, and the rest were in the range of 13,000 to 30,000.

The entire Atarjea System, and almost all of the Lima water system, is based on gravity-flow. Energy is not required to move water from one place to

another. The graphic illustration, entitled EL AGUA POTABLE: PLANTA DE TRATAMIENTO DE LAS AGUAS DEL RIO RIMAC, describes and illustrates the steps through which the water passes in the treatment process.

From the captation area, the water flows into a series of sedimentation tanks each is about 35 metres long through piping which is approximately 70 metres long (width: 2.4 metres).

At that point, the water may be directed into the treatment plant, or into the regulating reservoir -- the system's largest -- which can be seen on both the aerial photograph and the illustrative chart. This reservoir holds about 500,000 cubic metres of water. Its construction was completed in about 1970. As can be seen, three sides are constructed; the fourth is a natural rock surface.

When this tank was completed, and had been filled to about 30% of capacity, it burst at the point where the natural rock surface meets the man-made wall, causing flooding in central Lima (and, in fact, reaching the Palacio Nacional). The collapse was not due to seismic movement, and whether there was a design fault or a construction error is still in dispute. However, the damage was repaired, and concrete was pumped into the weak area under pressure. There have been no further collapses since 1970.

(Note: The Plant also controls four holding tanks of 40,000 cubic metres each and four additional of 13,000 cubic metres each, which store processed water.)

The purpose of the reservoir is to insure a steady flow of water to the plant and to the city, especially in the dry season. Its periodic cleaning usually takes 50 tractor days; but after the March, 1981 mudslides, four tractors had to work for 45 days each to scrape the mud out of the reservoir. The water purification process relies mainly on natural sedimentation. However,

the following other techniques are also used:

— Aluminium sulfate and lime are used as coagulants for purification. They are added to the water at two points in the plant. At one of these points, the water is pumped through tanks which keep the coagulants circulating through the water (rather than sinking under the weight of the particles that have already adhered to them) so that they may continue to attract such impurities. This is one of the plant's areas that is highly dependent on energy. In a normal month, like January, 1981, the plant used about 525 tons of aluminium sulfate for the refining process; in March, 1981, when the mudslide problems were especially severe, consumption rose to 1,025 tons.

— Sand is used, as shown on the chart, to remove any fine particles which may remain in the water after other processing has been completed.

— The water is then chlorinated, a process also dependent on energy, as well. Each month, the plant uses about 70 tons of chlorine, at the rate of about 0.002 kilos per cubic metre.

There are several critical functions at the plant which require power for their operation. (The locks on the River, water purification and others.) The plant relies on ELECTRO-LIMA for energy, and there is a special sub-station serving only the plant's needs. The plant has a gasoline powered, ONAN Brand, 80 horsepower generator (three-phase, 60 cycle) for back-up purposes. This level of power was designed as a backup for the 1956 plant production of about five cubic metres per second, a level which has since doubled. Thus, when ELECTRO-LIMA energy fails for any reason, only part of the plant can be powered. Its managers must periodically connect and disconnect discrete circuits, because not all the vital systems can be operated by the generator at one time. It has been estimated that the plant did not have normal ELECTRO-LIMA power, but were otherwise undamaged, it could provide a reduced amount of water, but with an impurities rate of 10 PPM.

Water Wells (Lima and El Callao)

About 40% of Lima's water is produced by water wells, as follows:

Section of City	Gross Number	In-Service	Out-of-Service
Lima	224	197	27
El Callao	40	32	8
	264	229	35

Map B illustrates the hydrogeological structure of the water table under Lima, while Map C illustrates the distribution of wells around the City.

At the present time, although the wells are fairly evenly distributed around Lima, some areas are more heavily dependent on them than others. In particular:

— The area north of the Rimac River is served almost exclusively by water produced by wells. Only a small part receives water from the Atarjea Water Treatment Plant.

— The extreme south of the City, in the Villa Maria del Triunfo area, still depends substantially on well production for its water even though, as will be described, a relatively new water system is providing service to the area.

— 80% of El Callao's water reportedly comes from its wells, even though it is connected to the City pipe system (the problem is excessive consumption by higher areas before water can reach the Callao zone.)

A list of all the wells in Lima, their water production capacity in litres per second, daily volume, monthly volume, and average number of hours per day and days per month of activity, separately for Lima and El Callao, are included in the accompanying supplementary volume. The sources of the information are the most recently available monthly reports provided to ESAL's Operations Division by its line managers.

Sample Analysis of Lima Wells

Chart IV on the following three pages provide key information for the more productive wells in Lima. Map D illustrates the location of these wells (Group I are filled in solid red; Group II in striped red; a third "back-up" group is filled in solid blue.).

Analysis of this data shows that the 24 major wells in Lima produce 129,917 cubic metres — nearly 130,000 cubic metres of water each day, which is nearly 30% of all water produced by wells in Lima. In fact, this 130,000 cubic metres represents about 9% of the total 1,400,000 cubic metres consumed by Lima each day.

In El Callao, the six most productive wells together account for about 26,000 cubic metres of water per day, roughly 30% of all well water produced by ESAL in El Callao (in this case 2% of all city-wide water production from all sources).

Chart V shows monthly production of wells by District.

Power for Wells

All of ESAL's wells require power for their operation. At present, this power is provided by ELECTRO-LIMA at the rate of about seven million KWH per month, representing 2-3% of all ELECTRO-LIMA production. Energy costs are approximately S/1600/2000 per cubic metre. For a breakdown of water well energy consumption see the Table at the following page. In general, each well has a discrete line connecting it to the nearest ELECTRO-LIMA secondary substation. Normally, this is a high-tension line, and each well has an aerial transformer which steps the current down from 10,000 volts to the well motor's needs.

However, complete reliance on electrical power is a relatively new

CONSUMPTION OF ELECTRICITY BY WATER WELLS

SAMPLE OF RECENT MONTHS

1980*

January	6,792,000 KWH
February	7,241,000 KWH
March	7,405,000 KWH
April	6,450,000 KWH
May	6,943,000 KWH
June	7,222,000 KWH
TOTAL	42,053,000 KWH =
	231,060 KWH per day average
	aprx 10,000 KWH per hour average

* Most recently available published data.

Source: Monthly Production Report, June, 1981
Operations Division

Chart IV (A)

GROUP I

PRINCIPAL WELLS OPERATED BY ESAL/LIMA BY MONTHLY PRODUCTION

	Identification Number	Name	Hours Per Day	Litros/ Segundo	Gauged	Daily Volume (Cubic Meters)	Days/ Month	Monthly Volume (M
1.	070	Caqueta	24	60	2/11/80	5184	23	119,232
2.	109	Caja de Agua N° 1	24	105	5/12/81	9072	30	272,160
3.	110	Caja de Agua N° 2	20	97	5/12/81	6984	30	209,620
4.	115	Los Rosales N° 2	20	90	2/12/81	6480	30	194,400
5.	131	La Molina Vieja	14	108	8/28/80	5443	30	163,296
6.	137	Santa Rosa	24	92	12/10/80	7948	30	238,464
7.	161	Ciudad San Felipe	20	72	6/1/81	5184	30	155,520
8.	177*	Matellini	24	61	5/27/81	5270	30	158,112
9.	184	El Sol de la Molina	24	77	1/19/81	6652	30	199,584
10.	185	El Sol de la Molina	24	58	1/8/81	5011	30	150,336
11.	186*	Mangomarca	24	70	5/12/81	6048	30	181,440
	213	Las Flores	24	82	8/18/80	7084	30	212,544
	Total		266	972		76360	353	2,254,708
	Average		22	81		6363	29	187,892

* Located near public parks.

Chart IV (B)

June, 1981 Data

GROUP II

	Identification Number	Name	Hours Per Day	Litros/ Segundo	Gauged	Daily Volume (Cubic Meters)	Days/ Month	Monthly Volume
1.	039	San Miguelito	24	49	4/14/81	4233	30	127,008
2.	094	San Martin de Porras N° 1	24	52	3/17/81	4492	30	134,784
3.	123	Maranga	24	50	4/21/81	4320	30	129,600
4.	129	Vista Alegre N° 2	24	53	5/28/81	4579	30	137,376
5.	138	El Naranjal	24	50	6/25/81	4320	28	120,960
6.	141	Canta	24	47	3/10/81	4060	30	121,824
7.	145	Santa Isabel	18	68	6/1/81	4406	30	132,192
8.	150	Maupa	12	95	3/24/81	4104	30	123,120
9.	155	Zarate N° 2	24	57	2/19/81	4924	30	147,744
10.	229	Shangari-La	14	95	6/9/81	4788	30	143,640
11.	246	San Silvestre	24	48	4/28/81	4147	30	124,416
12.	256	Canto Grande N° 6	24	60	6/15/81	5184	30	155,520
	Total		260	724		53557	358	1,598,184
	Average		22	60		4463	30	133,182

Group III (Wells with Substantial Litros por Segundo Capacity But Lower Daily Production)

	Identification Number	Name	Hours Per Day	Litros/ Segundo	Gauged	Daily Volume (Cubic Meters)	Days/ Month	Monthly Volume (M3)
1.	153	Residencial Monte Rico	10	90	3/20/81	3240	30	97,200
2.	222	Los Próceres	06	71	2/17/81	1533	30	46,008
3.	244	Santa Raquel	12	68	3/23/81	2937	30	88,128
	Total		28	229		7710	90	231,336
	Average		9	76		2570	30	77,112

CUADRO N° 9

PRODUCCION MENSUAL DE POZOS POR DISTRITOS - PRIMER SEMESTRE 1980
(en miles de M3)

DISTRITO	ENE.	FEB.	MAR.	ABR.	MAY.	JUN	TOTAL	%
Ate	1,395	1,311	1,431	1,395	1,427	1,464	8,423	8.5
Barranco	27	25	27	25	-	26	130	0.1
Breña	72	75	80	66	80	78	451	0.5
Comas	1,096	990	1,012	1,012	993	962	6,065	6.1
Chorrillos	563	529	569	553	572	553	3,339	3.4
El Agustino	62	58	62	60	62	60	364	0.4
Independencia	552	496	491	542	481	487	3,049	3.1
Jesús María	4	45	48	47	48	60	252	0.3
La Victoria	235	220	235	227	235	227	1,379	1.4
La Molina	590	618	672	832	953	923	4,588	4.6
Lima	417	390	417	404	453	421	2,502	2.5
Lince	108	101	108	105	108	105	635	0.6
Lurigancho	439	476	413	400	413	364	2,505	2.5
Lurín	-	-	-	-	-	-	-	-
Magdalena	39	37	39	38	39	38	230	0.2
Miraflores	224	207	221	214	221	214	1,301	1.3
Pueblo Libre	560	515	560	542	554	542	3,273	3.3
Puente Piedra	315	294	314	333	345	337	1,938	1.9
Rimac	543	500	535	509	535	518	3,140	3.1
San Juan de Lur.	1,260	1,178	1,253	1,219	1,132	1,124	7,166	7.2
San Juan de Miraf.	434	262	280	187	167	162	1,492	1.5
San Martín de P.	2,211	2,122	2,245	2,140	2,115	2,124	12,957	13.0
San Miguel	953	891	961	930	961	968	5,664	5.7
San Isidro	111	94	111	108	111	107	642	0.6
Santiago de Surco	2,027	1,913	1,968	1,749	1,747	1,580	10,984	11.0
Surquillo	477	447	477	462	492	415	2,770	2.8
Total Prov. Lima	14,714	13,794	14,529	14,099	14,244	13,859	85,239	85.6
Bellavista	916	855	915	884	915	885	5,370	5.4
Callao	965	903	965	960	992	861	5,646	5.7
Carmen de la Legua	153	143	153	148	153	148	898	0.9
La Perla	234	219	234	227	234	227	1,375	1.4
La Punta	179	168	179	174	179	174	1,053	1.0
Total Prov. Callao	2,447	2,288	2,446	2,393	2,473	2,295	14,342	14.4
Total Lima Callao	17,161	16,082	16,975	16,492	16,717	16,154	99,581	100.0

FUENTE: Informes mensuales - División Aguas Subterráneas y Oficina Callao.

development in the history of wells in Lima. In the past, many of the wells had stand-by generators, as electrical power was unreliable and blackouts were more common. Others had cabezales (gear head drives) mounted on them, which permitted their operation with gasoline or diesel engines.

As ELECTRO-LIMA's service became more reliable, ESAL managers felt that the generators, and to some degree the cabezales were superfluous.

Thus, many of the cabezales were removed and stored at the maintenance facility located at the Atarjea plant, where at least 15 - 30 of them remain today. Only a few generators remain, and they too are stored at the plant and are in rather dilapidated condition.

Most of the water wells would require between 100 horsepower and 150 horsepower engines to function.

At the moment, however, whenever ELECTRO-LIMA ceases to provide electrical power, the wells also cease operation. In addition to requiring energy for pumping, a number of the wells have supplementary pumping units (estaciones de rebombeo) to propel the water into the distribution system. A partial list of these units is included in the supplementary volume.

An intensive study of all wells in the City is being conducted under the World Bank Master Plan program co-operatively by ESAL and Engineering Science. Technicians are examining and systematically collecting data for each well. On the following pages, a blank form used to collect data (Chart VI) and a sample completed data sheet (Chart VII) are provided. A complete set of these sheets would probably be available through ESAL or Engineering Science. Based on the surveys completed to date, it is reported that none of the wells have standby generators or cabezales at present. Thus, they are entirely dependent on ELECTRO-LIMA for energy.

Chart VI

ES - ACISA

a su servicio
empresa de saneamiento de lima

ESAL

FICHA DE EVALUACION DE POZOS Fecha (1) N° ESAL

Otro nombre: (3) N° IRHS

Ubicación:

Departamento: Provincia Distrito:

Cota superficie, m Coordenadas (2) Lam:

Perforado por: Año Prof, m

Funcionando: Si ☐ No ☐

Caseta:	Superficial	☐	Buena	☐			
	Semienterrada	☐	Regular	☐	No tiene	☐	
	Enterrada	☐	Mala	☐			
Motor:	Eléctrico	☐	Diessel	☐	No tiene	☐	☐ Bueno
	Marca	Serie					☐ Regular
	HP		Amp	Volt	rpm		☐ Malo

	Bueno	Reg	Malo	No tiene						
Tablero					Marca		Serie			
Bomba					Marca		Serie		rpm	
Cabezal					Marca		Serie		HP	
Linterna					Marca		Serie			
Impulsores					Marca		diám	N°	tipo	
Tubería					Diám		Cantidad, m			
Ejes, fundas					Diám eje		Diám funda			
Lubricador										
Medidor Q					Marca		tipo		Diám	
Clorador					Marca		tipo			
Manómetro					Marca		rango			
Válvulas					Compuerta, n°vueltas abierta			N°de vueltas total		
Válv check					Marca		tipo			
Valv. alivio					Marca		tipo			

(1) Fecha inicial de la ficha (2) Plano Maestro de Pozos IGM 1979 escala 1: 5,000

(3) Inventario de Recursos Hidráulicos Subterráneos, DASS Ministerio de Agricultura.

Niveles en m Estático	Dinámico	lps Caudal	lps/m Capacidad específica		Día	Mes	Año

Perfil

Prof. m Estratos

Observaciones:

Conclusiones:

Recomendaciones:

Chart VII (A)

ES - ACISA

a su servicio
empresa de saneamiento de lima

FICHA DE EVALUACION DE POZOS Fecha (1) 18-07-80 N° ESAL 161

(3) N° IRHS

Otro nombre: SAN FELIPE §2

Ubicación: Calles Lima y Cajamarca

Departamento: LIMA Provincia LIMA Distrito: COMAS

Cota superficie, m Coordenadas (2) sin lámina IGM Lam: sin 1 IGM

Año 1970 Prof, m 80

Perforado por: P.ALEMANA, S.A.

Funcionando: 17 hs/día Si [X] No [ ]

Caseta: Superficial [X] Buena [X]
Semienterrada [ ] Regular [ ] No tiene [ ]
Enterrada [ ] Mala [ ]

Motor: Eléctrico [X] Diessel [ ] No tiene [ ] Bueno [ ] Regular [ ] Malo [ ]

Marca: NEMON Serie X4477253
HP: 75 Amp 174/87 Volt 220/4 rpm 1780

	Bueno	Reg	Malo	No tiene					
Tablero					Marca		Serie		
Bomba					Marca		Serie		rpm
Cabezal					Marca		Serie		HP
Linterna	X				Marca	sin marca	Serie		
Impulsores					Marca	BERKELEY	diám	8"	N° sin datos arch. ESAL
Tubería	X				Diám descarga	8"	largo Cantidad, m	54	tipo
Ejes, fundas					Diám eje	sin datos arch. ESAL.	Diám funda		
Lubricador	X								
Medidor Q				X	Marca		tipo		Diám
Clorador				X	Marca		tipo		
Manómetro	X				Marca		cant. rango	2	
Válvulas	X				Compuerta, n°vueltas abierta	39	N° de vueltas total	39	
Válv. check	X				Marca		tipo		
Valv. alivio	X				Marca		tipo		

(1) Fecha inicial de la ficha (2) Plano Maestro de Pozos IGM 1979 escala 1: 5,000

(3) Inventario Recursos Hidráulicos Subterráneos DASS Ministerio de Agricultura.

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Niveles en m Estático	Dinámico	lps Caudal	lps/m Capacidad específica		Día	Mes	Año
8.00	17.00	46 l/s					1970
8.00	23.00	64 l/s					1970
8.00	31.00	82 l/s					1970
9.50	15.50	60 l/s	REGISTROS OBTENIDOS DE LOS ARCHIVOS				1976
13.60	16.50	71 l/s	DE ESAL				1980
13.40					17	07	1980

Perfil

Prof. m Estratos

arena fina y gruesa

arena fina grava

cascajo arena fina poco arena

arcilla

cascajo arena fina arcilla

arcilla cura, piedra chica poca arena

piedra gde. arena poca. arcilla

anto.pozo

8.

Ø18"

19.

25.

ranurado

41.

Ø1[illegible]

53.

ranurado

76.

80.

Observaciones:

Conclusiones:

Recomendaciones:

MANTENIMIENTO PREVENTIVO

- PRUEBA HIDRAULICA CON EQUIPO EXISTENTE (CAUDAL, ABATIMIENTO, RECUPERACION)
- DESMONTAJE REVISION Y EVALUACION EQUIPO ESAL
- TEST DE VERTICALIDAD ALINEAMIENTO Y MED. DE PE[illegible]
- RECUPERACION DE FONDO
- DESARROLLO Y LIMPIEZA (CUCHARELO PISTONEO APLIC. DE DESINCRUSTANTE Y POLIFOSFATOS)
- RUMBEO DE AFORO

38b

AGRICOLA COMERCIAL INDUSTRIAL S. A

POZOS TUBULARES
JR SELLANA 1020 - CHACRA RIOS
TELEFONO N° 31 4676
LIMA - PERU

POZO ESAL Nº 161, SAN FELIPE

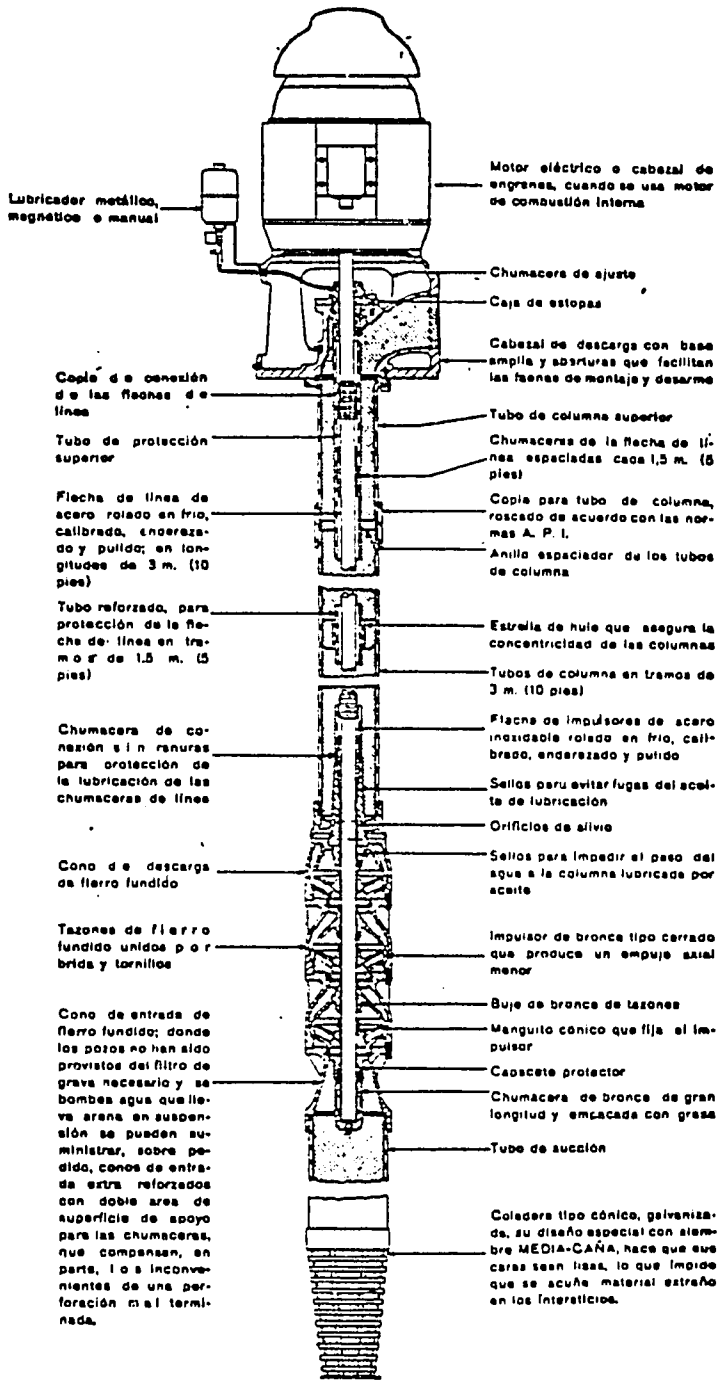
A).- Motor con carga de de 160 amp., aislamiento regular de 15 megons.

B).- Línea de conexión en buen estado.

C).- Tablero de control en buenas condiciones.

1/08/80.

DIAGRAM OF WATER WELL With Identification of Parts in Spanish



Lubricada por Aceite

Fig. 49. Bomba de pozo profundo lubricada por aceite, mostrando todas sus partes constructivas.

Gradual Decline in Underground Water Table

Numerous ESAL managers and other experts express concern about the gradually diminishing underground water supply. The Binney & Company map which is part of this study provides a hydrological analysis of Lima's underground water table configuration.

The water table under Lima has been dropping at the net rate of about 1.5 metres per year. Drilling regulations have been adjusted accordingly: new wells which formerly were required to have a depth of 50 or 100 metres will shortly be required to have a depth of 200 metres. Since the 1950's there has been some advocacy for exploring new ways to artificially "feed" the underground supply. The possible creation of such a system, which would directly drain water into the underground system, will be discussed in the forthcoming Master Plan.

Distribution

ESAL's distribution network covers approximately 23,825 hectares with 4,800 kilometres of various kinds of water piping (and roughly 4,400 kilometres of sewerage piping). About 408,000 homes are served directly by the system, providing such service to 3,400,000 people -- about 75% of the population. Chart VIII illustrates the evolution of water service and the proportion of the city's population directly served by this system from 1950 until 1979.

Map E illustrates the system which is implemented through four types of piping. ESAL does not have an exact estimate of the breakdown of this piping at the present time. However, it has completed about 75% of a survey of its distribution network, and the results -- by type of piping and size of pipes -- are listed in Chart IX.

The system is entirely conducted by gravity, and is regulated at five graduated levels in the city through water pressure reduction centres which

Chart IX

REDES DE AGUA

DIAMETRO ~~METRO~~ INTERIOR	PRETENSADO (*) Metros	C.REFORZADO Mts.	ASB.CEMENTO Mts.	FºFº Mts.	TOTAL
72"	5,453				5,453
64"		3,731			3,731
56"	3,490				3,490
54"	2,640				2,640
50"	1,320				1,320
42"	3,990				3,990
40"	8,929				8,929
36"	8,398	2,470			10,868
30"	9,527			1,401	10,928
28"		2,652			2,652
27"		90			90
24"	6,102	400		690	7,192
21"	4,798	11,480			16,278
20"	858	2,126			2,984
18"	7,918	2,360		4,583	14,861
16"	14,048	16,662	1,050		31,760
14"	10,613	12,966	8,364	5,592	37,535
12"	13,620	2,852	18,951	13,289	48,712
10"	4,477	10,048	55,195	16,398	86,118
8"		2,825		19,673	22,498
6"			262,533	130,964	493,497
4"			1'097,593	410,932	1'508,525
3"			38,727	16,872	55,599
	======	======	=========	========	==========
	108,515	70,662	1'582,413	620,394	2'381,984
					3341

(*) Las longitudes de tubería Pretensada son totales instaladas en 24,314 Has.
Las longitudes de CR, AC, FFº, se han obtenido sólo de 130 líneas replanteadas por Catastro y sirven aproximadamente a 17,334 Has.

appear on Map F as orange boxes.

The strongest system in the ESAL network is that shown as installed in 1969 by the Raymond Corporation of Chicago, Illinois. It conducts water through 72 inch steel reinforced concrete pipes from the Atarjea water treatment plant to Central Lima, gradually diminishing in size to 36, 16 and 10 inch piping. This is considered the City's most seismic-resistant network. It parallels the City's more vulnerable, original system.

Two additional distribution systems provide water to Villa El Salvador and Rimac District areas of Lima. The former system has been functioning for some time; the latter is just now beginning to come into service. These systems were installed by SUPER-CONCRETO DEL PERU, a subsidiary of an Argentinian-based multinational corporation. There have been some maintenance problems with this system since its installation. For reasons which have not been clearly established, the pipes periodically buckle in isolated areas. SUPER-CONCRETO DEL PERU has the equipment and supplies required to repair the system when this happens. But if the buckling is being caused by some type of chemical interaction with the soil, it could make them more vulnerable to seismic damage.

However, these systems do have rubber-joints between the pipes, which should allow significant flexibility and resistance to earthquakes.

As can be seen from Chart IX, a large proportion of the system is composed of asbestos-cement piping, produced in Peru, and which also generally has rubber joints between tubes. Of the 1200/1350 repairs required on the city's water system each year, about 1000/1200 are generated by the asbestos-cement tube system.

A significant amount of water distribution is not conducted through the pipe system. Instead, it is carried by tank trucks from water dispensers (surtidores) also operated by ESAL from its well production into the new, expanding areas of the city, called pueblos jovenes.

Charts X and XI provide data on the 182 tanktrucks officially registered with ESAL, whose carrying capacity is shown as 186,000 cubic metres per month. If this figure is accurate, it means that the tanktrucks officially registered (there are undoubtedly unregistered trucks as well) are absorbing about 10% of the well-water production of the City. As a rule, pueblo joven residents have fifty-five gallon oil drums or concrete tanks which they have constructed in front of their homes and in which the tanktruck water is deposited. Families in some areas have only small containers to collect the water in. In some areas, tranktruck delivery is used only during certain times of year when water supply or pressure in the piped system is inadequate.

In addition to the 182 officially registered tanktrucks, there may be an additional 100 capable of being fitted with available tanks to operate in emergencies. The Municipal Authorities have about 50 such trucks, currently used for watering areas verdes (parks), and the Peruvian Army may have ten such trucks available for their own use.

The capacity of these trucks is 2,000 gallons. They are operated by individual private owners who, in some parts of the City, have formed themselves into Tanktruck Owner Associations. ESAL provides water to truck owners at a cost of S/0.50 per cubic metre, which is very reasonable. However, tanktruck operation seems to be diminishing because of increased fuel and truck-replacement costs. The population in need of such water is not diminishing at a similar rate.

Statistics on tanktruck delivery of water have a disturbing element, which also calls into question assessments of the minimum quantity of water required in disasters.

If the current fleet of tanktrucks is currently delivering 186,000 cubic metres per month, their customers are consuming 6,200 cubic metres each day, equal to 6,200,000 litres.

SURTIDORES ADMINISTRADOS POR ESAL .-

SURTIDOR	Nº CAMIONES	M^3/MES	ZONAS DE ABASTECIMIENTO
Nº 1	15	16,000	Villa Hermosa, Sr. de los Milagros, Virgen del Carmen, Nocheto, Huáscar, Cooperativa Tayacaja, Cooperativa Universal, Los Chancas, Los Perales, Los Arboles, Menacho, Catalina Huanca y 7 de Octubre.
Nº 2	25	23,000	El Naranjal, Santa Luzmila, Infantes, El Parral, Manco Inca, La Merced, El Angel, Ramón Castilla, El Milagro, y Payet.
Nº 3	20	25,000	Playa Rimac, 200 Millas, Condevilla, Villegas, 9 de Octubre, Jorge Chá - vez y Virgen de las Mercedes.
Nº 4	12	13,000	Delicias de Villa, Buenos Aires de Villa, Tacala, Vista Alegre, San Juan de la Libertad, Tupac Amarú de Chorrillos, Santa Isabel de Chorrillos y Santa Teresa de Chorrillos.
Nº 9	18	17,000	Progreso, Villa Esperanza, Luis Porras Barrenechea, La Flor, El Polvorín, Bello Horizonte y Federico Villarreal.
Nº 16	37	31,000	San Hilarión, Melchorita, Canto Chico, 15 de Enero, Totorita, Providencia, Sagrado Madero, Huáscar y Canto Grande.
Nº 21	30	26,000	Collique, Santa Rosa, Nueva Esperanza, San Hilarión, Cooperativa Calichera, Año Nuevo, Cooperativa El Carmen, Paulo Sexto, Señor de los Milagros, San Juan y San Carlos.
Nº 6	17	24,000	La Campiña, San Gabriel, Villa Solaridad, Hogar Policial, Pamplona Alta, Villa Salvador.
S/N.	8	11,000	Nestor Gambetta, San Jorge, Santa Rosa, Santa Marina, Barboza, La Taboada, Ex-Fundo Márquez.
TOTAL	182	186,000	

Nota: El volumén promedio de los camiones cisternas es de 35 cilindros.= 2,000 galones

Chart XI

SURTIDORES DE ABASTECIMIENTO DE AGUA POTABLE ADMINISTRADOS POR ESAL

Surtidor Nº	Ubicación	Conectado a:	Nombre
1	Urb. Los Ficus - Ate.	Pozo Nº218.	(Provisional)
2	Av. Túpac Amaru Km. 7, Independencia.	Pozo Nº126.	"El Naranjal".
3	Av. Industrial y Enrique Heiggs - L.	Red - ESAL.	"Industrial".
4	Av. Los Incas y calle Vargas - Av. Panamericana Sur Km. 18 1/2, Delicias de Villa - Chorrillos.	Pozo Nº196.	"Delicias de Villa".
6	Carretera Panamericana Sur - Frente Urb. San Juan de Miraflores.	Pozo Nº222.	"Los Próceres".
9	Av. Suárez - Urb. Sta. Isabel - Carabayllo.	Pozo Nº146	"Santa Isabel".
16	Av. Las Flores y calle Nº15 - Urb. Las Flores, San Juan de Lurigancho.	Pozo Nº213.	"Las Flores".
s/n	Av. Huáscar, Cdra. 12 - Callao.	Pozo: Miranaves - Callao Nº508.	"La Chalaca".

FUENTE: División de Medidores.

ELABORACION: Oficina de Planificación.

Lima, setiembre de 1981.

MRG/cob.

c.c.: Arch.

Estimates of the population being served vary considerably. One group of experts estimated that 750,000 people -- about 15% of the city's population -- get water through the tanktruck system. If that is true, each person is consuming 8.2 litres per day, about 20% less than one international organization has suggested is the absolute minimum daily emergency requirement. It seems unlikely that less than 15% of the population is served by tanktrucks. In 1972, 20% of the population was served in this manner and the population of Lima has expanded considerably since then, without a notable reduction in the proportion of persons served.

If for argument's sake, it is assumed that 500,000 people -- 11% of the population -- are served by tanktrucks, then each recipient is consuming 12.4 litres per day.

The 1981 census, when its results are published, will establish the number of persons who have no access to public water-pipe distribution. This figure should be studied with respect to the 186,000 cubic metres delivered by tanktrucks in Lima each month.

For emergency fire-fighting purposes, ESAL also maintains a network of 4,500 fire hydrants (called GRIFOS). Book C (see oversized ringed volume), Ubicacion de Parques y Zonas Abiertas y de Grifos de Agua/Lima Metropolitana illustrates the distribution, by district and proximity to park areas, of the hydrant system. Because of variable water supply and pressure problems, the hydrants are not consistently effective. The hydrant network in general is connected to the old city distribution network, not to the more recent pipe installations.

Because of the critical functions it must perform, a sample analysis

of the water-supply, storage and sewage systems of twenty major city hospitals was developed by the Direccion General del Medio Ambiente of the Ministry of Health as Chart XII.

Water Storage

Map G shows the location of devated and underground water storage facilities in Lima and El Callao, indicating for each the storage capacity in cubic metres. These tanks tend to fill up during the evening hours, and to drain during the day. Most of them -- especially the elevated tanks -- are located close to wells.

In addition to this public water storage system, Lima once had -- and may again develop -- a rather extensive network of private storage tanks, especially in middle-class residential districts.

Before 1965, most homes attempted to equip themselves with storage tanks and pumps so that they would always have an emergency supply of water. One of the main reasons was that ESAL's water supply and pressure were irregular, and homes could easily be left without water if they depended exclusively on ESAL's service, which often reached them only at night.

In 1965, there was a substantial improvement in ESAL's water and pressure supply. People became accustomed to 24-hour service, and the tanks and pumps, if not dismantled and sold, were stored away or fell into disuse, which is the current state of home storage in Lima.

Demand in recent years has once again overtaken ESAL's supply, and there has been renewed interest in some private storage tanks. For example, Census Day 1981 (a Sunday) was an unusually bright and warm day. Most of the population engaged in athletic or other activity. They used so much water that the entire 500,000 cubic metre reservoir was emptied and there was little

MINISTERIO DE SALUD

DIRECCION DE SANEAMIENTO DEL MEDIO AMBIENTE

DIVISION DE SANEAMIENTO DEL MEDIO AMBIENTE

Información sobre la capacidad de almacenamiento de Agua Potable y sistema de eliminación de los desagües de los Centros Hospitalarios del Ministerio de Salud.

CENTRO HOSPITALARIO	Fuente de Abastecimiento	No.Cisternas	Capac. en m3	No.Bomb. Hidron.	Capac. en m3	No.tanq. elevado	Capac M3.	Cap tot almac.	Sistema de eliminación de desagües
Maternidad de Lima Cap. 452 Camas	De la red pública. 2 entradas de 2.5" c/u.	2	1,062	-	-	2	10	1,072	Emisor a red pub.8" 1 trampa de grasa de 3 m3
Víctor Larco Herrera Cap. 1,260 camas	De la red pública. 4 entradas de 2" c/u	7	189	1	3.20	1	24.80	217	Emisor a red pública de 8"
Inst.Nac.Enf. Neoplásicas - Cap. 142 Camas	De la red pública 2 ingresos de 2.1/2"y 1.1/4"	2	35	-	-	1	45	80	3 emisores a red pública - Un pozo de bombeo de 12 m3.
Ermilio Valdizán Cap. 415 Camas	Tiene un pozo tubular con bomba electroneumática	-	-	-	-	1	60	60	Emisor a red pública, 8"
Inst.Nac.de Rehabilitación - Cap.	De la red pública Ø 8"	1	18	-	-	1	7	25	Emisor a red pública de 8"
Arzobispo Loayza Cap. 800 Camas	De la Red Pública 1 pozo tubular para riego y limpieza	4	315.80	-	-	2	23.60	339	Tiene un pozo de bombeo de 8 m3 Emisor a red Pub.8"
Hosp. San José Cap. 50 Camas	De la red Pública	1	15	4	3	-	-	18	Emisor a red pública 8"
San Bartolomé Cap. 265 Camas	De la red pública 3 entradas (2 de 3/4" y 1 de 2" de Ø)	1	45	-	-	1	21.5	66.5	Emisor a red pública de 8"
Sto.Toribio de Mogrovejo Cap. 292 Camas	5 ingresos de red pública de 3/4"	-	-	-	-	-	-	-	Emisor a red pública de 8"
Hospital del Niño Cap. 700 Camas	2 ingresos de red pública de 2"	6	247.2	-	-	6	32	279.2	4 salidas de 4", una trampa de grasa y un pozo de bombeo
Hosp. Santa Rosa Cap. 180 Camas	3 ingresos de red pública de 1.1/2"	4	302	4	36	-	-	338	2 salidas a red Pública de 6"
Hipólito Unánue Cap. 794 Camas	1 ingreso de la red pública de 4 Ø	2	134	-	-	2	41	175	1 Trampa de grasa de 1 m3, salida 8"
Cayetano Heredia Cap. 276 Camas	1 ingreso de 2.1/2" de red pública	2	160	-	-	2	80	240	Directo a la red pública
Mat.Inf. de Collique Cap. 300 Camas	1 ingreso de 2.1/2" de red pública	1	100	-	-	1	53.8	153.8	Directo a la red pública
San Juan de Dios Cap. 1,000 Camas	Pozo (ESAL)	-	-	2	8	3	60	68	Directo a la red pública
Asist.Púb.de Miraflores Cap.	1 ingreso de 1.1/4"	1	71.5	2	3.06	1	22.05	96.16	1 salida de 6" 1 pozo bombeo 7.6 m3 1 tramp.grasa 1 m3
Asist.Pub.Chorrillos	1 ingreso de 1"	1	1	-	-	-	-	1	1 salida directa de 4"
Hosp.Dos de Mayo Cap. 1,100 Camas	De la red pública	2	51.8	-	-	1	35.53	87.33	1 emisor de 8" a la red pública
Hosp. Central No. 1 Cap. 876 Camas	3 ingresos de la red pub. de 4", 2" y 2"	4	5,211	4	12	-	-	5,223	1 emisor de 12" a la red pública
Hosp. Central No. 2 Cap. 1,333 Camas	1 entrada de 6" de la red pública 3 pozos profundos	10	4,642	2	7.6	-	-	4,649	1 emisor de 12" a la red pub.;sistema por montantes en edif.; Red de grasas con trampa; sistema de bombeo agua de retorno.

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water in the city. Even the National Palace had no water.

If within the next few years, however, a major earthquake should occur, household storage of water should not be considered a major asset in recovery efforts.

Consumption

Unlike the electricity sector, where about 50% of all energy is consumed by the industrial sector, the overwhelming majority — 93% -- of water produced by ESAL is consumed domestically. Commercial consumers account for an additional 6% of consumption, and the balance, less than 1%, is consumed by industries and Government agencies.

Chart XIII illustrates the proportionate consumption for each sector for Lima, Callao, and for the city as a whole. Chart XIV provides similar data by District in Metropolitan Lima.

Census data from 1961 and 1972, tend to support the conclusion that about three quarters or more of Lima's population is now served by the ESAL water pipe distribution system. Unpublished data provided by the Ministry of Housing, which is responsible for the water sector, is as follows:

Evolution of Water Services	1961		1972	
Full Service (In Home)	187,600	54%	389,400	62%
Semi-Service (Public)	140,400	41%	112,700	18%
No Service	16,900	5%	124,000	20%
TOTAL	344,900/100%		626,100/100%	

ESTIMACION DE LA POBLACION SERVIDA

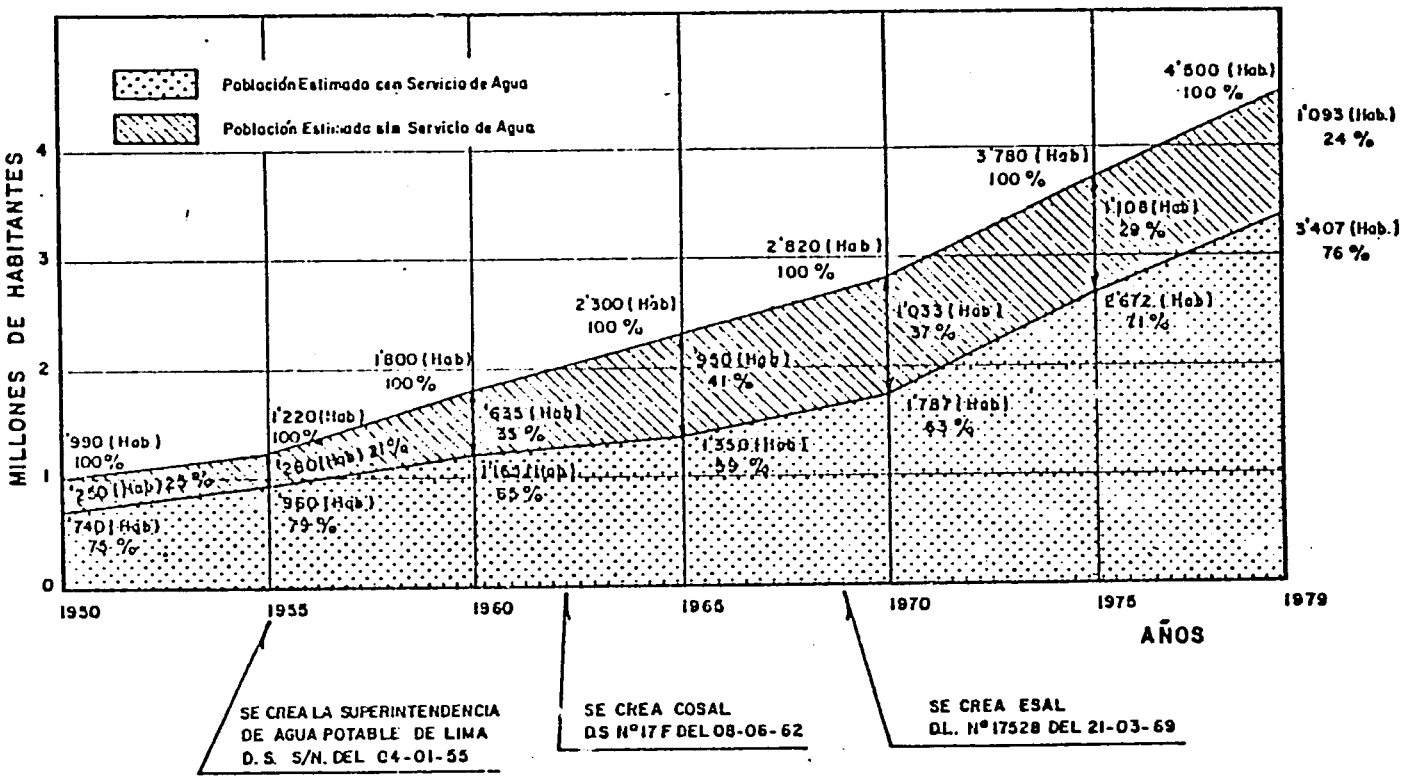
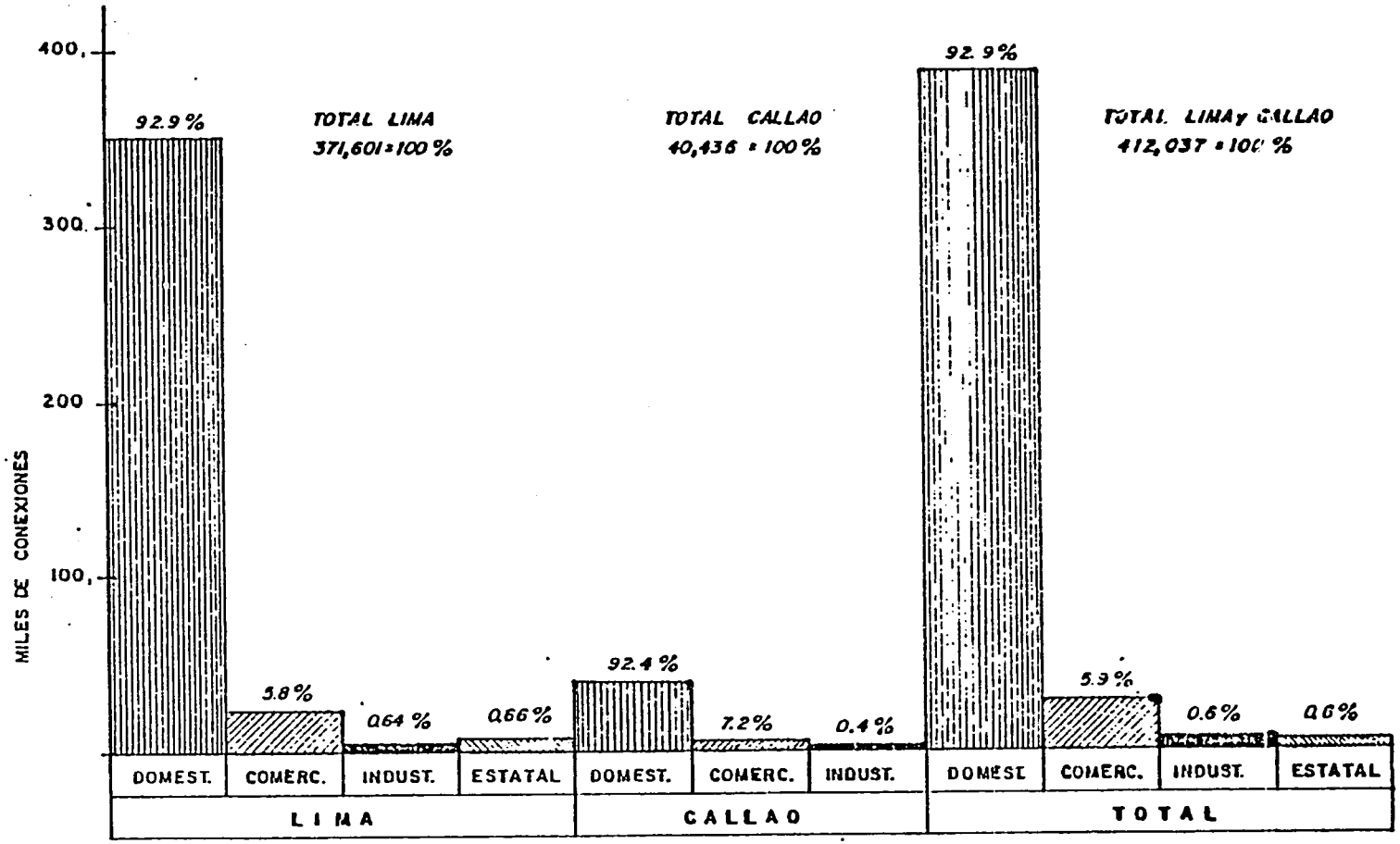


Chart VIII

Chart XIII

GRAFICO N° 6



N° DE CONEXIONES POR TARIFA DIFERENCIADA (Al 30.06.80)

Nota : Incluye servicios cerrados.

CUADRO Nº 16

DISTRIBUCION PORCENTUAL DE CONEXIONES POR DISTRITOS TIPO DE FACTURACION Y TARIFA DIFERENCIADA

DISTRITO	TARIFA			CERRADOS	FACTURACION			TOTAL
	COM.	COM.	IND.		CARGO FIJO	PROM.	LECTURA	
Lima	86.1	11.8	2.1	11.3	21.3	20.9	46.5	37,933
Ancón	-	-	-	100.0	-	-	-	1
Ate	93.4	3.9	2.7	11.1	42.4	15.1	31.4	7,798
Barranco	93.3	6.3	0.4	9.2	20.1	14.4	56.3	5,755
Carabayllo	97.2	2.8	-	6.6	17.0	30.7	45.7	921
Breña	90.2	8.6	1.2	5.8	15.7	10.3	68.2	10,304
Comas	97.8	2.2	0.0	11.6	21.6	21.8	45.0	15,261
Chorrillos	96.6	3.2	0.2	12.2	21.0	28.5	38.3	8,059
El Agustino	95.2	4.4	0.4	13.6	22.7	29.8	33.9	5,957
Jesús María	93.7	6.1	0.2	7.3	33.0	7.1	52.6	8,179
La Molina	97.2	2.8	0.0	-	23.8	32.4	25.2	2,222
La Victoria	83.2	15.5	1.3	10.0	20.7	21.0	48.3	23,197
Lince	93.2	6.6	0.2	4.6	18.8	10.0	66.6	9,279
Lurigancho	100.0	-	-	70.8	2.4	24.4	2.4	41
Lurín	100.0	-	-	-	98.7	1.3	-	620
Magdalena	95.1	4.7	0.2	4.1	14.7	9.6	71.6	6,936
Miraflores	93.1	6.7	0.2	5.6	16.9	14.5	53.0	16,052
Pachacamac	95.9	4.1	-	-	99.4	0.4	0.2	465
Pueblo Libre	96.6	2.9	0.5	4.1	18.0	11.0	66.9	13,586
Puente Piedra	85.0	14.1	0.9	2.2	97.7	0.1	-	1,731
Rimac	94.0	5.5	0.5	8.8	18.9	19.1	53.2	15,462
San Bartolo	100.0	-	-	-	-	-	100.0	1
San Isidro	95.8	4.1	0.1	5.5	22.1	15.1	57.3	12,012
Independencia	96.7	3.3	0.0	8.9	38.4	11.6	41.1	12,034
S.J.de Miraf.	97.4	2.5	0.1	34.7	14.5	15.0	35.8	20,499
San Luis	91.9	6.5	1.6	8.0	16.9	20.4	54.7	5,960
S.M.de Porras	95.3	4.2	0.5	6.5	23.9	23.0	46.6	35,629
San Miguel	95.6	4.1	0.3	7.7	18.3	15.7	58.3	13,142
Surco	96.1	3.8	0.1	8.3	21.2	23.1	47.4	16,999
Surquillo	92.1	7.4	0.5	8.8	21.8	19.2	50.2	12,962
Villa María	99.7	0.3	-	34.3	3.6	31.1	31.0	4[illegible],789
San J.de Lurig.	96.3	3.3	0.4	11.5	23.4	24.4	40.7	10,029
Total Lima	93.9	5.5	0.6	12.9	20.3	19.7	47.1	372,815
Callao	91.2	8.2	0.6	3.9	42.9	18.2	35.0	22,544
Bellavista	96.0	3.8	0.2	1.9	18.8	10.8	68.5	9,329
C.de la Legua	99.8	0.2	-	0.4	99.6	-	-	1,455
La Perla	97.0	2.9	0.1	2.4	51.4	9.4	36.8	5,013
La Punta	96.8	3.2	-	2.3	10.5	10.5	76.7	1,161
Total Callao	93.6	6.0	0.4	3.1	39.4	14.4	43.1	39,502
TOTAL Lima - Callao	93.9	5.5	0.6	11.9	22.2	19.2	46.7	412,317

FUENTE: Listados de Informática por Distritos.

Nota 1): Estatales están incluidos en Cerrados, incluye nuevas incorporaciones que no figuran en listados (Lurín, Pachacamac, Puente Piedra).

Nota 2): (0.0) porcentaje no significativo; (-) no existencia de conexiones.

Other Water Systems

The ESAL water system currently provides all the drinking water for the City. However, there are four other important water-related systems described here because of their possible importance in the event of a major earthquake in the City.

System No. 1: Underground Irrigation System in Lima

On an average day, about 17 cubic metres per second of water run through the Rimac River. Of these, about ten are absorbed by the Atarjea Water Treatment Plant. However, an additional five cubic metres per second are absorbed by the irrigation system in the Rimac Valley. This system is illustrated on Chart XV which appears on the following page and on the larger size Map H.

The overall management of the irrigation system is the responsibility of the Ministry of Agriculture's Rimac District Office. As can be seen on the chart, the water absorbed by this system is distributed widely through the Valley, but there are three captation areas close to Lima which are still functioning: those at Ate, Surco and Huatica. The extensive piping system from the latter captation point provide water for all the public parks and public and many private green areas of Lima. The distribution network and management of consumption is handled by the Municipality of Lima; but the captation system and main trunklines are managed by the Ministry of Agriculture.

The local distribution channels are simple concrete tubes or canals which run under the streets of Lima. They are highly contaminated because they receive no treatment and, in fact, are used as depositories for waste and garbage.

According to the Ministry of Agriculture, there is no reasonable published

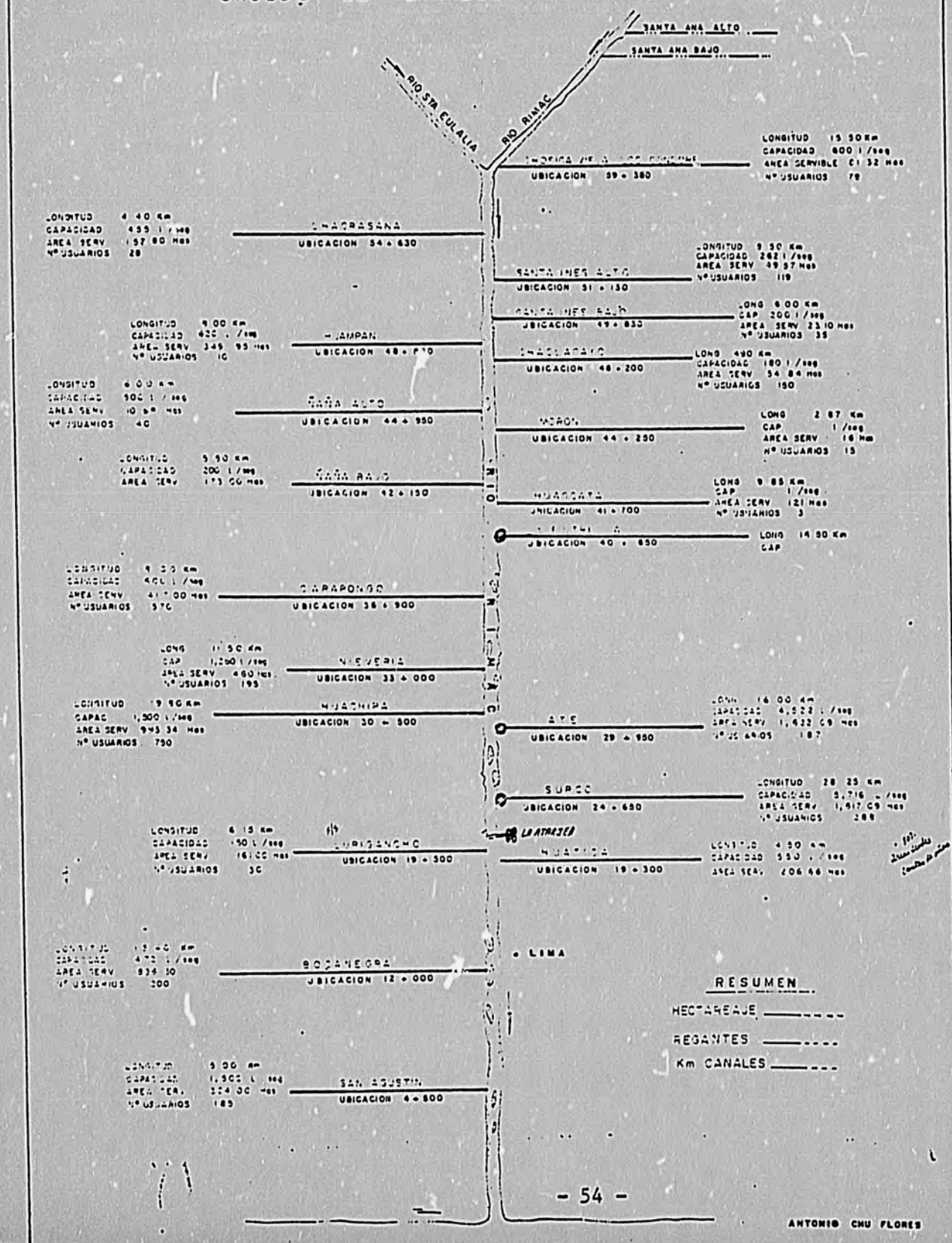
Best Available Document

Chart XV

(3)

DISTRITO DE RIEGO RIMAC

CROQUIS DE CANALES PRINCIPALES



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map for the local channels, but the Municipality probably has some district-level maps.

System No. 2: Agricultural Irrigation in the Chillon Valley

Agriculture is still practiced in the Valley of the Chillon River, which runs north of the City of Lima. Because the coastal valley is very dry, wells are used to provide water for farms.

In the supplementary volume accompanying this study, a chart produced in 1978 of all of the wells in the Chillon Valley is provided by district. Of particular interest from this data were a series of five wells (see Chart XVI at the following page and Map I) which, in normal times, can provide about 25 million litres of water per day. These wells do not use electricity for power but, instead, depend on diesel generators. Thus, they are not vulnerable to power failures in Lima. These wells fall under the supervision of the Ministry of Agriculture. For a complete base list of all wells in the Chillon Valley see the supplementary volume.

System No. 3: Industrial Wells

It is estimated that there are approximately 440 industrial wells in Lima. Not all of these are still functioning, and most have such small rates of production that they are not of concern to this study.

However, a number of major industries have wells which can produce at the rate of 50 litres per second and have their own independent stand-by power sources. According to ESAL, these industries are:

Vidrios Industriales

Curtiembre EL AGUILA

GOODYEAR

Chart XVI

FIVE WELLS WHICH OPERATE WITH DIESEL POWER NEAR LIMA

District	ID No.	Depth (Meters)	Year	Motor Brand	Motor Type	HP	Pump Brand	Pump Type	Diam.	Use	L/S	1978 Prod. (Annual)
Puente Piedra/ Potrero Choque A. Hda. T. Ingo	44	55	1957	McLaren	D	100	Johnston	TV	-	Irrig.	75	985,500
Puente Piedra/ Alfonso Casinelli	142	44	-	Deutz	D	84	Peerless	TV	10"	Irrig.	70	1,570,000
Comas/ Urb. Pro-Pozo N° 2	212	103	1973	General Motors	D	50	HIDROSTAL	TV	-	Domestic	50	1,183,600
Carabayllo/ Huancoy Coop.	14	4,50	-	Fordson	D	-	U. S. (Motors?)	TV	-	Irrig.	70	788,400
Carabayllo/ Sector Sabroso Lote 1, Ex-Hacienda San Lorenzo	40	85	1970	Rockford	D	100	Floway	TV	10"	Irrig.	80	2,522,880

TOTAL FOR FIVE WELLS

L/S Capacity: 345

Average Annual Production: 7,050,380 m^3 = 7,050,380,000 liters

Average Monthly Production: 587,500 m^3 = 587,500,000 liters

COPSA (Compania Oleaginosa del Peru)

PILSEN Callao

Cerveza CRISTAL

Compania Nacional de Cerveza

Hospital del Empleado (Social Security Hospital)

Hospital Naval (Navy Hospital - Callao)

Ministerio de Guerra

Division Aerotransportada

Escuela de Oficiales - Peruvian Air Force

Eternit

System No. 4: Private Water Dispensers - Shallow Wells

Because of some unusual aspects of the configuration of underground water supplies, there are a few places in Lima where wells tap water at a depth of only about six or eight metres. These kinds of wells can be operated with small gasoline or diesel generators (6 - 10 KVA). Almost all are in the hands of the private sector. However, they are not used very much because the tanktruck operators prefer to buy from ESAL, a cheaper source.

According to ESAL, the shallow wells are located in the following areas:

- Kilomètre 28, Carretera a Canta, junto a una caseta blanca, costado izquierdo de la pista
- Campoy - Avenida Principal costado derecho de un deposito de cerveza en el Interior de un campo deportivo
- Lotizacion EL CLUB - Pasando Campoy, espalda de la Avenida EL AGUILA, 2 cuadras antes del Restaurant EL PIONERO
- Surtidor Las Delicias de Villa (ESAL)

- Pasando el Surtidor unos 2 kilometros, hay una afloracion de agua con estacionamiento de la misma

- Costa Verde comprendida entre Chorrillos y Barranco.

Brief Description of Lima Sewerage System

Three maps of the Lima sewerage system (MAPS J and K and F) describe the nature of the trunk and distribution lines.

Sewerage is conducted through Lima by gravity. However, there are 10 points where sewage is pumped at stations which require electrical energy. Three of these are critical to the system:

(a) One pumps sewage from Callao into a main trunk line which deposits the untreated waste into the Ocean (see sewage maps).

(b) Two receive sewage from central Lima and, on the Pacific Coast at Miraflroes, pump it north and south to the points where it flows into the Pacific.

The first is especially important because the system could become quickly clogged in the absence of energy, finally packing in such a manner as to preclude pumping once energy were re-established.

About 65% of the City's sewage is pumped into the Pacific at the northern side of the City; the balance is pumped out at the southern side.

Unlike the water system, much of those lines are joined with rubber joints, the sewage system pipes are joined almost exclusively with unreinforced concrete joints which would be vulnerable to damage in an earthquake.

Review of the Literature

After-action reports and evaluations for three major earthquakes in Latin America (Peru 1970, Managua 1972, Guatemala 1976) were reviewed in preparing this report. They offer some provocative — and in some cases repetitive — lessons and recommendations on post-disaster water management.

Peru 1970

Of particular interest is the U.S. Southern Command Disaster and Assistance (sic) Survey Team After Action Report, prepared in July, 1970 by DAST Commander Robert S. Beightler. The report includes, as an Appendix, comments by the Sanitary Engineer of the DAST team, Captain Victor W. Wehman Jr.

Among his comments, those related to Chimbote itself were of special interest and are repeated or paraphrased in their entirety as follows:

Excerpted from Report

System before Disruption by Earthquake This water production system for the public of Chimbote consists of three submergible chlorinated well pump stations serving about 40% of the city by direct distribution, and one Santa Corporation process water well (chlorinated) which is not usually used for public consumption. The Santa Corporation also has a high pressure water line (process water, non-chlorinated) coming directly from the Santa River.

Another water system available in the area is the new housing system of Buenos Aires. This subdivision is near Chimbote airport and has a complete water treatment plant which treats water brought in from the Santa River. The plant consists of primary lagooning of the water, coagulation, flocculation, sedimentation, filtering and chlorination of water, and was designed for a consumer population of 10,000 at 150 gallons/capita.

System after Disruption by Earthquake

a. All three Chimbote main water wells had been damaged to some extent. In all three cases the buildings surrounding them (reinforced concrete) were cracked, but not collapsed. Each well had sand-clogging up the well casings due to the tremors, however, by Thursday all three wells had been flushed.

All pump equipment was working except for minor repairs.

The main water storage reservoir (concrete) was not damaged.

The city uses steel pipe and the distribution system was very segmented. It was easy to see broken sections in the sand as the water turned it a reddish-brown color. Location of the breaks in the streets will be no problem. Engineer Gonzales estimated three weeks full-time working to restore the main line, but only if he gets the correct construction equipment.

Each pumping station has facilities to input vertical filling points (standpipes) for water trucks. Since only 40% of the city normally gets main distributed water, the practice of bringing water to the people in water trucks is an old one.

b. The Santa Corporation water well was functional Thursday afternoon with repairs being made to the water lines by line crews organized and paid by the Santa Corporation. The crews were operating with three front end loaders, a D-6 dozer, and about six dump trucks. The Santa Corporation well (chlorinated) also had vertical standpipes for distribution to water trucks available.

c. The Buenos Aires water system was severely damaged. The inlet structure on the Rio Santa had changed elevations, not allowing water to flow into the line. The realignment ... should take about three weeks ...

The water treatment plant had considerable damage to the flocculating and sedimentation works, but little or no damage to the filters, pumps, filter-back wash elevated storage tank, chlorinators, or main concrete storage reservoirs. With repairs to the inlet, a large volume of portable water can be produced and distributed.

Recommendations

CPT Wehman recommends the use of water trucks and 55-gallon drums until (about one month) the normal distribution lines can be restored. He suggests such trucks be brought in from Lima, and there should be enough trucks to keep 25,000 gallons "on the move" in Chimbote. About 300 of the 55-gallon drums are recommended.

Beyond that, he suggests specified heavy equipment required to repair the system.

He also includes several long-term recommendations:

1. "It was nearly impossible to arrange for surface transportation" to carry out their duties. "Four to five jeeps for 25 men" would greatly facilitate and improve operating efficiency.

2. Portable water testing kits (similar to the HACH Model DREL) would add greatly to specific determination of water production and distribution problems.

3. Mobil purification units such as those produced in Germany should be placed into alert storage in the Canal Zone.

Managua 1972

Two reports concerning critical water problems which emerged after the pre-Christmas earthquake in Managua in 1972, are of interest.

An After-Action Summary: Disaster Relief Operations prepared by Lieutenant Colonel Billy J. Chance, includes a description of the U.S. response to the earthquake:

The report indicates the following:

1. The water pumping station was not badly damaged and could pump water at full capacity of 20 million gallons per day. However, much of the water was lost through broken water mains. But about 25% of the population was served in this manner.

2. Much of the population received water from tanktruck distribution. There were 20 mobile tanks carrying about 300,000 gallons of water per day to temporary storage tanks and water distribution centres. (The U.S. provided six 400-gallon storage units.)

3. Six privately-owned water systems which were not functioning because of the breakdown in electrical energy distribution were back into operation on the fourth day with the assistance of generators. (The report indicates that the U.S. provided two generators, of 60 KVA and 100 KVA, respectively.)

4. As emergency supplementary measures:

-- U.S. aircraft flew 350,000 gallons of water in 5-gallon water containers, tankers and trailers. Water tanktrucks and trailers which were sent to Managua as part of the 21st Evacuation Hospital complement were diverted to meet other emergency needs immediately after the earthquake.

-- To assure the flow of fresh water, five truck mounted water purification units were brought in from the Continental United States and U.S. Southern Command in Panama.

In October, 1974, about two years after the earthquake, Ing. Normando Porras, Chief of the Sewage Division in Managua, had an opportunity to reflect on the earthquake. He prepared a 12-page summary of what occureed, which is included in its entirety in the supplementary volume, Item E. However, some of his comments, which concerned principally the water system, were:

1. The Managua water system had 615 kilometres of tubing, between 30 inches and 2 inches in diameter. The system suffered approximately 1.15 faults per kilometre, and the most affected type of pipes were asbestos cement in the dimensions of four to twelve inches.

2. About 40,000 homes -- roughly 80% of the population — were served by piped water in their homes before the earthquake. Of these, about three quarters suffered interrupted service after the earthquake.

Although the water production system was functioning within 24 hours of the earthquake, the problem was that the distribution system was completely destroyed, so very few people were getting water.

By the end of February, roughly two months after the earthquake, home-service had been restored to 18,000 families, roughly half the population receiving service before the earthquake. By the end of May, 1973, six months after the earthquake, 24,000 homes — about 60% of those served before the earthquake — had water systems re-established.

In repairing the water system, the water authority took the pipes of greatest width first and worked their way down. After the earthquake, they were losing 75% of the water pumped through the system. At the end of six months, 50% was still being lost.

3. In the emergency period, water was distributed to the entire city except the zones which the Government wanted evacuated.

The water authorities organized tanktrucks from the Departamento de

Carretera, the Ministerio del Distrito Nacional, the Guardia Nacional, and private companies. These were supplemented by tanktrucks provided by the U.S. Government from Panama.

In addition, some wells were equipped with diesel generators.

4. Some interesting sidelights: the water authority salvaged from the rubble about 13,000 water meters, which were used in new systems. Because of the interruption of service, the water authority's income was 50% lower than anticipated, creating a fiscal crisis for the water authority just when they had maximum need for working capital. After the earthquake, the water authority decided to construct six deep wells on the outskirts of town.

Guatemala 1976

Guatemala City escaped the kind of severe earthquake damage which befell the Highlands and some Eastern areas of the country. Thus, the experience was generally in the rural mountain areas, whose villages' water systems were fed by natural mountain springs in most cases.

Still, at the II Seminario Sobre Ingenieria Sanitaria en Situacion de Catastrofe, Ing. Jose Gilberto Araneda C. of INCOM, the Municipal Development Agency of the Government of Guatemala, commented:

Fuentes de Agua

El comportamiento de estas fue de lo mas variado ya que un gran numero incrementara su caudal temporalmente en periodos variables indudablemente dependio de la conformacion de las capas aculferas y a la topografia del lugar. Hubo casos en que estas decrecieron al punto de agotarse completamente para emerger en lugares aledanos y aun desparecer.

Es importante tomar en cuenta que posiblemente los efectos del terremoto persistieron - dandose recientemente la desaparicion de un caudal apreciable de 18 Lts. - s (777 pajas) en San Miguel Duenas donde se tenia registros de mas de tres anos y hubo de superar la obra de introduccion de agua proyectada. Casos similares se han planeado en San Martin Jilotepeque, Atescatempa,

San Miguel Petapa - aunque este caso pueden existir otros factores como serian la localizacion y perforacion de pozos en areas aledanas cuya influencia debera ser establecida.

Los sistemas de bombeo existentes en el area afectada no presentaron efectos Inmediatos, pues al repararse las lineas de conduccion fueron puestos en servicio, sin embargo se pudo notar posteriormente cierto incremento en desperfectos en un periodo relativamente corto, debido en algunos casos al efecto de la osciliacion provocada por los temblores, a la operacion forzada que tuvieron y el cuidado deficiente que se le dio por parte de los operadores.

Los pozos en servicio para las poblaciones algunos en areas aparentemente danadas, no han presentado a la fecha problemas estando todos en consideracion teniendose eso si conocimiento de varios pozos particulares que si fueron afectados, y que hubo necesidad de abandonarlos.

Ing. Jose Gilberto Araneda C.
INFOM
"Experiencias del Terremoto de Guatemala, en Relacion a Sistemas de Agua Potable y Alcantarillado en Areas Urbanas" p 34

Variations in water levels of rural water systems were definitely noted by the USAID emergency relief program. In fact, some of the principal labor-intensive work projects undertaken by rural communities with USAID reflow funds were used to excavate the sites where natural water springs had formerly emerged in search of a new, deeper point where such water might be tapped after the earthquake. In the meantime, the water systems of many rural villages remained with little water supply.

Of interest are some of the recommendations which emerged from the Guatemala Seminar:

1. Quality Analysis Kits: Portable kits should enable water technicians to make quick, physical, chemical and bacteriological analyses of water (same as Recommendation No. 2 made by Captain Wehman after the Peru experience).

2. Emergency Stocks An adequate stock of emergency replacement pipes, engineer and pumps parts, and other vital equipment, should be maintained so that it will be ready in case of an emergency.

3. Systems Inventory: A complete set of plans, maps and other data concerning the distribution network should be maintained, including the location of pipes -- indicating the kind of pipe, size, location and distance from control points.

Other information included in various reports which form a part of the seminar's conclusions, have some application to the Lima situation:

1. EMPAGUA -- the Guatemala City water authority -- reported that in the earthquake one well lost its verticality, and another which had been troublesome before the earthquake went out of order. The other seven wells in their system, however, survived in tact. Wells received EMPAGUA's earliest attention because they required only the reconnection of power to begin production. Wells were considered the sector of the system most easily susceptible to repair.

2. A private company (not named, but could have been HYDROTRONICS) was retained to detect and identify leaks in the distribution system.

Other Lima-Related Literature

Three publications issued within the last ten years provide some further information about the Lima water system. They are:

1. Los Recursos de Agua para La Gran Lima, Binnie and Partners, Consulting Engineers, by assignment of the Ministry for Overseas Development of the British Government, was issued in September 1970. This was the study which originally proposed the use of Montaro River water to augment the Lima water supply. Its first volume is a summary of a rather extensive series of documents, some of which are available in the USAID Office ofEngineering.

2. Some rather general comments on the vulnerability of the Lima water system are included in:

Proteccion de Lima Metropolitana Ante Sismos Destructivos, Ing. Julio Kuroiwa H., Universidad Nacional de Ingenieria (UNI). Prof. Kuroiwa is a member of the Science Advisory Committee of the National Civil Defense System.

Proteccion de los Servicios de Agua y Desague ante la Ocurrencia de un Sismo de Grado VIII M.M., by (Ing.) Carlos Enrique Moran Tello, conducted under Ing. Kuroiwa's supervision.

CURRENT AND PROPOSED PLANS FOR POST-DISASTER RECOVERY

ESAL Emergency Plan On February 6, 1981, ESAL published its official emergency plan for re-establishing water supply in Lima after a major earthquake. Directive No. 002-81/VC-8310, prepared by the Planning Office, is included in its entirety in the supplementary volume. (See Item F)

The plan focuses specifically on establishing lines of authority in the event of a disaster within the ESAL organization and proposes the establishment of emergency procedures in such a case. It does not deal with substantive strategies for re-establishment of water supply in case of a disaster, but requires other offices of the ESAL organization to do so.

Plan Alfa Centauro At the time the emergency plan was published, the National Civil Defense Organization undertook to make US $44,000 available to critical sectors of City service to plan for a major earthquake. Terms of reference (outlined in a document which appears in the supplementary volume Item G) were developed for a study of the vulnerabilities of the City water system in case of a major earthquake. These terms of reference were apparently based on a proposal submitted by Ing. Julio Kuroiwa H., on behalf of Kuroiwa-Kagan Associates, a private consulting firm in Lima.

The proposed study contains four parts:

1. ATARJEA Site Study: Soil analysis, geological considerations, topography, anti-seismicity of installations, proposals for strengthening intake, trunklines, reservoir and electrical installations, and the treatment facility as a whole. COST: US$8,800

2. Plans and Specifications for repair and strengthening the ATARJEA: COST: US$18,000

3. RESERVOIR Study: COST: US$7,700

4. Zone Parks, the design of a system to provide water to the city's parks, then designated as refuge areas, and to provide a system for the removal of sewage COST: US$2,700

5. BEHAVIORAL ANALYSIS of the ESAL Water System under earthquake conditions. Action Plan to respond to earthquake.

COST: US$7,700

TOTAL COST: US$44,000

Since this outline and budget were developed, ESAL reports that costs have increased by 30%. At the outset, ESAL planned to award the contract to Ing. Kuroiwa's firm. However, fiscal authorities insisted that the terms of reference be put out to public bid, and this was scheduled to take place later in 1981.

At this writing, it is not actually certain whether the funds have been made available to ESAL and whether the study will be carried out.

CEPIS Water Supply Project

In March 1981, the Pan-American Center for Sanitary Engineering and Environmental Sciences (CEPIS), whose headquarters are in Lima, developed a proposal which was different from the Kuroiwa-Kagan Associates proposal to ESAL. CEPIS planned to submit their US$100,000 three-month research package to USAID. However, ESAL did not accept the CEPIS proposal.

CEPIS' terms of reference were the following:

1. Assessment of vulnerability of the water system.

2. Establish how 10 to 30 litres of water each day could be provided to Lima's five million inhabitants in an emergency.

3. Study alternate energy sources for wells, such as generators, gear head drives, motors/vehicles/fuel required to drive them, etc.

4. Use of tank trucks, storage vessels and home storage during emergency distribution.

5. Treatment of water at delivery point and at homes.

6. A series of related services such as training, motivation and support for ESAL personnel, community participation and education, harmonizing this plan with other plans for restoration of water supply, organizations, communications and other.

7. This study would produce an EMERGENCY PLAN (which would be its final report) and a DEMONSTRATION OF FEASIBILITY.

A copy of the entire proposal is included in the supplementary volume Item H.

ESAL's Response: We Need Equipment

The ESAL response to CEPIS' initiative was to propose a different approach, in a US$150,000 package which was prepared during the same month as the CEPIS proposal. (A copy of the entire ESAL proposal is included in the supplementary document Item I.)

The proposal suggests that a "model disaster response prototype" be developed. Most of the project's funds would be used to provide portable water purification units, underwater and other pumps.

However, as of this writing, neither the Plan Alfa Centauro, nor the CEPIS or ESAL projects have received funding approval, and it is not known if any are under serious consideration by funding agencies.

Vulnerabilities of the Lima Water System

In a major earthquake, Lima's water and sewerage system could be considerably damaged. While it is impossible to predict the extent of damage, this section will attempt to outline areas of vulnerability assessed by ESAL and private sector engineers, hydrogeologists, geophysicists and other technicians concerned with earthquake engineering.

Vulnerabilities: Production Sector

The Atarjea Water Treatment Plant has a number of vulnerable points. In an earlier section, the plant's problems with huaicos - mudslides in the Rimac River — was described. The section highlighted the ability of the plant to manipulate the seven locks on the river which permit the plant to select the water which is taken in through the captation points. These very substantial concrete and steel structures appear well constructed, but they could fail. In addition, although they can be raised and lowered manually, the locks should have a source of stand-by power, and therein lies one of the plant's current weaknesses: an inadequate source of stand-by power for all of its operations.

The five-hundred thousand cubic metre reservoir represents another vulnerable point. With its three man-made walls, and fourth natural rock-surface wall, there could be faults at the points where the two types of structures interface. This happened before, in 1970, when the reservoir was only 30% full, without the additional provocation of an earthquake. Although since it was repaired the problem has not recurred, a major earthquake could provoke a similar breach.

In 1970, water escaping the reservoir ran into Lima at the rate of three to four kilometres per hour, and was a considerable nuisance. The greatest

danger from the reservoir would occur if it were full when a major earthquake caused a collapse in the structure. The amount of water cascading into town would be triple what it was in 1970 and it could cause serious damage and injuries. It could certainly aggravate problems of transitibility of the streets in downtown Lima, where the greatest amount of building collapses might be expected and where the largest number of persons injured would be located.

In addition, there is a small population which lives close to the Atarjea reservoir which would find itself at considerable risk. It has been requested that the population be moved elsewhere, but to date it remains.

Some proportion of the sedimentation tanks and other concrete tanks and trunklines might be damaged as well. It is the view of the technical staff of the plant that in the worst case they would be able to continue providing a much reduced quantity of water to the City, and that the quality of the water (parts per million of impurities) would be poor.

Perhaps the March, 1981, huaico phenomenon is indicative: production had to be cut, at times, by 75%. But in case of earthquake damage, the plant has some by-pass lines which ought to permit some type of onward water movement and would be susceptible to emergency repairs. Still the 60% of the city's water production which comes from the plant would be in doubt.

The wells, which produce the remaining 40% of production, might fare better:

1. Hydrogeologists and other experts unanimously agree that no major change in the underground water table would occur in a major earthquake. They argue that there would be varying degrees of water excitation in the first thirty minutes after the earthquake, but that there is no reason to believe that the expansive underground water supply system would be damaged.

If there were some alteration in the water level, it would not be enough to alter the ability of the wells to continue producing. (They tend to be more concerned with the gradual reduction in the level, at the rate of 1.5 metres per year; measures are being explored -- and are included in the World Bank Master Plan -- to artifically increase the amount of water fed into the underground channels).

2. Previous experience (Chimbote 1970, Guatemala 1976), and professional assessments by Peruvian technicians are not conclusive about the extent of damage which can be expected in the water wells themselves. However, they tend to agree that 20% or less of Lima's principal 225 wells would be severely damaged. A twisting effect or loss of verticality is not foreseen, although some shearing would be possible, depending on the nature of the seismic waves. There could be some sand-clogging at the base of the wells in some cases. But the overall assessment by national and international experts is that the wells themselves would, in their overwhelming majority, remain in tact. Such damage as is estimated tends to be geographically targeted to the La Molina, Chorrillos/Barranco and Callao areas because of their sandy soil quality and seismic histories.

Wells which had considerable maintenance problems before such an earthquake would also tend to be included within the 20% which might suffer more than minor, quickly reparable problems.

The main vulnerability of the wells is their power source, ELECTRO-LIMA. Should electrical power be more than temporarily interrupted after a major earthquake, the wells would, at present, cease functioning and remain inoperable. The use of generators for a significant number of wells is not feasible: even to operate the 24 principal producers, 24,100 - 150 KVA generators would be required. Such resources do not exist in Peru and probably could not be

quickly shipped in from abroad. There is no prioritized plan at present for emergency connection of the wells by ELECTRO-LIMA.

This means that in an emergency, ELECTRO-LIMA's response would have to be either ad hoc -- i.e. reconnecting wells according to some criteria not necessarily reflecting useful priorities, or ESAL and ELECTRO-LIMA would have to meet and set priorities, which could slow down recovery considerably. This is especially true because it seems doubtful whether any constructive work would be accomplished in the first 12 - 16 hours after an earthquake.

In addition, there are no alternative sources of energy prepared at present. There are some gear head drives at the Atarjea plant, but the installation of numbers of them might well take days in an emergency, perhaps longer.

There was considerable speculation about the quality of well construction in Lima, compared with, for example, Chimbote. The consensus was that the newer wells are much stronger than the old ones and that the quality of such work in Lima tends to be higher than the quality of work in Chimbote was at the time of the 1970 earthquake. But cost is also a factor: in those days, a well cost about S/2000 per metre to construct; today the cost is S/150,000. In times of economic crisis, contractors sometimes cut corners in order to deliver a piece of work within the allowed budget.

Technicians are also careful to point out that the quality of soils in Chimbote, which was quite sandy, was considerably different from the quality of most of Lima's soils, and, as a result, the wells should receive somewhat less of an impact in a severe earthquake.

It is difficult to assess the survivability of the underground and elevated tanks. One Peruvian professional intimately familiar with both the specifications and actual construction of the elevated tanks estimated that

no more than 20% would be in danger of collapsing in a major earthquake. He tended to be conservative in such estimates, so this appeared to be a credible maximum estimate.

Contamination of the wells could occur in two ways:

(a) The sewerage system could suffer numerous ruptures, permitting sewerage then in the trunklines to filter out. However, there is a layer of about 30 metres of earth between the sewage lines and the underground water supply, and it was unanimously agreed by Peruvian and international professionals that this was adequate to remove bacteriological waste which could contaminate the underground water supply, at least for a period of several months. Thereafter, if the amount of waste filtering into the ground continued at a steady base, the ground could get saturated with impermeable materials and filtration would slow down considerably.

(b) If sewerage rose to the surface, it would flow into the wells from above.

Both of these possibilities are considered remote. Nevertheless, ESAL does not currently possess the equipment or number of trained persons adequate to conduct quick emergency water quality tests.

Vulnerabilities: Distribution Sector

Without reference to a major earthquake, ESAL is having some problems at the moment with the lines to Villa El Salvador and Rimac installed by SUPER-CONCRETO DEL PERU. Thus, it is expected that under the pressure of an earthquake, even more such problems with these lines could be expected.

ESAL is confident that the major trunklines installed by the Raymond Corporation of Chicago will resist any major earthquake. This means that some water distribution could continue through Lima.

However, views concerning the smaller-diameter distribution lines vary considerably. Numerous technicians fear that the asbestos-cement piping -- the most troublesome in normal times -- could be separated, crushed together and broken or fractured in a major earthquake and that considerable portions of the City could be left without channels for water distribution. In general, it could be expected that some, but not all, of Lima could be cut off from normal water distribution.

One knowledgeable veteran of the water management field argued that a major maintenance effort with the city's valve system is required at present. Were this sytem to be brought into better working order, the city would be easier able to control the flow of water in the parts of the system which might survive an earthquake. This would also permit manipulation of water pressure when there are urgent needs for it (for combating fires, for example) in normal times.

One aspect of the vulnerability of the distribution system is a complaint by one senior official that spare parts, despite their best efforts, are not kept in stock. This is especially true for the larger size pipes (72" for example) but also for smaller ones. From this particular vulnerability will arise one of the study's recommendations for USAID post-disaster participation.

Pueblos jovenes — zones served by water tanktrucks, where water is stored in 55 gallon drums or other such containers — are not vulnerable to a breakdown in the distribution system, as they have no pipes. However, in normal times and, especially, after an earthquake, the tanktrucks delivering water to them meet no health standards. It might be important to chlorinate or otherwise treat tanktruck water in an emergency to diminish health risks.

Vulernabilities: Sewerage System

As opposed to the water system, the sewerage system is even more brittle and vulnerable, as the joints between 90% of its pipes are made of simple concrete, a rigid and unreinforced type of construction which would lend itself to fractures. These lines tend to run underneath the water lines, so risk of contamination is relative.

One international expert classifies two levels of sewerage risk in Lima:

(a) The system could suffer numerous fractures, considerably increasing the amount of leakage of sewage waste into the ground. This is not a problem, he argues, because the system has thousands of such leaks right now, and the sewerage safely filters into the ground.

(b) A severe collapse in identified areas stops the flow of sewerage, causes it to back up and to flood into the streets. One area particularly vulnerable to such an effect is Miraflores/San Isidro, which occasionally has such problems at present. Its sewerage system is old and inadequate. At the moment, sewerage is often backed up into the manholes because the system cannot handle the volume produced in those areas (also the location of the residence of many USAID officials).

Thus, the international expert believes that severe sewage-waste flooding problems would occur in isolated areas of the city, but not on a widespread basis.

However, other technicians foresee a gloomier scenario concurred in by some local municipal officials, of more considerable flooding around the City.

This matter should be pursued by OFDA with AID Water Expert Victor Wehmann.

Recommendations

Having considered the City's vulnerabilities to a major earthquake, this section will propose a number of disaster-related activities which could reduce the vulnerabilities or accelerate the City's ability to respond in the event of an earthquake. It will also recommend some actions which could be taken by USAID to assist the City after such an earthquake.

Disaster Mitigation and Operations Planning

1. Stand-By Power for La Atarjea Water Treatment Plant. The proposal that the Atarjea be equipped with a 300 KVA generator adequate for its normal and emergency operating needs appears a reasonable one which should receive priority attention in capital investment programs. Such an alternative is under consideration by the World Bank as part of its current loan development for the Lima water sector. In the course of this study, the importance of such back-up power after disasters such as earthquakes and terrorist attacks was discussed with the Bank.

2. Identification of Priority Wells for Electrical Reconnection. If ELECTRO-LIMA will be capable of re-establishing some electrical energy to the City, the most critical wells, such as the list of 24 included herein, should receive priority. A list of the most critical wells should be developed, prioritized and co-ordinated with other suggestions included herein, and passed to ELECTRO-LIMA for study. A map of Lima, showing these wells and the location of the three electrical sub-stations closest to each, should be developed.

If the sub-station which currently supplies a given well remains functional, but electrical energy cannot be safely connected to the district as a whole, the discrete 10,000 volt line to the well can be activated nevertheless

If that sub-station is destroyed, emergency lines can be established to allow for supply of energy from any of the nearest sub-stations which have survived. However, it seems advisable that such planning should take place in advance, rather than after an earthquake.

In addition to the priority wells based on production, wells which serve current water dispensing units (surtidores), key pumping stations, the three major sewage pumping stations (especially in El Callao), La Atarjea Water Treatment Plant, and other vital water facilities should be included in such a plan.

3. Gear head drives (cabezales) in ESAL's possession are in the process of being reconditioned. Financial assistance should be provided to ESAL if needed for spare parts and repairs to these units, keeping in mind that the cost of a new unit is about US$4,000.

It is proposed that such units be placed at an early date on the critical wells so that in an emergency they can be immediately connected with diesel powered engines and activated. The modifications in the cement housing required to fit them to such an engine can be made under emergency conditions. This planning should include a match-up of RPM's required to run the gear head drives with engines likely to be available.

4. Surtidores — water dispending units — could be vital resources in the event of a major earthquake. Any well can be adapted with a surtidor, and the cost of doing so per well (see sketch at following page) is less than US$1,000 each. At least twenty wells should be provided with this emergency facility, which should include valves which can regulate the flow of water through the surtidores. According to ESAL, no additional pumping other than that provided by the well normally is needed to make such a unit function.

Such surtidores can fill tanktrucks, can be connected to emergency hose-lines for distribution, or can even fill bladder-tanks. The small investment

involved appears warranted.

Once such units were in place, only the overhead pipe would need to be erected — work of 30 - 60 minutes -- to make the unit functional.

5. Water Storage Tank Specifications Appendix V suggests a review of the specifications for water tank construction. This suggestion is based on a study by a private sector water engineer on technical aspects of failures in such tanks in other disasters, in particular, Managua.

Upon review and concurrence by USAID engineers, this suggestion could be communicated to the Ministry of Housing, which is responsible for all water-related matters.

6. Worst Case Scenario: Although water supply is a serious post-disaster consideration, Lima's backup resources include:

(a) The well system. For example, 24 wells produce nearly 130,000 cubic metres per day in normal times.

(b) Five wells in the Chillon Valley, dependent on no outside energy source, produce 24,000 cubic metres of water per day.

(c) Industrial wells within Lima, which have their own standby power, and Shallow Wells, which require minimum generator capacity which is well within Lima's capacity to provide, can produce considerable quantities of water.

(d) The regadio system can provide some water in the City, even though it would have to be purified before it would be adequate for human consumption.

However, should all of the above fail and should, in fact, the Rimac River fail to continue to provide usable water, there is a final possible contingency tapping the waters of the Chillon and Lurin Rivers, which run, respectively, to the north and south of Lima.

Tapping the Chillon River has long been considered an option in the development of Lima's water system. At present, under the Master Plan,

the possibility of constructing a Water Treatment Plant at Puente Magdalena, about seven kilometers above the beginning of the Lima Water System in the Chillon Valley, is being considered. At the following pages, Charts XVII, XVIII and XIX illustrate the geographical area; show (increasing) projected rates of water flow from 1980 through 2000, and the quantity of available water (in cubic metres per second) by month at that spot.

One Peruvian technician has suggested that a similar spot exists on the Lurin River, at Cieneguille.

The quality of river water at both of the proposed captation points is said to exceed that of the Rimac, although the Chillon point is considered the more feasible of the two.

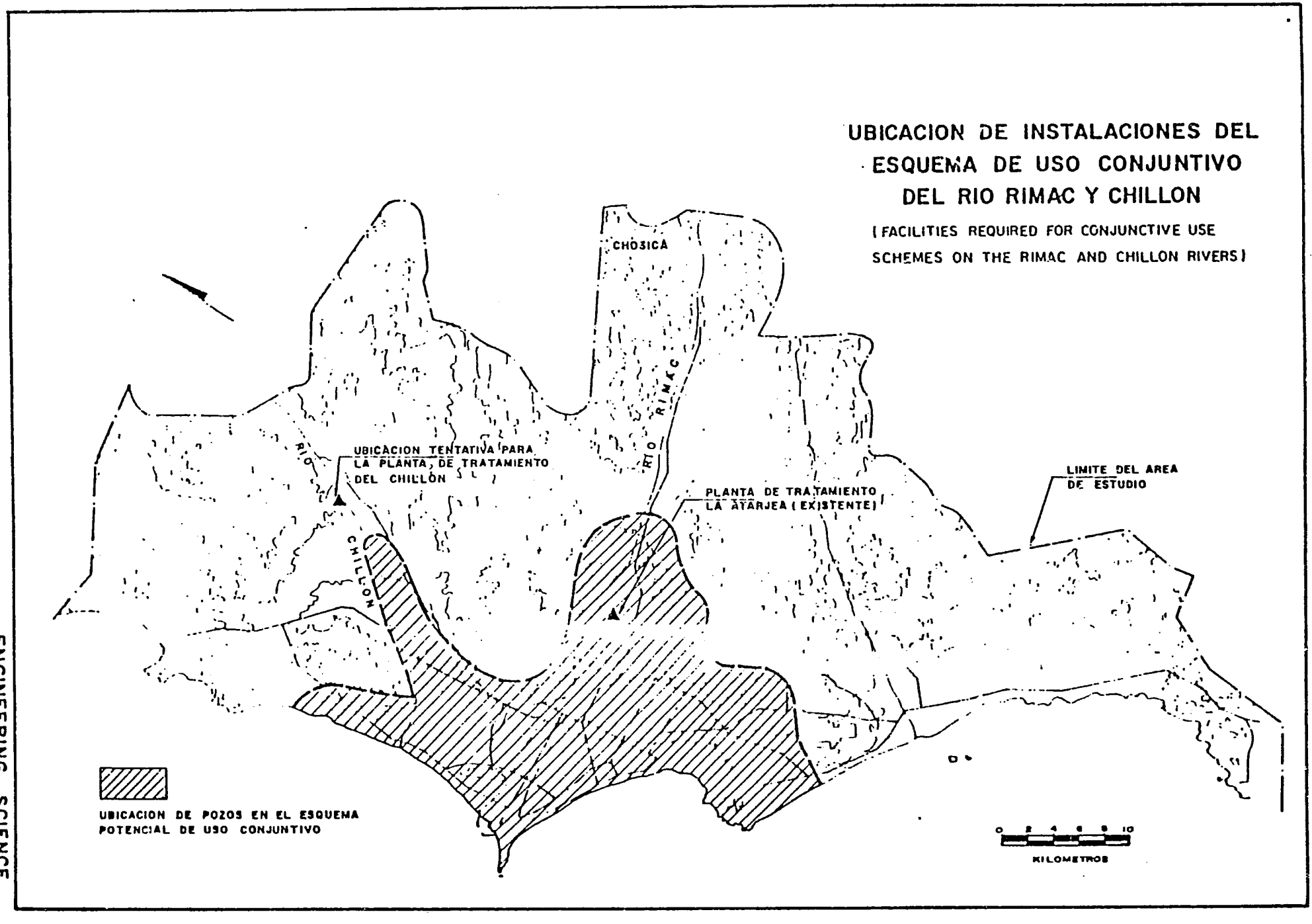
Given the high degree of concern over water supply for Lima, further study of the use of this information in a worst-case emergency could be conducted, especially in connection with the technicians from Engineering Science who have already done some of the basic work on this problem.

In this connection, it would be useful if USAID/Washington could provide to USAID/Peru the catalogues and specifications for the newly developed PVC "soft" piping which can be used for emergency installation of conduct lines. This piping could have other emergency uses, and data for it should be on file with the Misison Disaster Plan.

6. One disaster preparedness expert has suggested that water tank trucks should be required to be filled when not in use during evenings or weekends to insure that an immediate emergency mobile supply of water is always available.

7. It would be useful to ascertain whether sewage likely to back-up if power fails in El Callao can in an emergency be bypassed directly into the sea.

Chart XVII


UBICACION DE INSTALACIONES DEL
ESQUEMA DE USO CONJUNTIVO
DEL RIO RIMAC Y CHILLON
(FACILITIES REQUIRED FOR CONJUNCTIVE USE
SCHEMES ON THE RIMAC AND CHILLON RIVERS)
CHOSICA
RIO RIMAC
RIO CHILLON
UBICACION TENTATIVA PARA
LA PLANTA DE TRATAMIENTO
DEL CHILLON
PLANTA DE TRATAMIENTO
LA ATARJEA (EXISTENTE)
LIMITE DEL AREA
DE ESTUDIO
UBICACION DE POZOS EN EL ESQUEMA
POTENCIAL DE USO CONJUNTIVO
0 2 4 6 8 10
KILOMETROS

FLUJO PROMEDIO PROYECTADO DEL RIO CHILLON EN EL PUENTE MAGDALENA

(PROJECTED FLOW IN CHILLON RIVER AT PUENTE MAGDALENA)

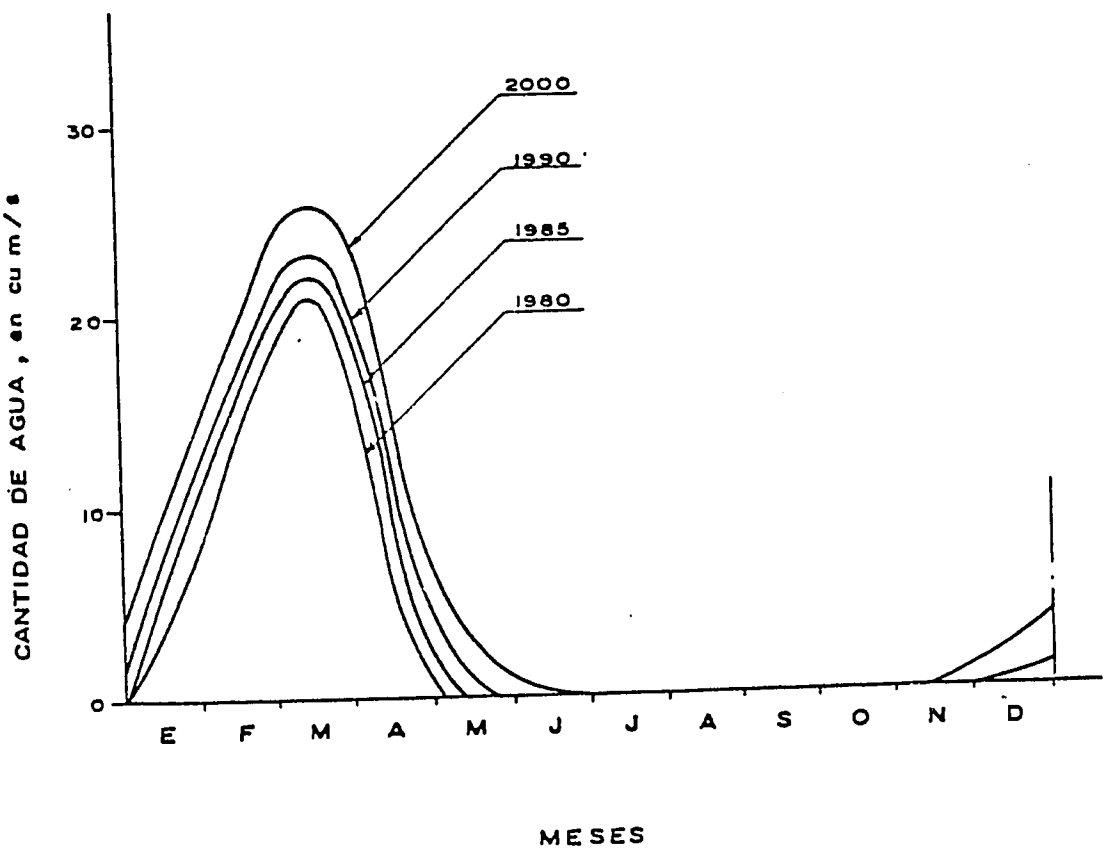


TABLA 8.7

CAUDAL PROYECTADO EN EL RIO CHILLON EN EL PUENTE MAGDALENA

Item	Caudal Promedio Mensual, en cu m/s												Prom.
	J	F	M	A	M	J	J	A	S	O	N	D	
Caudal promedio en el Puente Magdalena (prom.1920-1980)	13.08	22.83	29.67	15.32	5.49	2.90	2.10	1.91	1.66	2.10	2.55	5.43	8.75
Exfiltración a la cuenca de agua subterránea	-	-	-	-	-	-	-	-	-	-	-	-	-
Demanda Agrícola Estimada													
1980	8.9	8.9	8.8	8.0	7.3	6.6	5.8	7.7	7.5	7.4	6.3	7.0	7.5
1985	7.6	7.6	7.5	6.8	6.2	5.6	4.9	6.6	6.4	6.3	5.4	5.9	6.4
1990	6.3	6.3	6.3	5.6	5.1	4.7	4.1	5.4	5.2	5.2	4.4	4.9	5.3
2000	3.7	3.7	3.7	3.3	3.0	2.7	2.4	3.2	3.1	3.1	2.6	2.9	3.1
Caudal en el Puente Magdalena													
1980	4.1	13.9	20.9	7.3	-	-	-	-	-	-	-	-	3.8
1985	5.5	15.2	22.2	8.5	-	-	-	-	-	-	-	-	4.3
1990	6.8	16.5	23.4	9.7	0.4	-	-	-	-	-	-	0.5	4.7
2000	9.4	19.1	26.0	12.0	2.5	0.2	-	-	-	-	0.1	2.5	6.0

Table Produced by: Engineering Science

7. Counter-Contamination Measures Although the risk of widespread contamination in a major earthquake is not generally considered probable, such risk can be generated by various kinds of alterations in the environment and it would be important to monitor water quality in an earthquake emergency. This would include River Water, Regadio Water, Well Water and Tank Truck Water.

It would be important to develop a wider capacity within the Peruvian community to conduct such water testing. At the moment, the number of persons trained to conduct such tests is fairly limited, as is the equipment. Portable water testing equipment and training for an expanded number of ESAL technicians would be a small but wise investment.

8. Construction of New Wells Under a loan from a German institution, eighteen large new wells are being constructed. It might be feasible to suggest that such wells, which will be among the most modern and productive in the City, be equipped with gear head drives right from the design stage. The increased cost per well would be a very small percentage of overall costs. They might be equipped with emergency valves to permit their use as water dispensers in emergencies as well.

Not all of the wells would require such equipment. But it would be useful for the wells which render the greatest production be so equipped.

9. Because they would be critical to providing medical attention after an earthquake in Lima, contingency plans should be made for providing water to major hospitals (100 beds or more). This study has provided some baseline data on hospital water systems which, as described in the medical report, is being elaborated upon. Once final data have been established, contingency plans for supplying water on a priority basis to hospitals should be made.

USAID: Post-Disaster Options

1. Technical Assistance/Liaison: Initial liaison and technical assistance and with water authorities could be provided by AID's Office of Engineering. However, there are two experts who, for different reasons in each case, would be excellent resource personnel for the Mission and, perhaps, for ESAL:

(a) Victor H. Wehman Mr. Wehman is a water expert who is a member of the USAID/Washington staff. He has handled water emergencies in Peru before, as the DAST Water Engineer in 1970. He also managed the Guatemala water emergency situation in 1976. He has wide field and technical experience.

(b) John M. McGill is a U.S. water engineer whose resume also demonstrates the widest international experience in water matters. However, in addition Mr. McGill has worked on the Lima water supply system for two years. He knows the ESAL officials and is knowledgeable of the water and sewerage systems -- their vulnerabilities and needs. He will be in Lima only until the end of 1981, but his firm, ENGINEERING SCIENCE, might well consider seconding him to USAID in an emergency. His resume appears as Appendix I to this volume.

It would be wise to call in one or both of these technicians as soon as it is ascertained that a major emergency in Lima exists.

2. Full Circle Clamp Couplings Appendix II to this volume provide technical information concerning an emergency repair system for the city's water pipe system. ESAL has used the Rockwell International clamp coupling system with great success: it has cut repair time down by 80%, reduced costs, and requires NO SPECIAL TOOLS OR EQUIPMENT to install.

To assist in emergency repair of the water distribution system, which should begin immediately, USAID could make an important contribution by using air transport to provide an emergency supply of such parts to ESAL so that it would be able to begin and accelerate its emergency repair program. Such

supplies should be consigned to ESAL's Director of Operations and should be delivered from air carrier to ESAL truck directly.

Prior to ordering, of course, coordination with ESAL's Water Lines Manager should be effected to get the final sizes and number of units of each kind required.

The larger the size, the more difficult it is to purchase "off the shelf". Also, care should be taken to insure that specifications for diameter are specified as interior or exterior diameter, even though each coupling device has some margin and flexibility in it.

This would not be an inexpensive input. However, under emergency conditions, it is recommended that the brand known to ESAL technicians, as shown in the attached catalogue, be used for procurement purposes unless the manufacturer cannot supply the full quantity in time. In such an emergency, there would be little point in introducing new products, new specifications, or new systems.

3. Gear-head Drives Appendix III provides specifications and catalogue data for gear head drives. Such units, manufactured by U.S. Motors but assembled in Peru by HIDROSTAL S.A., can be procured locally. Technical data concerning such local procurement is included in Appendix III. In normal times, HIDROSTAL has a supply of 20 100HP and 20 150HP units in stock. Their costs are US$2,525 and US$4,100 respectively. The appropriate model numbers and other ordering information is in the Appendix.

If such cabezales are purchased, it is recommended that they be provided to ESAL on a loan basis. USAID ought to have a supply of these units in its emergency stock in Panama. Many Latin American countries use wells which, in an emergency, might benefit from such alterative-energy units.

4. Water Purification Units OFDA currently has, in stock, seven

water purification units which can process 20,000 gallons each per day (TOTAL theoretical capacity: 140,000 gallons per day = 635,000 litres = 636 cubic metres per day). Of the 50 million litres which PAHO has calculated as the city's minimum daily requirement, the amount which can be purified by these units represents just over 1% of what is needed. Thus, in terms of supplying water for the population, the impact of these units would be negligible. Further, each unit would require three HUEY helicopter trips to be moved from one place to another.

Thus, if water purification units are to be used, they must be for only absolutely essential and critical services — for example, hospitals or isolated zones left with no other alternative water source whatever. They must be used for discrete functions. In the case of Lima, the city would almost have to be approaching a worst-case scenario in order for such units to be employed cost effectively.

5. Water Bladders: Water bladders are temporary water storage tanks made of rubberized canvas , which can be erected anywhere. They can be folded up for transportation purposes and have been used by USAID with considerable success in past disasters. The bladders permit localized storage of water in areas where the normal distribution network has broken down. Their capacity may be 2,000 gallons or 3,000 gallons each.

If the water distribution network breaks down in major sectors of Lima, these bladders would be ideal for two reasons:

(a) They would enable ESAL to place them in the most localized areas — for example, near residential areas where people are remaining near their homesites; or in temporary or permanent resettlement areas for persons left homeless by the disaster. They can help to make a decentralized water supply strategy possible, instead of forcing the population to congregate in longer lines at more centralized distribution points. Their placement is discussed

more under the overall shelter strategy section of this study.

(b) They enable maximum utilization of tanktrucks. At present, tanktrucks are used as retail-dispensers of water in outlying areas. With the bladder tank system, the tanktruck is used only to carry water, not to store or distribute it.

Given the rather limited carrying capacity of the Lima fleet, it will be important that the tanktrucks be used only for transportation. The bladders would complement such a strategy.

The number of such bladders which might be available should be ascertained by OFDA and communicated to the USAID/Peru Mission Disaster Relief Officer.

6. Plastic Water Jugs In some situations, it may be necessary to use plastic water containers to distribute water in the city -- to residents or to institutions. Appendix IV lists major producers of such jugs and their prices. A three-gallon container sells for between US$2 and US$3 each. In the Dominican Republic after Hurricane David, such containers were procured by the Government and filled with fresh water by the beer and soda companies, which had access to pure water. This is strictly an emergency measure.

7. Water Testing Kits and Personnel Disaster assistance military personnel from Panama might be prepared to come to Lima with portable water testing kits, to conduct surveys of City water. It would be preferable to train local technicians from ESAL in their use and to make some of these units available to SENAPA -- the national water co-ordinating agency -- for use in emergencies throughout Peru. But, if this cannot be done, some immediate assistance with equipment and personnel would be appropriate.

8. Local sanitation -- including the establishment of emergency sanitation units to remove human waste materials -- might be necessary in

some areas, especially in resettlement areas. Literature concerning one unit which has been used with great success in such emergencies — the OXFAM Sanitation Unit — is included in the supplementary volume. If AID is to be involved in this field, it might consider consultation with technical assistance personnel with field experience in this speciality. One such expert is Mr. James Howard, OXFAM Disaster Co-ordinator, whose services might be provided by OXFAM or through some co-operative agreement.

9. Construction Battalions After the earthquake in Guatemala (1976) and Hurricane David in Dominica (1979), the U.S. military provided the services of construction or SEABEE battalions. Their participation in post-disaster operations was fairly successful. They are trained, skilled and disciplined teams which are completely self-equipped and self-supporting. Should the Government of Peru so desire, there are two tasks associated with water supply which they could undertake: recovery of the Water Treatment Plant; and repair of major water trunk lines.

10. Assistance Not Considered Appropriate

(a) Generators. In terms of water production, international donors are not in a position to provide a number of generators adequate to make even a small impact on water supply. Furthermore, they will undoubtedly be better local options, some of which are provided in this report. Nevertheless, governments which have suffered disasters inevitably request such equipment, and the U.S. Ambassador and USAID Director will be besieged by such requests. It appears that it would not make sense to divert management time, energy and money to such a purpose.

(b) Hydrotronics. Although the HYDROTRONICS system has been employed after earthquakes in the region, it should be noted that ESAL has two fully equipped mobile units purchased from HYDROTRONICS with personnel trained by

HYDROTRONICS. Thus, the chances that such external provision of these services would be needed are diminished. In fact, should neighboring countries suffer earthquake disasters, Peru could consider providing this type of assistance to them. For complete information on the HYDROTRONICS system see the supplementary volume.

11. Although it is a remote possibility, supplies of chlorine and aluminium sulfate used at the Treatment Plant could be destroyed or damaged in an earthquake (or, for example, if the major reservoir is ruptured they could be caught in the flow). It might be necessary to consider an emergency shipment of such chemicals, but the chances would appear to be remote.

LIST OF CONTACTS

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ESAL
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Ing. Fernando Dapelo Zazzali
Superintendent
ESAL - Callao Zone
El Callao
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Ing. Juan Ramos Tapia
Sub-Gerente de Producción
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Ing. Juan Carlos Ruiz
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Ing. (Bernadino) Jaime Salcedo Lobaton
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ESAL
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Ing. Plácido Aguirre Alata
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Dirección de Operaciones
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Ing. Max Rabines Spelucín
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Same Address as Ing. Arana
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Encargado de la Gerencia Central
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Ing. John Monroe McGill
See Appendix for
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two lefts)
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Director General
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Jose Sotero Peirano
Jefe de Ingenieria
Ejército Peruano
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Phone 720997

Ing. Fernando Rincon Bazo
Alcalde Acc. (Deputy Mayor
Municipalidad de Lima
frente al Palacio Nacional
Lima

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Already Described under
Engineering Science - Privae Sector

Victor H. Wehman Jr.
USAID Water Specialist
USAID
Washington ,D. C.

Mr. James Howard
OXFAM Technician, Specialist
in Local Sewage Systems in Emergencies
(Currently on assignment in
Somalia)
OXFAM
274 Banbury Road
Oxford, England
Phone: 0865-56777
(Can be contacted through
Tony Jackson or Michael Harris,
Director of Overseas Operations,
OXFAM)

APPENDICES

APPENDIX I

Biographical Data: Ing. John M. McGill

APPENDIX I

Biographical Data

JOHN M. MCGILL

Sanitary Engineer/Project Representative

Personal Information

Married, two children, 14 and 13

[redacted]

Hobbies: trekking; cross-country running
Languages: English, German

Education

B.A. in Mathematics, 1959, Bowdoin College, Brunswick, Maine
B.S. in Civil and Sanitary Engineering, 1963, University of Maine, Orono, Maine
M.S. in Environmental Health Engineering, 1969, University of Texas, Austin, Texas

Professional Affiliations

Registered Civil Engineer (California No.16571, New York No. 44080, Arizona No. 7958)
American Society of Civil Engineers, Member
Water Pollution Control Federation, Member
American Public Health Association, Member
American Water Works Association, Member
Arizona Society of Sanitary Engineers, Board of Directors

Experience Record

Over twenty years experience in the practice and administration of Civil and Sanitary Engineering, the last six years of which were in Nepal, India, Indonesia and Peru.

1963-1965 California Department of Water Resources, Water Quality Branch, Los Angeles, California. Junior Civil Engineer on regional master planning for water and sewerage facilities and wastewater reclamation feasibility studies for San Diego County, Ventura County, and the Coachella Valley. Assistant Civil Engineer on stormwater drainage and groundwater basin pollution control studies. Design, construction, and preparation of operation and maintenance manuals for an experimental extraction-type sea-water intrusion barrier.

1965-1966 State of California Water Resources Agency, Construction Branch, San Fernando, California. Assistant Civil Engineer on estimating payment quantities and development of payment guidelines for large-scale hydraulic structures on the Tehachapi Mountain Section of the California water plan, including tunnels, canals, dams, stormdrain channels, and access roads.

1966-1968 New York State Health Department, Albany, New York. Senior Sanitary Engineer in charge of developing and administering a state-wide vector control program. Distribution of program funds, and providing local health agencies with technical advice. Responsible for review of consultant's reports on urban planning and proposed stage legislation dealing with environmental control.

Rennsalaeer Polytechnic Institute, Albany, New York. Lecturer in Sanitary Engineering; member of the staff (part-time) teaching courses in hydraulics and design.

1968-1969 University of Texas, Austin, Texas. Graduate study for M.S. in Environmental Health Engineering, recipient of U.S.P.H.S. Fellowship.

1969-1971 Engineering-Science, Arcadia, California. Project Engineer on water supply, drainage, sewerage and water reclamation/investigations and designs including: design of biological treatment facilities to treat petro-chemical wastes;design of microscreening facilities for suspended solids removal in secondary effluent; development of wastewater reclamation programs for coastal California cities; investigation of alternatives for domestic and industrial wastes management in the Los Angeles Harbor Area; and expansion and modification of reclamation facilities and study of reuse potentials for the City of Burbank, California.

1971-1973 Engineering-Science, Tucson, Arizona. Project Director and Site Representative for an urban systems engineering demonstration program to develop short, medium, and long-range water, wastewater, and solid waste management programs for the eastern one-third of Pima County, Arizona.

1973-1975 City of Tucson, Arizona, Water and Sewer Department, Assistant Director responsible for planning and development, design, and implementation of water resources and sewerage management facilities and programs. Implemented plans for utilization of reclaimed water for industry, urban landscaping, agricultural irrigation, and groundwater recharge. Development of applications for State and Federal grants for water and wastewater projects. Assisted in reorganizing the existing water and sewer utility. Major responsibilities in the areas of budgeting and personnel management for a 400-member organization.

1975-1976 Engineering-Science, Kathmandu, Nepal. Project Manager and Site Representative for urban water supply and sewerage projects in Nepal. Responsible for planning, study, design, and construction management services to the Nepalese Government.

1976-1978 Engineering-Science, Madras, India. Site Representative for master planning, feasibility studies, and design of water supply and sewerage facilities for Madras, a project sponsored by the World Health Organization for the Government of India. Long-range sector planning, pre-investment feasibility studies, land-use planning, and design of immediate works facilities for water supply and sewerage systems.

1978-1980 Engineering-Science, Medan, Indonesia. Site Representative for Medan Urban Development, Housing, Water Supply and Sanitation Project. A USAID and Government of Indonesia Sponsored project to develop a long range urban development plan, immediate and long-term housing improvement schemes, and master plans for water supply, wastewater, drainage, and solid wastes systems.

Preinvestment feasibility studies were also carried out with a view towards financial involvement by International financing agencies.

1980-date Engineering-Science, Lima, Peru. Project Manager for Metropolitan Lima water and wastewater master plan investigation. A World Bank and Government of Peru sponsered project to develop long range water and wastewater management system plans, and identify Immediate Works projects to meet emergency needs.

Appendix II

Specifications for Full Circle Clamp Couplings

APPENDIX II

FULL CIRCLE CLAMP COUPLINGS

FOR EMERGENCY REPAIRS

OF ESAL LIMA WATER DISTRIBUTION NETWORK

Provided by: Sub-Gerencia de Redes
ESAL
Ing. Jaime Salcedo Lobaton

Note: This is the catalogue of the producer which has been used by ESAL in the past and which includes their customary specifications.

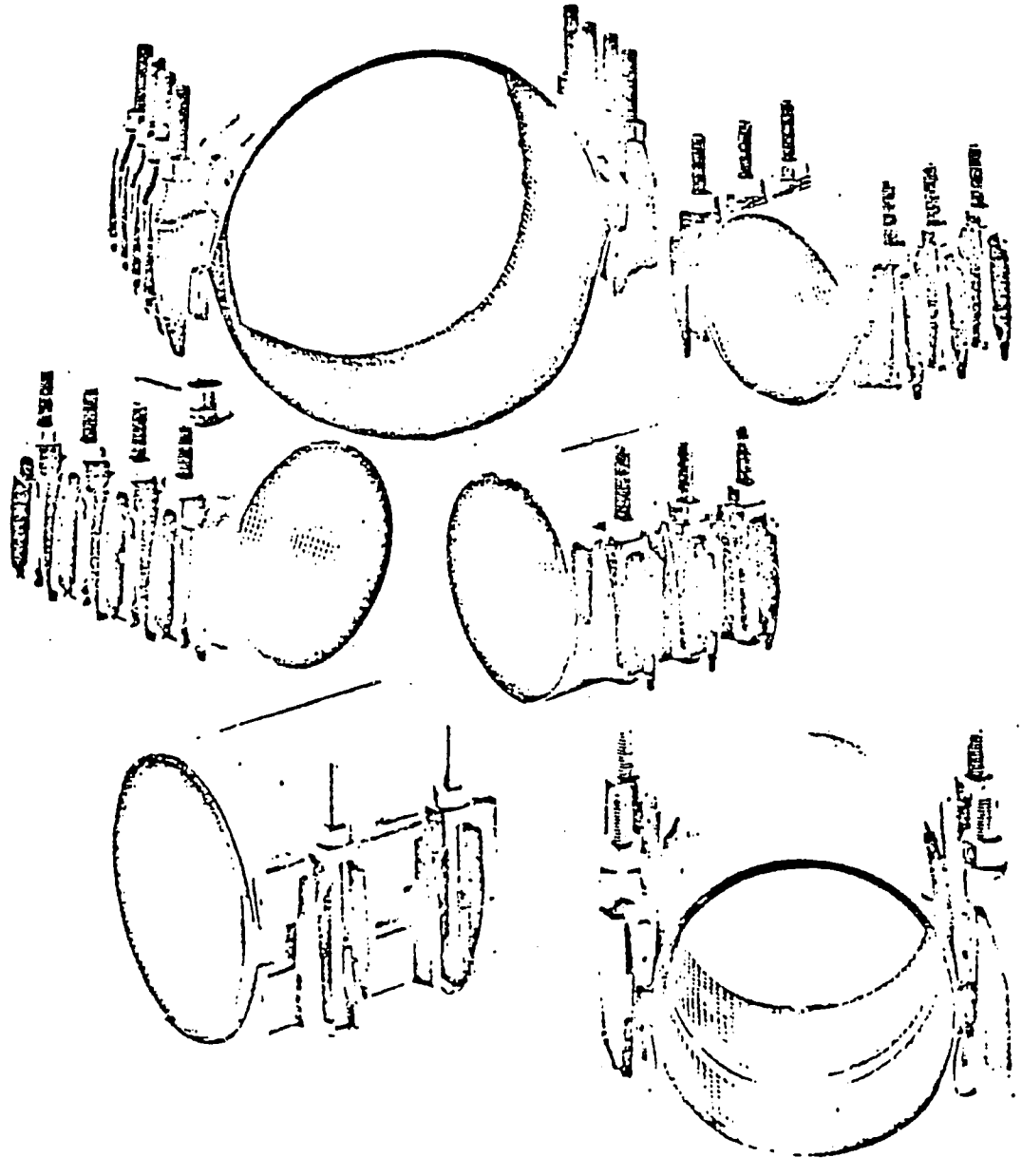
Rockwell

CC-200 (2/79)

clamp and coupling products

full circle® clamp couplings

226 227 228 238 239 256 257



Rockwell International

...where science gets down to business

Rockwell

clamp and coupling products

FULL CIRCLE® CLAMP COUPLINGS are flexible repair clamps consisting of one or more stainless steel band sections to which cast lugs are securely attached to accommodate bolts and nuts for the purpose of mounting the clamp on pipe. It has a full encirclement tapered, overlapping gasket with a bonded-in stainless steel bridge plate to span the band opening between the lugs, to provide a full circumferential seal on the pipe.

A FULL CIRCLE CLAMP COUPLING is fast and simple to install, and requires no special tools. The clamp is wrapped around the pipe, properly positioned over the area to be repaired or connected, and the bolts tightened. This compacts the rubber gasket tightly against the full circumference of the pipe wall forming a permanent seal.

NOT JUST A REPAIR CLAMP

Full Circle Clamp Couplings are often used as a coupling to join plain end pipe for new installations and pipe replacement programs.

ROCKWELL FULL CIRCLE CLAMP COUPLINGS have been proven superior in many years of service. Some of the reasons why are:

ENGINEERED BOLT PULL: Lugs and bolts are of the proper size and balanced design.

ENGINEERED GASKET SEAL: Gridded, tapered gasket design employs all natural forces to maximum advantage and provides a permanent, leakproof seal.

FLEXIBILITY: conforms to pipe irregualarities.

ADAPTABILITY: Each size fits several sizes of pipe.

STRENGTH: Provides a wide margin of safety.

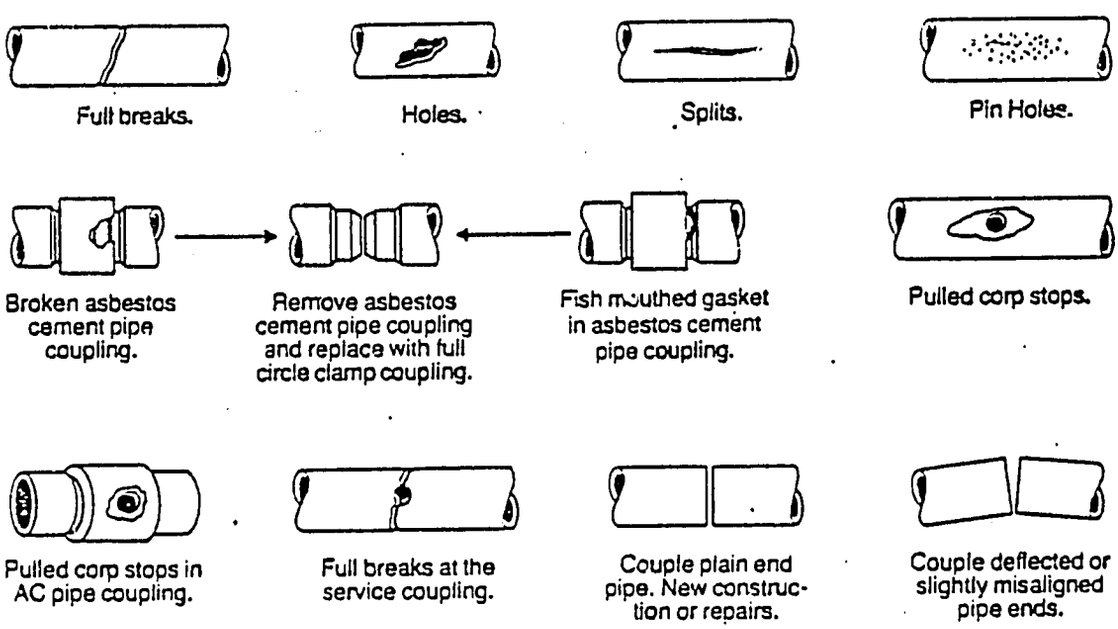
LIGHT WEIGHT: Easy installation by one man.

FAST: Can be installed quickly with simple wrench.

AVAILABILITY: From more than 600 Rockwell stocking distributors, backed up by Rockwell "extra-effort" response to emergency needs.

Rockwell full circle clamp couplings solve these piping problems

Cast iron, asbestos cement, plastic, steel, copper



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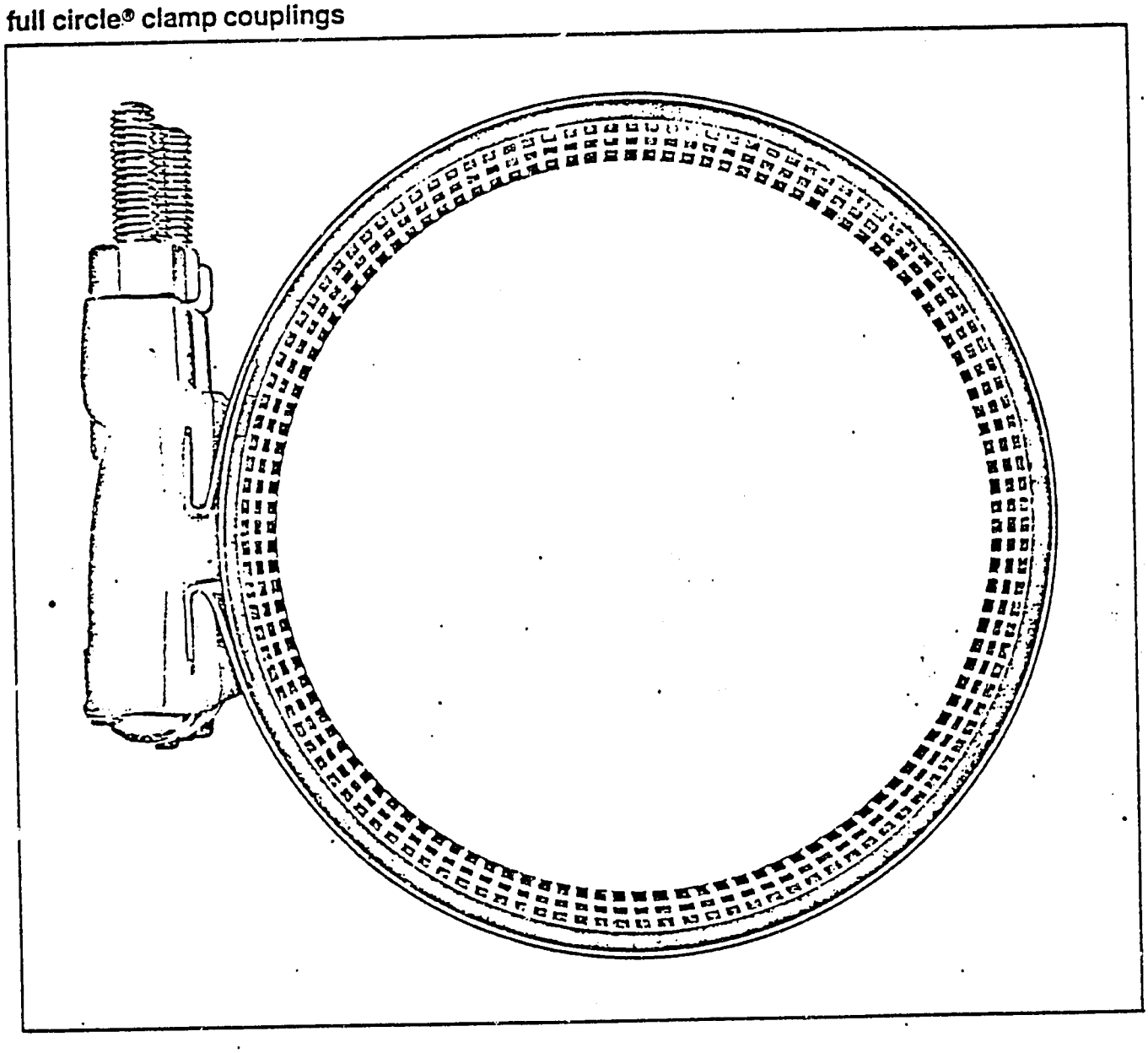
Rockwell

Clamp and Coupling products

full circle® clamp couplings



The Rockwell Full Circle® method of pipe repair is a quick, economical, permanent solution to pipe repair problems that requires less crew, equipment, and special materials than other methods. Compare the ease of the Full Circle method to that of split mechanical sleeves or replacing a section of pipe.

You will discover the Full Circle method means:

- Less pipeline downtime
- Less material and labor cost
- Less crew, equipment, excavation and scheduling complications
- No need for extra pipe or fittings
- No need for complete line shutdown and possible contamination
- No special tools or special skills required for installation

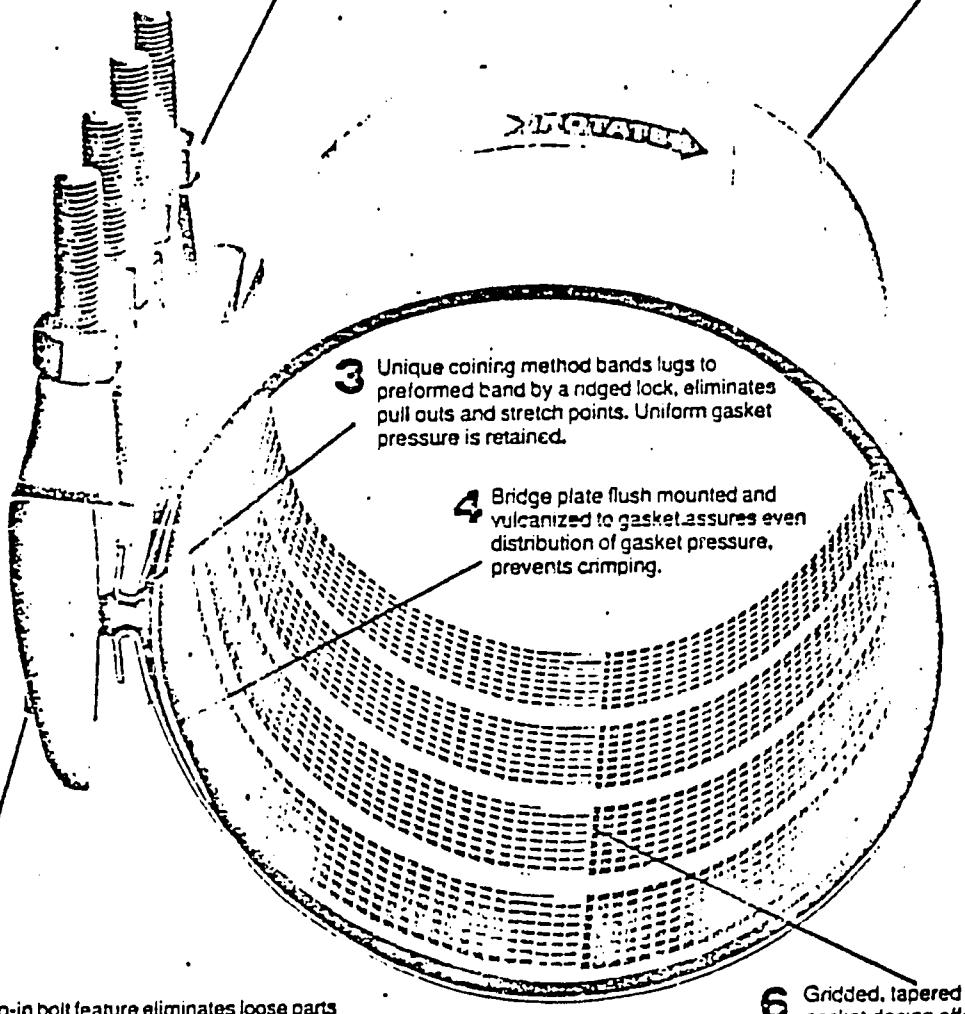
Quick...Permanent...Economical

Rockwell

Clamp and Coupling products

1 Lugs with mutually supporting sliding fingers to assure proper bolt alignment while tightening. Permits maximum torque without bending of bolts and increases clamp range.

2 Full circumference, single or multiple section stainless steel bands available in 7½", 10", 12½", 15", 20" and 30" widths.

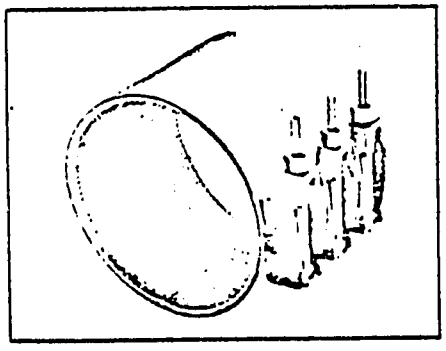


3 Unique coining method bands lugs to preformed band by a ridged lock, eliminates pull outs and stretch points. Uniform gasket pressure is retained.

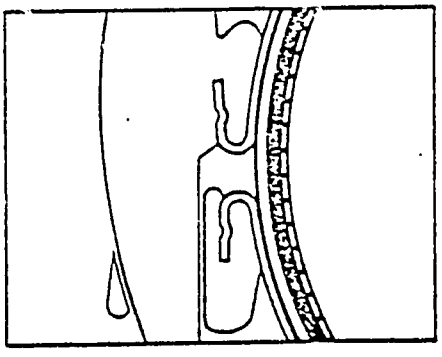
4 Bridge plate flush mounted and vulcanized to gasket assures even distribution of gasket pressure, prevents crimping.

5 Drop-in bolt feature eliminates loose parts saves time and aids installation under adverse conditions.

6 Gridded, tapered overlapping gasket design offers superior full circumferential sealing ability. Full adjustment to rough pipe surface.



Rockwell coining process that securely attaches the lugs to the band.



Full Circle Clamps can be furnished with copper conductors for electrical continuity of pipe lines.

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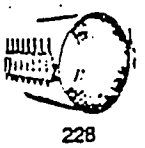
Selection Guide & Index

CLAMP TYPE	DESCRIPTION	METRIC NOMINAL SIZES MM	NOMINAL PIPE SIZE	WORKING PRESS	TEMP. RANGE	PAGE NUMBER
226	Band: Single Lugs: Malleable or Ductile Iron Gasket: Grade 30 Bolts: Low Alloy	50 Thru 300	2" Thru 12"	Up to 300* PSI	-40°F. To 150°F.	200.6 Thru 200.8
227	Super Range Band: Double Lugs: Malleable or Ductile Iron Gasket: Grade 30 Bolts: Low Alloy	100 Thru 300	4" Thru 12"	Up to 300* PSI	-40°F. To 150°F.	200.9
 228	Band: Multiple Lugs: Malleable or Ductile Iron Gasket: Grade 30 Bolts: Low Alloy	300 And Larger	12" And Larger	Up to 300* PSI	-40°F. To 150°F.	200.10 And 200.11
238	Band: Single Lugs: Malleable or Ductile Iron Gasket: Grade 60 Bolts: Low Alloy Taps: NPT or CC	100 Thru 200	4" Thru 8"	Up to 300* PSI	-20°F. To 212°F.	200.12 And 200.13
239	Super Range Band: Single Lugs: Malleable or Ductile Iron Gasket: Grade 60 Bolts: Low Alloy Taps: NPT or CC	100 Thru 300	45 Thru 12"	Up to 300* PSI	—20°F. To 212°F.	200.14 Thru 200.15
256	Band: Single Lugs: Cast Stainless Steel Gasket: Grade 30 Bolts: Stainless Steel	50 Thru 300	2" Thru 12"	Up to 300* PSI	-40°F. To 150°F.	200.16 Thru 200.19
257	Super Range Band: Double Lugs: Cast Stainless Steel Gasket: Grade 30 Bolts: Stainless Steel	100 Thru 300	4" Thru 12"	Up to 300* PSI	-40°F. To 150°F.	200.20 And 200.21

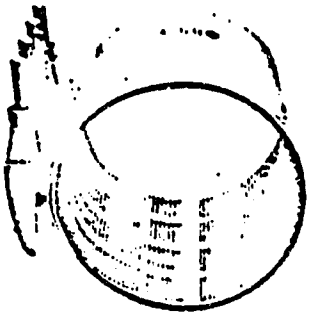
Selecting proper clamp 200.21
Useful installation tips 200.21
Special installations 200.21
Improvising large clamps 200.21
Installation instructions 200.21

*Pressure is dependent on pipe size, extent of damage and service conditions. Suitable anchorage must be provided when excessive pipe movement could occur.

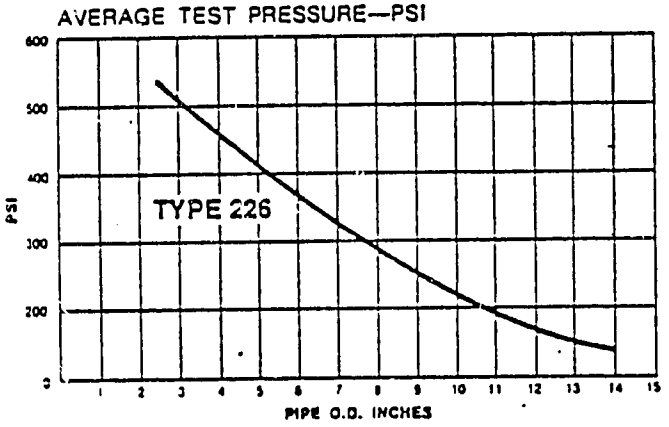
Rockwell

clamp and coupling products

226 single band full circle®



ROCKWELL 226 FULL CIRCLE CLAMP COUPLING provides a fast, economical, permanent means of coupling or repairing full circumferential breaks and other types of damage on cast iron, asbestos, cement, steel, copper, plastic, fiberglass and other types of pipes. The lugs are securely attached to the band by a coining process and have mutually supporting fingers to permit maximum torqueing of the bolts. The gasket is a lap type with molded tapered ends and a fine gridded surface to conform to irregularities on the pipe surface. The bridge plate molded flush into the gasket to prevent wrinkling in the lug area and ensure uniform full circumferential sealing. Bolts and nuts are low alloy steel.



AVERAGE TEST PRESSURE REFLECTS TESTS MADE AT RECOMMENDED BOLT TORQUE (70 FOOT POUNDS—½" BOLT—[illegible] FOOT-POUNDS—½" BOLT) ON NOMINAL PIPE SIZES WITH [illegible]" MAXIMUM PIPE GAP

MATERIAL SPECIFICATIONS

BAND: Stainless steel type 304.

LUGS: Malleable Iron ASTM A47 grade 32510 or ductile iron per ASTM A536 grade 60-40-18, at Rockwell's option, with mutually supporting sliding fingers.

GASKET: Grade 30—standard—specially compounded rubber of all new materials with ingredients to produce superior storage characteristics, performance and resistance to set after installation. Recommended for water, salt solutions, mild acids, and bases. Temperature range −40°F. to 150°F. Lap type gasket has fine grid and molded tapered ends.

BRIDGE PLATE: Stainless steel type 304 recessed flush and bonded into gasket.

Bolts: High strength low alloy steel with heavy semi-finished hexagon nuts to AWWA C111 (ANS1-A21. 11) standards.

Material specifications are subject to change.

BAND WIDTH INCHES	NUMBER OF BOLTS	BOLT SIZES
7½ 10 12 15 20 30	3 4 5 6 8 12	½" × 5½" For clamp ranges 2.35" thru 4.73" O.D.
		⅝" × 6⅞" For clamp ranges 4.74" thru 14.40" O.D.

226 single band full circle®

U.S.					METRIC			
NOM. PIPE SIZE INCHES	O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER	NOM. PIPE SIZE MM	O.D. RANGE MM	WIDTH MM	WGT. E.A. KG.
2	2.35-2.63	7½ 10 12½ 15	7 9 12 14	226-023807-000 226-023810-000 226-023812-000 226-023815-000	50	60-66	190 254 317 381	3.2 4.1 5.5 6.4
2¼-2½	2.70-3.00	7½ 10 12½ 15	7 10 12 14	226-027507-000 226-027510-000 226-027512-000 226-027515-000	57-65	69-76	190 254 317 381	3.2 4.5 5.5 6.4
3	2.97-3.25	7½ 10 12½ 15	7 10 12 14	226-030007-000 226-030010-000 226-030012-000 226-030015-000	80	76-82	190 254 317 381	3.2 4.5 5.5 6.4
3	3.46-3.70	7½ 10 12½ 15	8 10 12 15	226-035007-000 226-035010-000 226-035012-000 226-035015-000	80	88-93	190 254 317 381	3.6 4.5 5.5 6.8
3-4	3.73-4.00	7½ 10 12½ 15	8 11 13 15	226-037507-000 226-037510-000 226-037512-000 226-037515-000	80-100	95-101	190 254 317 381	3.6 5.0 5.9 6.8
3-4	3.96-4.25	7½ 10 12½ 15	8 11 13 15	226-040007-000 226-040010-000 226-040012-000 226-040015-000	80-100	101-107	190 254 317 381	3.6 5.0 5.9 6.8

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226 single band full circle®

U.S.					METRIC			
NOM. PIPE SIZE INCHES	O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER	NOM. PIPE SIZE MM	O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
4	4.45-4.73	7½	8	226-045007-000	100	114-120	190	3.6
		10	11	226-045010-000			254	5.0
		12½	13	226-045012-000			317	5.9
		15	16	226-045015-000			381	7.3
4	4.74-5.14	7½	11	226-048007-000	100	121-130	190	5.0
		10	15	226-048010-000			254	6.8
		12½	18	226-048012-000			317	8.2
		15	22	226-048015-000			381	10.0
		20	29	226-048020-000			508	13.2
		30	44	226-048030-000			762	20.0
4-5	4.95-5.35	7½	11	226-050007-000	100-125	126-135	190	5.0
		10	15	226-050010-000			254	6.8
		12½	18	226-050012-000			317	8.2
		15	22	226-050015-000			381	10.0
		20	29	226-050020-000			508	13.2
		30	44	226-050030-000			762	20.0
4-5	5.22-5.62	7½	11	226-052507-000	100-125	133-142	190	5.0
		10	15	226-052510-000			254	6.8
		12½	19	226-052512-000			317	8.6
		15	23	226-052515-000			381	10.4
		20	30	226-052520-000			508	13.6
		30	45	226-052530-000			762	20.4
6	5.95-6.35	7½	12	226-060007-000	150	152-161	190	5.5
		10	16	226-060010-000			254	7.3
		12½	20	226-060012-000			317	9.1
		15	24	226-060015-000			381	10.9
		20	32	226-060020-000			508	14.5
		30	48	226-060030-000			762	21.8
6	6.56-6.96	7½	12	226-066307-000	150	167-176	190	5.5
		10	16	226-066310-000			254	7.3
		12½	20	226-066312-000			317	9.1
		15	24	226-066315-000			381	10.9
		20	32	226-066320-000			508	14.5
		30	49	226-066330-000			762	22.3
6	6.84-7.24	7½	13	226-069007-000	150	174-183	190	5.9
		10	17	226-069010-000			254	7.7
		12½	21	226-069012-000			317	9.5
		15	25	226-069015-000			381	11.4
		20	32	226-069020-000			508	14.5
		30	50	226-069030-000			762	22.7
6	7.05-7.45	7½	13	226-071007-000	150	180-189	190	5.9
		10	17	226-071010-000			254	7.7
		12½	21	226-071012-000			317	9.5
		15	25	226-071015-000			381	11.4
		20	34	226-071020-000			508	15.4
		30	51	226-071030-000			762	23.2
6	7.45-7.85	7½	13	226-074507-000	150	190-199	190	5.9
		10	17	226-074510-000			254	7.7
		12½	21	226-074512-000			317	9.5
		15	26	226-074515-000			381	11.8
		20	35	226-074520-000			508	15.9
		30	52	226-074530-000			762	23.6
8	7.95-8.35	7½	14	226-080007-000	200	202-212	190	6.4
		10	18	226-080010-000			254	8.2
		12½	22	226-080012-000			317	10.0
		15	27	226-080015-000			381	12.3
		20	36	226-080020-000			508	16.3
		30	54	226-080030-000			762	24.5
8	8.54-8.94	7½	14	226-086307-000	200	217-227	190	6.4
		10	19	226-086310-000			254	8.6
		12½	23	226-086312-000			317	10.4
		15	28	226-086315-000			381	12.7
		20	37	226-086320-000			508	16.8
		30	55	226-086330-000			762	25.0
8	8.99-9.39	7½	14	226-090507-000	200	229-238	190	6.4
		10	19	226-090510-000			254	8.6
		12½	23	226-090512-000			317	10.4
		15	28	226-090515-000			381	12.7
		20	38	226-090520-000			508	17.3
		30	56	226-090530-000			762	25.4

226 single band full circle®

U.S.					METRIC			
NOM. PIPE SIZE INCHES	O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER	NOM. PIPE SIZE MM	O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
8	9.27-9.67	7½	14	226-094007-000	200	236-245	190	6.4
		10	19	226-094010-000			254	8.6
		12½	24	226-094012-000			317	10.9
		15	29	226-094015-000			381	13.2
		20	38	226-094020-000			508	17.3
		30	57	266-094030-000			762	25.9
8-10	9.70-10.10	7½	15	226-100007-000	200-250	247-256	190	6.8
		10	20	226-100010-000			254	9.1
		12½	25	226-100012-000			317	11.4
		15	30	226-100015-000			381	13.6
		20	39	226-100020-000			508	17.7
		30	59	226-100030-000			762	26.8
10	10.64-11.04	7½	15	226-107507-000	250	271-280	190	6.8
		10	21	226-107510-000			254	9.5
		12½	26	226-107512-000			317	11.8
		15	31	226-107515-000			381	14.1
		20	41	226-107520-000			508	18.6
		30	61	226-107530-000			762	27.7
10	11.04-11.44	7½	16	226-111007-000	250	281-290	190	7.3
		10	21	226-111010-000			254	9.5
		12½	26	226-111012-000			317	11.8
		15	31	226-111015-000			381	14.1
		20	42	226-111020-000			508	19.1
		30	62	226-111030-000			762	28.2
10	11.34-11.74	7½	16	226-114007-000	250	289-298	190	7.3
		10	21	226-114010-000			254	9.5
		12½	26	226-114012-000			317	11.8
		15	31	226-114015-000			381	14.1
		20	42	226-114020-000			508	19.1
		30	63	226-114030-000			762	28.6
10	11.75-12.15	7½	16	226-117507-000	250	299-308	190	7.3
		10	21	226-117510-000			254	9.5
		12½	27	226-117512-000			317	12.3
		15	37	226-117515-000			381	16.8
		20	43	226-117520-000			508	19.5
		30	64	226-117530-000			762	29.1
10-12	12.00-12.40	7½	16	226-120007-000	250-300	305-314	190	7.3
		10	22	226-120010-000			254	10.0
		12½	27	226-120012-000			317	12.3
		15	33	226-120015-000			381	15.0
		20	44	226-120020-000			508	20.0
		30	66	226-120030-000			762	30.0
12	12.52-13.02	7½	17	226-127507-000	300	321-330	190	7.7
		10	22	226-127510-000			254	10.0
		12½	28	226-127512-000			317	12.7
		15	33	226-127515-000			381	15.0
		20	45	226-127520-000			508	20.4
		30	67	226-127530-000			762	30.4
12	13.10-13.50	7½	17	226-132007-000	300	333-342	190	7.7
		10	23	226-132010-000			254	10.4
		12½	29	226-132012-000			317	13.2
		15	34	226-132015-000			381	15.4
		20	46	226-132020-000			508	20.1
		30	68	226-132030-000			762	30.9
12	13.40-13.80	7½	17	226-134007-000	300	341-350	190	7.7
		10	23	226-134010-000			254	10.4
		12½	29	226-134012-000			317	13.2
		15	35	226-134015-000			381	15.9
		20	46	226-134020-000			508	20.9
		30	69	226-134030-000			762	31.3
12-14	13.70-14.10	7½	18	226-137007-000	300-350	348-358	190	8.2
		10	23	226-137010-000			254	10.4
		12½	29	226-137012-000			317	13.2
		15	35	226-137015-000			381	15.9
		20	47	226-137020-000			508	21.3
		30	70	226-137030-000			762	31.8
12-14	14.00-14.40	7½	18	226-140007-000	300-350	356-365	190	8.2
		10	24	226-140010-000			254	10.9
		12½	30	226-140012-000			317	13.6
		15	35	226-140015-000			381	15.9
		20	47	226-140020-000			508	21.3
		30	71	226-140030-000			762	32.2

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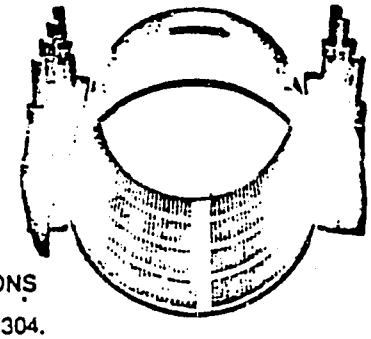
Rockwell

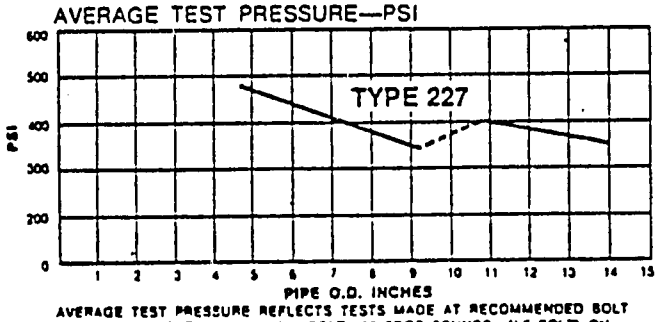
clamp and coupling products

227 super range double band full circle®



ROCKWELL 227 SUPER RANGE FULL CIRCLE CLAMP COUPLING provides a fast, economical, permanent means of coupling or repairing full circumferential breaks and other types of damage on cast iron, asbestos cement and other types of pipes with similar outside diameter. A single clamp is required to connect or repair all classes of cast iron or asbestos cement in each nominal pipe size 4" through 12". The lugs are securely attached to the band by a coining process and have mutually supporting fingers to permit maximum torqueing of the bolts. The gasket is a lap type with molded tapered ends and a fine gridded surface to conform to irregularities on the pipe surface. The bridge plate is molded flush into the gasket to prevent wrinkling in the lug area and ensure uniform full circumferential sealing. Bolts and nuts are low alloy steel.

AVERAGE TEST PRESSURE—PSI



AVERAGE TEST PRESSURE REFLECTS TESTS MADE AT RECOMMENDED BOLT TORQUE. (70 FOOT POUNDS—½" BOLT—90 FOOT POUNDS—⅝" BOLT) ON NOMINAL PIPE SIZES WITH ⅛" MAXIMUM PIPE GAP

MATERIAL SPECIFICATIONS

BAND: Stainless steel type 304.

LUGS: Malleable iron ASTM A47 grade 32510 or ductile iron per ASTM A536 grade 60-40-18, at Rockwell's option, with mutually supporting sliding fingers.

GASKET: Grade 30—standard—specially compounded rubber of all new materials with ingredients to produce superior storage characteristics, performance and resistance to set after installation. Recommended for water, salt solutions, mild acids, and bases. Temperature range −40°F. to 150°F. Lap type gasket has fine grid and molded tapered ends.

BRIDGE PLATE: Stainless steel type 304 recessed flush and bonded into gasket.

BOLTS: High strength low alloy steel with heavy semi-finished hexagon nuts to AWWA C111 (ANSI-A21. 11) standards.

Material specifications are subject to change.

BAND WIDTH INCHES	NUMBER OF BOLTS	BOLT SIZES
7½ 10 12½ 15 20 30	6 8 10 12 16 24	⅝" × 6⅞" For 4", 6" & 8" clamp sizes.
		¾" × 8¼" For 10" & 12" clamp sizes.

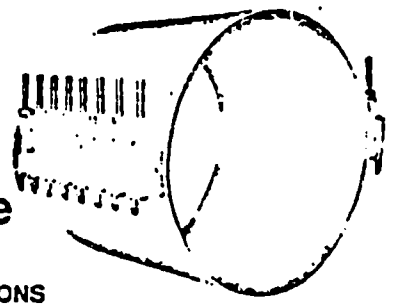
227 super range double band full circle®

U.S.					METRIC			
NOM. PIPE SIZE INCHES	O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER	NOM. PIPE SIZE MM	O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
4	4.74-5.57	7½	20	227-048007-000	100	121-141	190	9.1
		10	27	227-048010-000			254	12.3
		12½	32	227-048012-000			317	14.5
		15	40	227-048015-000			381	18.2
		20	53	227-048020-000			508	24.1
		30	80	227-048030-000			762	36.3
6	6.84-7.64	7½	22	227-069007-000	150	174-194	190	10.0
		10	29	227-069010-000			254	13.2
		12½	36	227-069012-000			317	16.3
		15	43	227-069015-000			381	19.5
		20	57	227-069020-000			508	25.9
		30	86	227-069030-000			762	39.0
8	8.99-9.79	7½	23	227-090507-000	200	229-248	190	10.4
		10	31	227-090510-000			254	14.1
		12½	38	227-090512-000			317	17.3
		15	46	227-090515-000			381	20.9
		20	61	227-090520-000			508	27.7
		30	92	227-090530-000			762	41.8
10	11.04-12.24	10	48	227-111010-000	250	281-310	254	21.8
		15	71	227-111015-000			381	32.2
		20	95	227-111020-000			508	43.1
		30	144	227-111030-000			762	65.4
12	13.14-14.34	10	50	227-132010-000	300	334-364	254	22.7
		15	75	227-132015-000			381	34.1
		20	99	227-132020-000			508	45.0
		30	149	227-132030-000			762	67.7
12	13.65-14.65	10	50	227-136510-000	300	347-372	254	22.7
		15	76	227-136515-000			381	34.5
		20	101	227-136520-000			508	45.9
		30	151	227-136530-000			762	68.6

Rockwell

Clamp and Coupling products

228 full circle® for large diameter pipe



ROCKWELL 228 FULL CIRCLE CLAMP COUPLING provides a fast, economical permanent means of coupling or repairing full circumferential breaks and other types of damage on pipes 12" nominal sizes and larger. The lugs are securely attached to the band by a coining process and have mutually supporting fingers to permit maximum torqueing of the bolts. The gasket is a lap type with molded tapered ends and a fine gridded surface to conform to irregularities on the pipe surface. The bridge plate is molded flush into the gasket to prevent wrinkling in the lug area and ensure uniform full circumferential sealing. Bolts and nuts are low alloy steel.

2 BAND WIDTH INCHES	NUMBER OF BOLTS	BOLT SIZES
10 15 20 30	8 12 16 24	¾" × 8¼"
3 BAND WIDTH INCHES	**NUMBER OF BOLTS**	**BOLT SIZES**
10 15 20 30	12 18 24 36	¾" × 8¼"

MATERIAL SPECIFICATIONS

BAND: Stainless steel type 304.

LUGS: Malleable iron ASTM A47 grade 32510 or ductile iron per ASTM A536 grade 60-40-18, at Rockwell's option, with mutually supporting fingers.

GASKET: Grade 30—standard—specially compounded rubber of all new materials with ingredients to produce superior storage characteristics, performance and resistance to set mild acids, and bases. Temperature range −40°F. to 150°F. Lap type gasket has fine grid and molded tapered ends.

BRIDGE PLATE: Stainless steel type 304 recessed flush and bonded into gasket.

BOLTS: High strength low alloy steel with heavy semi-finished hexagon nuts to AWWA C111 (ANS1-A21. 11) standards.

Material specifications are subject to change.

228 full circle for large diameter pipe

2 BAND CLAMP

U.S.				METRIC		
O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER	O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
14.38-15.13	10 15 20 30	72 101 127 177	228-20143810-000 228-20143815-000 228-20143820-000 228-20143830-000	366-384	254 381 508 762	32.7 45.9 57.7 80.4
15.07-15.82	10 15 20 30	72 101 128 180	228-20150710-000 228-20150715-000 228-20150720-000 228-20150730-000	383-401	254 381 508 762	32.7 45.9 58.1 81.7
15.92-16.67	10 15 20 30	74 103 130 183	228-20159210-000 228-20159215-000 228-20159220-000 228-20159230-000	405-423	254 381 508 762	33.6 46.8 59.0 83.1
16.56-17.31	10 15 20 30	75 105 131 185	228-20165610-000 228-20165615-000 228-20165620-000 228-20165630-000	421-439	254 381 508 762	34.1 47.7 59.5 84.0
17.15-17.90	10 15 20 30	76 107 133 189	228-20171510-000 228-20171515-000 228-20171520-000 228-20171530-000	436-454	254 381 508 762	34.5 48.6 60.4 85.8
17.82-18.57	10 15 20 30	78 108 134 193	228-20178210-000 228-20178215-000 228-20178220-000 228-20178230-000	453-471	254 381 508 762	35.4 49.0 60.1 87.6

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2 BAND CLAMP

U.S.				METRIC		
O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER	O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
18.46-19.21	10 15 20 30	78 109 136 196	228-20184610-000 228-20184615-000 228-20184620-000 228-20184630-000	469-487	254 381 508 762	35.4 49.5 61.7 89.0
19.23-19.98	10 15 20 30	80 112 138 200	228-20192310-000 228-20192315-000 228-20192320-000 228-20192330-000	489-507	254 381 508 762	36.3 50.9 62.7 90.8
19.90-20.65	10 15 20 30	81 113 140 203	228-20199010-000 228-20199015-000 228-20199020-000 228-20199030-000	506-524	254 381 508 762	36.8 51.3 63.6 92.2
20.70-21.45	10 15 20 30	82 115 143 211	228-20207010-000 228-20207015-000 228-20207020-000 228-20207030-000	526-544	254 381 508 762	37.2 52.2 64.9 95.8
21.52-22.27	10 15 20 30	82 117 146 211	228-20215210-000 228-20215215-000 228-20215220-000 228-20215230-000	547-565	254 381 508 762	37.2 53.1 66.3 95.8
22.12-22.87	10 15 20 30	85 119 148 214	228-20221210-000 228-20221215-000 228-20221220-000 228-20221230-000	562-580	254 381 508 762	38.6 54.0 67.2 97.2
22.90-23.65	10 15 20 30	86 122 151 217	228-20229010-000 228-20229015-000 228-20229020-000 228-20229030-000	582-600	254 381 508 762	39.0 55.4 68.6 98.5

3 BAND CLAMP

U.S.				METRIC		
O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER	O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
23.28-24.38	10 15 20 30	103 149 186 269	228-30232810-000 228-30232815-000 228-30232820-000 228-30232830-000	592-619	254 381 508 762	46.8 67.7 84.4 122.1
24.38-25.48	10 15 20 30	105 152 189 273	228-30243810-000 228-30243815-000 228-30243820-000 228-30243830-000	620-647	254 381 508 762	47.7 69.0 85.8 123.9
25.70-26.80	10 15 20 30	107 153 191 276	228-30257010-000 228-30257015-000 228-30257020-000 228-30257030-000	653-680	254 381 508 762	48.6 69.5 86.7 125.3
26.48-27.58	10 15 20 30	108 156 194 279	228-30264810-000 228-30264815-000 228-30264820-000 228-30264830-000	673-700	254 381 508 762	49.0 70.1 88.1 126.7
27.65-28.75	10 15 20 30	111 160 199 285	228-30276510-000 228-30276515-000 228-30276520-000 228-30276530-000	703-730	254 381 508 762	50.4 72.6 90.4 129.4
28.73-29.83	10 15 20 30	113 162 204 289	228-30287310-000 228-30287315-000 228-30287320-000 228-30287330-000	730-757	254 381 508 762	51.3 73.6 92.6 131.2
29.62-30.72	10 15 20 30	115 165 206 293	228-30296210-000 228-30296215-000 228-30296220-000 228-30296230-000	753-780	254 381 508 762	52.2 74.9 93.5 133.0

Rockwell

clamp and coupling products

238 single band tapped full circle®

ROCKWELL 238 FULL CIRCLE CLAMP COUPLING for new service connections or repairs to damaged or broken pipe at service connections, utilizing a welded stainless steel outlet and providing a full circumferential seal. O.D. ranges are designed to fit cast iron, asbestos cement, steel, plastic and most other types of pipe. The lugs are securely attached to the band by a coining process and have mutually supporting fingers to permit maximum torqueing of the bolts. The gasket is a lap type with molded tapered ends and a fine gridded surface to conform to irregularities on the pipe surface. The bridge plate is molded flush into the gasket to prevent wrinkling in the lug area and ensure uniform full circumferential sealing. Bolts and nuts are low alloy steel.

MATERIAL SPECIFICATIONS

BAND: Stainless steel type 304.

LUGS: Malleable iron ASTM A47 grade 32510 or ductile iron per ASTM A536 grade 60-40-18, at Rockwell's option.

GASKET: Grade 60—compounded to resist—oil, natural gas, acids, alkalies, most (aliphatic) hydrocarbon fluids, water and many chemicals. Temperatures −20°F. to 212°F. Lap type gasket has fine grid and molded tapered ends.

BRIDGE PLATE: Stainless steel type 304 recessed flush and bonded into gasket to prevent wrinkling of gasket at the lug bridge area.

BOLTS: High strength low alloy steel with heavy semi-finished hexagon nuts to AWWA C111 (ANSI-A21. 11) standards. Optional stainless steel bolts and nuts are type 304.

Material specifications are subject to change.

238 single band tapped full circle

¾" AND 1" NPT TAPS

U.S.					METRIC		
NOM. SIZE AND O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER ¾" NPT(20mm)	CATALOG NUMBER 1" NPT(25mm)	NOM. SIZE AND O.D.RANGE MM	WIDTH MM	WGT. EACH KG.
4 4.45-4.73	7½ 12½	9 14	238-045007-006 238-045012-006	238-045007-008 238-045012-008	100 114-120	190 317	4.1. 6.4
4 4.74-5.14	7½ 12½	12 19	238-048007-006 238-048012-006	238-048007-008 238-048012-008	100 121-130	190 317	5.5 8.6
6 6.56-6.96	7½ 12½	14 22	238-066307-006 238-066312-006	238-066307-008 238-066312-008	150 167-176	190 317	6.4 10.0
6 6.84-7.24	7½ 12½	14 22	238-069006-008 238-069012-006	238-069007-008 238-069012-008	150 174-183	190 317	6.4 10.0
8 8.54-8.94	7½ 12½	15 24	238-086307-006 238-086312-008	238-086307-008 238-086312-008	200 217-227	190 317	6.8 10.9
8 8.99-9.39	7½ 12½	15 24	238-090507-006 238-090512-006	238-090507-008 238-090512-008	200 229-238	190 317	6.8 10.9

¾" AND 1" CC TAPS

U.S.					METRIC		
NOM. SIZE AND O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER		NOM. SIZE AND O.D.RANGE MM	WIDTH MM	WGT. EACH KG.
			¾" CC(20mm)	1" CC(25mm)			
4 4.45-4.73	7½ 12½	12 19	238-045007-007 238-045012-007	238-045007-009 238-045012-009	100 114-120	190 317	5.5 8.6
4 4.74-5.14	7½ 12½	12 19	238-048007-007 238-048012-007	238-048007-009 238-048012-009	100 121-130	190 317	5.5 8.6
6 6.56-6.96	7½ 12½	14 22	238-066307-007 238-066312-007	238-066307-009 238-066312-009	150 167-176	190 317	6.4 10.0
6 6.84-7.24	7½ 12½	14 22	238-069007-007 238-069012-007	238-069007-009 238-069012-009	150 174-183	190 317	6.4 10.0
8 8.54-8.94	7½ 12½	15 24	238-086307-007 238-086312-007	238-086307-009 238-086312-009	200 217-227	190 317	6.8 10.9
8 8.99-9.39	7½ 12½	15 24	238-090507-007 238-090512-007	238-090507-009 238-090512-009	200 229-238	190 317	6.8 10.9

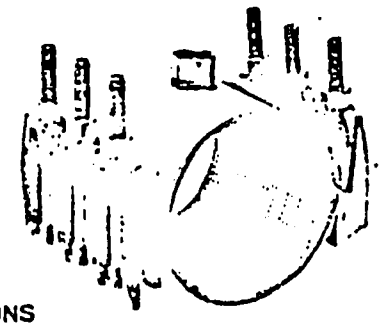
1¼", 1½" AND 2" NPT TAPS

U.S.						METRIC		
NOM. SIZE AND O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER			NOM. SIZE AND O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
			1¼" NPT (32mm)	1½" NPT (40mm)	2" NPT (50mm)			
4 4.45-4.73	12½	19	238-045012-010	238-045012-012	238-045012-014	100 114-120	317	8.6
4 4.74-5.14	12½	19	238-048012-010	238-048012-012	238-048012-014	100 121-130	317	8.6
6 6.56-6.96	12½	22	238-066312-010	238-066312-012	238-066312-014	150 167-176	317	10.0
6 6.84-7.24	12½	22	238-069012-010	238-069012-012	238-069012-014	150 174-183	317	10.0
8 8.54-8.94	12½	24	238-086312-010	238-086312-012	238-086312-014	200 217-227	317	10.9
8 8.99-9.39	12½	24	238-090512-010	238-090512-012	238-090512-014	200 229-238	317	10.9

Rockwell

clamp and coupling products

239 super range double band tapped full circle®



ROCKWELL 239 SUPER RANGE FULL CIRCLE CLAMP COUPLING for new service connections or repairs to damaged or broken pipe at service connections, utilizing a welded stainless steel outlet and providing a full circumferential seal. 4 inch clamps have an O.D. range to fit steel pipe through all classes of cast iron and asbestos cement pipe. 6 inch through 12 inch clamps are available in two O.D. ranges. One to fit steel pipe through all classes of cast iron and asbestos cement pipe. The lugs are securely attached to the band by a coining process and have mutually supporting fingers to permit maximum torqueing of the bolts. The gasket is a lap type with molded tapered ends and a fine gridded surface to conform to irregularities on the pipe surface. The bridge plate is molded flush into the gasket to prevent wrinkling in the lug area and ensure uniform full circumferential sealing. Bolts and nuts are low alloy steel.

MATERIAL SPECIFICATIONS

BAND: Stainless steel type 304.

LUGS: Malleable iron ASTM A47 grade 32510 or ductile iron per ASTM A536 grade 60-40-18, at Rockwell's option.

GASKET: Grade 60—compounded to resist—oil, natural gas, acids, alkalies, most (aliphatic) hydrocarbon fluids, water and many chemicals. Temperatures −20°F. to 212°F. Lap type gasket has fine grid and molded tapered ends.

BRIDGE PLATE: Stainless steel type 304 recessed flush and bonded into gasket to prevent wrinkling of gasket at the lug bridge area.

BOLTS: High strength low alloy steel with heavy semi-finished hexagon nuts to AWWA C111 (ANSI-A21. 11) standards. Optional stainless steel bolts and nuts are type 304.

Material specifications are subject to change.

239 super range double band tapped full circle

¾" AND 1" NPT TAPS

U.S.					METRIC		
NOM. SIZE AND O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CODE CATALOG NUMBER ¾" NPT (20 mm)	CODE CATALOG NUMBER 1" NPT (25 mm)	NOM. SIZE AND O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
4 4.44-5.24	7½ 12½	21 33	239-045007-006 239-045012-006	239-045007-008 239-045012-008	100 113-133	190 317	9.5 15.0
6 6.62-7.42	7½ 12½	23 37	239-066307-006 239-066312-006	239-066307-008 239-066312-008	150 169-188	190 317	10.4 16.8
6 6.84-7.64	7½ 12½	23 37	239-069007-006 239-069012-006	239-069007-008 239-069012-008	150 174-194	190 317	10.4 16.8
8 8.62-9.42	7½ 12½	24 39	239-086307-006 239-086312-006	239-086307-008 239-086312-008	200 219-239	190 317	10.9 17.7
8 8.99-9.79	7½ 12½	24 39	239-090507-006 239-090512-006	239-090507-008 239-090512-008	200 229-248	190 317	10.9 17.7
10 10.75-11.72	10 15	49 72	239-107510-006 239-107515-006	239-107510-008 239-107515-008	250 273-297	254 381	22.2 32.7
10 11.04-12.24	10 15	49 72	239-111010-006 239-111015-006	239-111010-008 239-111015-008	250 281-310	254 381	22.2 32.7
12 12.75-13.92	10 15	51 76	239-127510-006 239-127515-006	239127510-008 239-127515-008	300 324-353	254 381	23.2 34.5
12 13.14-14.34	10 15	51 76	239-132010-006 239-132015-006	239-132010-008 239-132015-008	300 334-364	254 381	23.2 34.5

¾" AND 1" CC TAPS

U.S.					METRIC		
NOM. SIZE AND O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CODE CATALOG NUMBER		NOM. SIZE AND O.D.RANGE MM	WIDTH MM	WGT. EACH KG.
			¾" CC (20mm)	1" CC (25mm)			
4 4.44-5.24	7½ 12½	20 32	239-045007-007 239-045012-007	239-045007-009 239-045012-009	100 113-133	190 317	9.1 14.5
6 6.62-7.42	7½ 12½	23 37	239-066307-007 239-066312-007	239-066307-009 239-066312-009	150 169-188	190 317	10.4 16.8
6 6.84-7.64	7½ 12½	23 37	239-069007-007 239-069012-007	239-069007-009 239-069012-009	150 174-194	190 317	10.4 16.8
8 8.62-9.42	7½ 12½	24 39	239-086307-007 239-086312-007	239-086307-009 239-086312-009	200 219-239	190 317	10.9 17.7
8 8.99-9.79	7½ 12½	24 39	239-090507-007 239-090512-007	239-090507-009 239-090512-009	200 229-248	190 317	10.9 17.7
10 10.75-11.72	10 15	49 72	239-107510-007 239-107515-007	239-107510-009 239-107515-009	250 273-297	254 381	22.2 32.7
10 11.04-12.24	10 15	49 72	239-111010-007 239-111015-007	239-111010-009 239-111015-009	250 281-310	254 381	22.2 32.7
12 12.75-13.92	10 15	51 76	239-127510-007 239-127515-007	239127510-009 239-127515-009	300 324-353	254 381	23.2 34.5
12 13.14-14.34	10 15	51 76	239-132010-007 239-132015-007	239-132010-009 239-132015-009	300 334-364	254 381	23.2 34.5

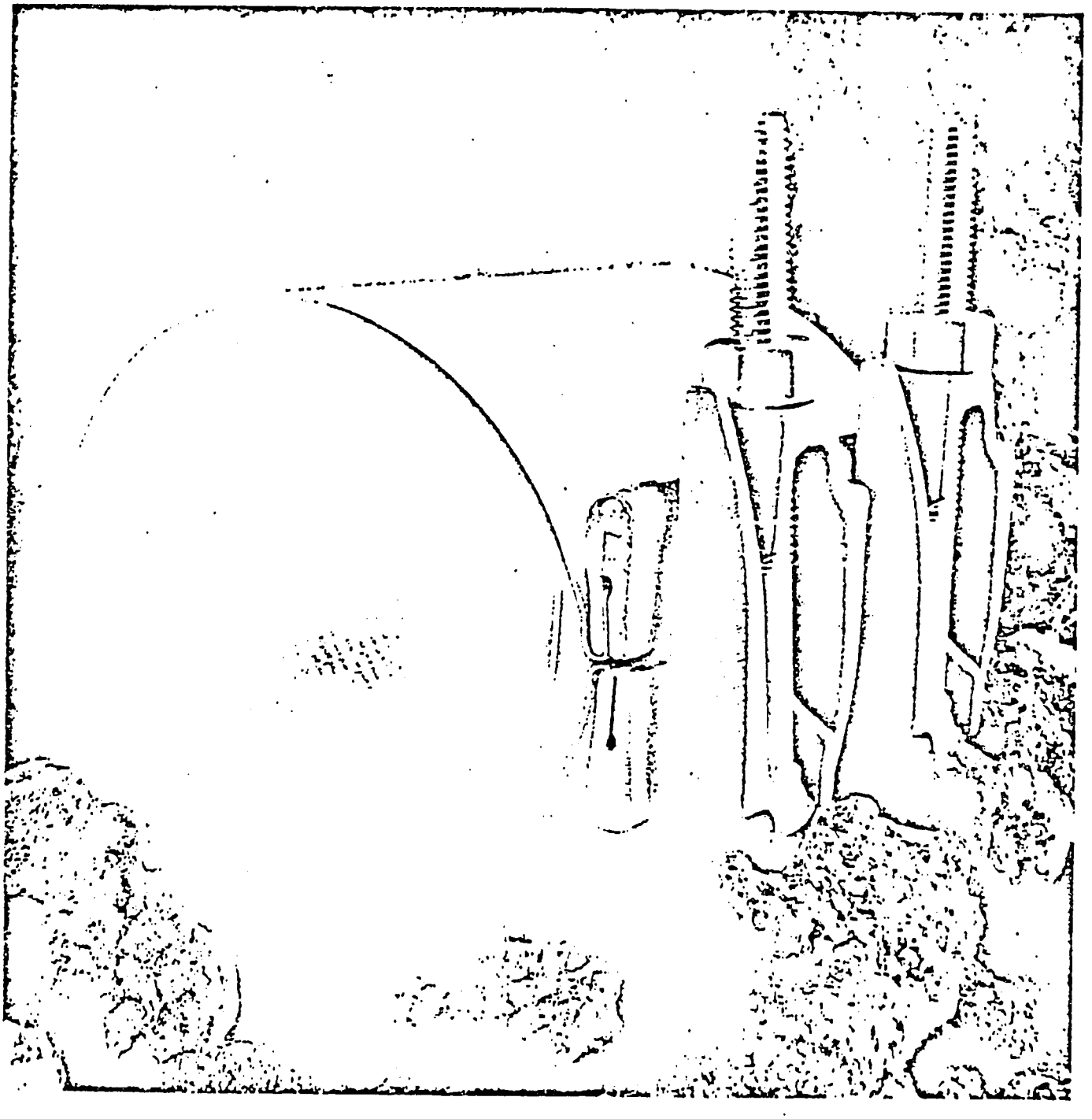
1¼", 1½" AND 2" NPT TAPS

U.S.						METRIC		
NOM. SIZE AND O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER			NOM. SIZE AND O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
			1¼" NPT (32mm)	1½" NPT (40mm)	2" NPT (50mm)			
4 4.44-5.24	12½	33	239-045012-010	239-045012-012	239-045012-014	100 113-133	190 317	15.0
6 6.62-7.42	12½	37	239-066312-010	239-066312-012	239-066312-014	150 169-188	190 317	16.8
6 6.84-7.64	12½	37	239-069012-010	239-069012-012	239-069012-014	150 174-194	190 317	16.8
8 8.62-9.42	12½	39	239-086312-010	239-086312-012	239-086312-014	200 219-239	190 317	17.7
8 8.99-9.79	12½	39	239-090512-010	239-090512-012	239-090512-014	200 229-248	190 317	17.7
10 10.75-11.72	10 15	49 72	239-107510-010 239-107515-010	239-107510-012 239-107515-012	239-107510-014 239-107515-014	250 273-297	254 381	22.2 32.7
10 11.04-12.24	10 15	49 72	239-111010-010 239-111015-010	239-111010-012 239-111015-012	239-111010-014 239-111015-014	250 281-310	254 381	22.2 32.7
12 12.75-13.92	10 15	51 76	239-127510-010 239-127515-010	239-127510-012 239-127515-012	239-127510-014 239-127515-014	300 324-353	254 381	23.2 34.5
12 13.14-14.34	10 15	51 76	239-132010-010 239-132015-010	239-132010-012 239-132015-012	239-132010-014 239-132015-014	300 334-364	254 381	23.2 34.5

Rockwell

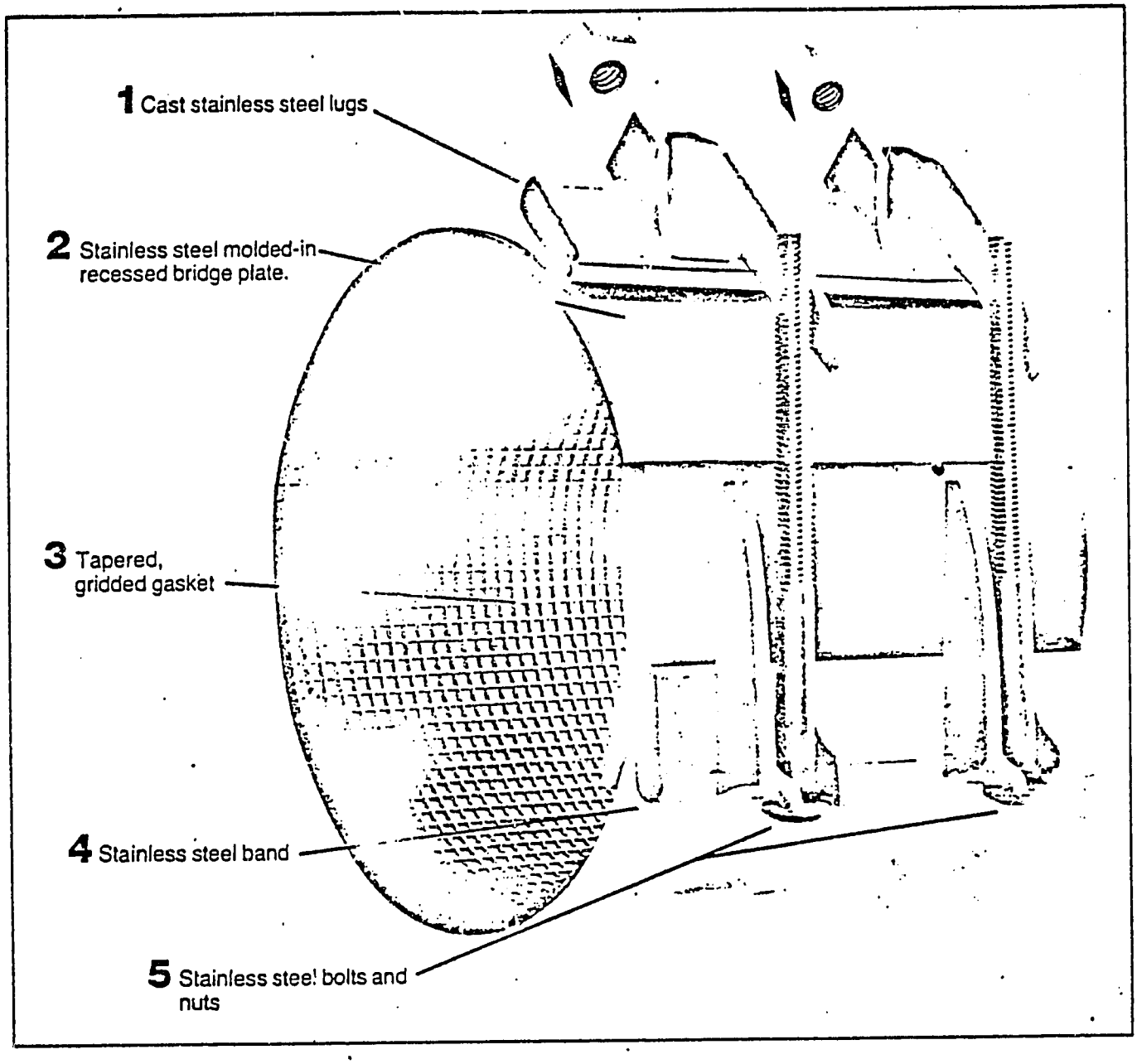
clamp and coupling products

ALL STAINLESS STEEL
Full Circle Clamp Couplings
no welds-no hot spots
balanced design
nominal sizes 2" through 12"



Rockwell engineers, with more than 100 years of combined leadership in the design and development of pipeline products, have produced the ideal solution for soil conditions requiring a stainless steel clamp.

The balanced design of "the cool clamp for hot soil" combines superior strength and corrosion resistance with all of the time-proven Full Circle Clamp features and benefits, to provide permanent, leak proof seals on all types of pipe.



1. **Cast Stainless Steel Lugs**
   Constructed with CF8 cast stainless steel lugs (type 304 equivalent). Interlocking stabilizing fingers provide a rigid joint with paralled alignment and allow maximum torque loads to be applied to the bolts. The lugs are attached by Rockwell's coining process. There is no welding in the lug area. The anti-corrosion properties of the stainless steel band are fully preserved.

2. **Stainless Steel Recessed Armor Plate**
   Type 304 or better recessed flush with the gasket molding process. This feature insures even gasket pressure at all points around the circumference of the pipe.

3. **Tapered, gridded gasket**
   Molded Tapered ends provide full, uniform sealing capacity at the lap joint through the full O.D. range of the clamp. The fine gridded surface provides a network of seals around the damaged area and superior sealing ability on rough or pitted pipe.

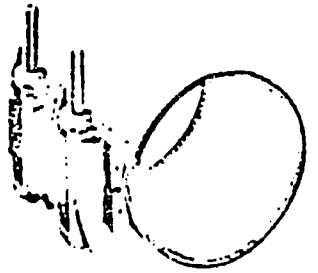
4. **Stainless Steel Bands**
   Bands are of type 304 stainless steel or better to meet the exacting requirements of corrosion resistance, flexibility and strength.

5. **Stainless Steel Bolts and Nuts**
   Type 304 or better. Double radius head and square neck design facilitate easy installation and maximum tightening. Course series rolled threads are factory treated to resist galling.

Rockwell

Clamp and Coupling products

256 single band full circle® all stainless steel



ROCKWELL 256 FULL CIRCLE CLAMP COUPLING designed especially for HOT SOIL or other aggressive environments provides a fast economical, permanent means of coupling or repairing full circumferential breaks and other types of damage on cast iron or asbestos cement, steel, copper, plastic, fiberglass and other types of pipes. The lugs are securely attached to the band by a coining process and have mutually supporting fingers to permit maximum torqueing of the bolts. The gasket is a lap type with molded tapered ends and a fine gridded surface to conform to irregularities on the pipe surface. The bridge plate is molded flush into the gasket to prevent wrinkling in the lug area and ensure uniform full circumferential sealing. Bolts and nuts are type 304 stainless steel.

MATERIAL SPECIFICATIONS:

LUGS: CF8 Austenetic cast stainless steel. (Type 304 stainless steel equivalant in a cast state.)
BAND: Type 304 stainless steel.
GASKET: Grade 30 specially compounded general purpose rubber of all new materials. Recommended for water, salt solutions, mild acids and bases. Lap type with molded, tapered ends and fine gridded surface. Temperature range −40°F. to 150°F.
BRIDGE PLATE: Type 304 stainless steel recessed flush and bonded into gasket.
BOLTS AND NUTS: Type 304 stainless steel with rolled threads, factory treated to resist galling.

Material specifications subject to change.

256 single band full circle all stainless steel

U.S.					METRIC			
NOM. PIPE SIZE INCHES	O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER.	NOM. PIPE SIZE MM	O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
2	2.35-2.63	7½ 11¼	5.6 8.4	256-023807-000 256-023811-000	50	60-68	190 285	2.5 3.8
2¼-2½	2.70-3.00	7½ 11¼	5.6 8.4	256-027507-000 256-027511-000	57-65	69-76	190 286	2.5 3.8
3	2.97-3.25	7½ 11¼	6.0 9.0	256-030007-000 256-030011-000	80	75-82	190 288	2.7 4.1
3	3.46-3.70	7½ 11¼	6.6 9.9	256-035007-000 256-035011-000	80	88-83	190 286	3.0 4.5
3-4	3.73-4.00	7½ 11¼	6.6 9.9	256-037507-000 256-037511-000	80-100	95-101	190 286	3.0 4.5
4	3.96-4.25	7½ 11¼	6.6 9.9	256-040007-000 256-040011-000	100	101-107	190 286	3.0 4.5
4	4.45-4.73	7½ 11¼	6.6 9.9	256-045007-000 256-045011-000	100	114-120	190 286	3.0 4.5
4	4.74-5.14	7½ 11¼ 15 22½	9.6 14.4 19.2 28.8	256-048007-000 256-048011-000 256-048015-000 256-048022-000	100	121-130	190 286 381 572	4.4 6.5 8.7 13.1
4-5	5.22-5.62	7½ 11¼ 15 22½	9.6 14.4 19.2 28.8	256-052507-000 256-052511-000 256-052515-000 256-052522-000	100-125	133-142	190 286 381 572	4.4 6.5 8.7 13.1

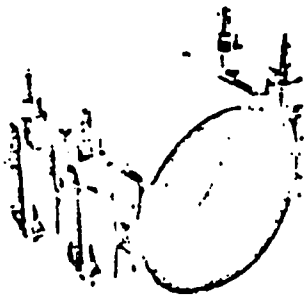
112A

U.S.					METRIC			
NOM. PIPE SIZE INCHES	O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER	NOM. PIPE SIZE MM	O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
6	6.56-6.96	7½ 11¼ 15 22½	9.9 14.9 19.8 29.7	256-066307-000 256-066311-000 256-066315-000 265-066322-000	150	167-176	190 286 381 572	4.5 6.8 9.0 13.5
6	6.84-7.24	7½ 11¼ 15 22½	10.9 16.4 21.8 32.7	256-069007-000 256-069011-000 256-069015-000 256-069022-000	150	174-183	190 286 381 572	4.9 7.4 9.9 14.8
6	7.05-7.45	7½ 11¼ 15 22½	10.9 16.4 21.8 32.7	256-071007-000 256-071011-000 256-071015-000 256-071022-000	150	180-189	190 286 381 572	4.9 7.4 9.9 14.8
6	7.45-7.85	7½ 11¼ 15 22½	10.9 16.4 21.8 32.7	256-074507-000 256-074511-000 256-074515-000 256-074522-000	150	190-199	190 286 381 572	4.9 7.4 9.9 14.8
8	8.54-8.94	7½ 11¼ 15 22½	11.9 17.9 23.8 35.7	256-086307-000 256-086311-000 256-086315-000 256-086322-000	200	217-227	190 286 381 572	5.4 8.1 10.8 16.2
8	8.99-9.39	7½ 11¼ 15 22½	11.9 17.9 23.8 35.7	256-090507-000 256-090511-000 256-090515-000 256-090522-000	200	229-238	190 286 381 572	5.4 8.1 10.8 16.2
8	9.27-9.67	7½ 11¼ 15 22½	11.9 17.9 23.8 35.7	256-094007-000 256-094011-000 256-094015-000 256-094022-000	200	236-245	190 286 381 572	5.4 8.1 10.8 16.2
10	10.64-11.04	7½ 11¼ 15 22½	12.9 19.4 25.8 38.7	256-107507-000 256-107511-000 256-107515-000 256-107522-000	250	271-280	190 286 381 572	5.9 8.8 11.7 17.6
10	11.04-11.44	7½ 11¼ 15 22½	13.9 20.9 27.8 41.7	256-111007-000 256-111011-000 256-111015-000 256-111022-000	250	281-290	190 286 381 572	6.3 9.5 12.6 18.9
10	11.34-11.74	7½ 11¼ 15 22½	13.9 20.9 27.8 41.7	256-114007-000 256-114011-000 256-114015-000 256-114022-000	250	289-298	190 286 381 572	6.3 9.5 12.6 18.9
10	11.75-12.15	7½ 11¼ 15 22½	13.9 20.9 27.8 41.7	256-117506-000 256-117511-000 256-117515-000 256-117522-000	250	299-308	190 286 381 572	6.3 9.5 12.6 18.9
12	12.62-13.02	7½ 11¼ 15 22½	14.9 22.4 29.8 44.7	256-127507-000 256-127511-000 256-127515-000 256-127522-000	300	321-330	190 286 381 572	6.8 10.2 13.5 20.3
12	13.10-13.50	7½ 11¼ 15 22½	14.9 22.4 29.8 44.7	256-132007-000 256-132011-000 256-132015-000 256-132022-000	300	333-342	190 286 381 572	6.8 10.2 13.5 20.3
12	13.40-13.80	7½ 11¼ 15 22½	14.9 22.4 29.8 44.7	256-134007-000 256-134011-000 256-134015-000 256-134022-000	300	341-350	190 286 381 572	6.8 10.2 13.5 20.3
12	13.70-14.10	7½ 11¼ 15 22½	15.9 23.9 31.8 47.7	256-137007-000 256-137011-000 256-137015-000 256-137022-000	300	348-358	190 286 381 572	7.2 10.9 14.4 21.7
12	14.00-14.40	7½ 11¼ 15 22½	15.9 23.9 31.8 47.7	256-140007-000 256-140011-000 256-140015-000 256-140022-000	300	356-365	190 286 381 572	7.2 10.9 14.4 21.7

Rockwell

clamp and coupling products

257 super range double band full circle® all stainless steel



ROCKWELL 257 SUPER RANGE FULL CIRCLE CLAMP COUPLING designed especially for HOT SOIL or other aggressive environments provides a fast economical, permanent means of coupling or repairing full circumferential breaks and other types of damage on similar outside diameters. A single clamp is required to connect or repair all classes of cast iron or asbestos cement in each nominal pipe size 4" through 12". The lugs are securely attached to the band by a coining process and have mutally supporting fingers to permit maximum torqueing of the bolts. The gasket is a lap type with molded tapered ends and a fine gridded surface to conform to irregularities on the pipe surface. The bridge plate is molded flush into the gasket to prevent wrinkling in the lug area and ensure uniform full circumferentail sealing. Bolts and nuts are type 304 stainless steel.

MATERIAL SPECIFICATIONS

LUGS: CF8 Austenetic cast stainless steel. (Type 304 stainless steel equivalant in a cast state.)
BAND: Type 304 stainless steel.
GASKET: Grade 30 specially compounded general purpose rubber of all new materials. Recommended for water, salt solutions, mild acids and bases. Lap type with molded, tapered ends and fine gridded surface. Temperature range −40°F. to 150°F.
BRIDGE PLATE: Type 304 stainless steel recessed flush and bonded into gasket.
BOLTS AND NUTS: Type 304 stainless steel with rolled threads, factory treated to resist galling.

Material specifications subject to change.

256 single band full circle all stainless steel

U.S.					METRIC			
NOM. PIPE SIZE INCHES	O.D. RANGE INCHES	WIDTH INCHES	WGT. EACH LBS.	CATALOG NUMBER	NOM. PIPE SIZE MM	O.D. RANGE MM	WIDTH MM	WGT. EACH KG.
4	4.74-5.54	7½ 11¼ 15 22½	17.2 25.8 34.4 51.6	257-048007-000 257-048011-000 257-048015-000 257-048022-000	100	121-141	190 286 381 572	7.8 11.7 15.6 23.4
6	6.84-7.64	7½ 11¼ 15 22½	19.2 28.8 38.4 57.6	257-069007-000 257-069011-000 257-069015-000 257-069022-000	150	174-194	190 286 381 572	8.7 13.1 17.4 26.2
8	8.99-9.97	7½ 11¼ 15 22½	20.2 30.3 40.4 60.6	257-090507-000 257-090511-000 257-090515-000 257-090522-000	200	229-248	190 286 381 572	9.2 13.8 18.3 27.5
10	11.04-11.84	7½ 11¼ 15 22½	22.2 33.3 44.4 66.6	257-111007-000 257-111011-000 257-111015-000 257-111022-000	250	281-310	190 286 381 572	10.1 15.1 20.2 30.2
10	11.60-12.40	7½ 11¼ 15 22½	22.2 33.3 44.4 66.6	257-116007-000 257-116011-000 257-116015-000 257-116022-000	250	295-314	190 286 381 572	10.1 15.1 20.2 30.2
12	13.14-13.94	7½ 11¼ 15 22½	23.2 34.8 46.4 69.6	257-132007-000 257-132011-000 257-132015-000 257-132022-000	300	334-364	190 286 381 572	10.5 15.8 21.1 31.6
12	13.65-14.45	7½ 11¼ 15 22½	24.2 36.3 48.4 72.6	257-136507-000 257-136511-000 257-136515-000 257-136522-000	300	347-372	190 286 381 572	11.0 16.5 22.0 33.0

113P

SELECTING THE PROPER FULL CIRCLE CLAMP COUPLING:

Determine the exact outside diameter — O.D. — of the pipe to be repaired. Select the type of clamp — (single band, super range, all-stainless steel, etc.). Select the clamp that has an O.D. range that includes the O.D. size of the pipe to be repaired.

The width of the clamp should be sufficient to provide at least 3" of clamp on solid pipe on each side of the break or damaged area on pipes 12" O.D. or smaller. On pipes 14" O.D. or larger the clamp should provide at least 4" of clamp on solid pipe on each side of the break or damaged area.

USEFUL INSTALLATION TIPS:

Always clean the pipe as throughly as possible.

Place a reference mark on the pipe. After completing the installation this can be used to check the clamp for proper position over the break or damaged area.

Lubricating the pipe with water, soap solution or other suitable lubricant helps to overcome friction and allows proper seating of the gasket.

Cleaning and lubricating the bolt threads will reduce friction and permit greater torque transfer to the lugs.

Leaving sufficient pressure on the line to keep water flowing will assist in preventing foreign matter or contaminants from entering the pipeline.

A Full Circle Clamp Coupling can be assembled loosely alongside the break and slid over the break if the pipe is well lubricated.

Allowing the water level to rise above the pipe will minimize spraying water. Full Circle Clamp Couplings can be installed quickly and easily under water.

Completely tightening the centermost bolt(s) first will usually stop spraying water.

Drilling a small hole at each end of a crack in the pipe will usually relieve stresses and prevent the crack from spreading.

For Torque recommendations see installation instructions on page 22.

SPECIAL INSTRUCTIONS

Breaks with a minor amount of deflection can be repaired with a Full Circle Clamp Coupling. The best method is to use a longer clamp with multiple lug sections. Align the joint in the lug sections with the break. The clamp will articulate to conform to the deflection. Breaks with a major amount of deflection should be repaired with a Rockwell 437 cut-in coupling.

Breaks with a minor amount of pipe misalignment can be repaired using a Full Circle Clamp Coupling. Breaks with greater misalignment should be repaired by using a Rockwell 437 Cut-In coupling, using two Rockwell Flexible Couplings and a short section of pipe or by realigning the pipe and using a Full Circle Clamp Coupling

When a gap between the ends of the pipe is 1 inch or greater a short section of pipe should be put in the opening or a thin strip of sheet metal wrapped around it to provide support to the Full Circle gasket.

When a section of pipe wall equal to 40% or more of the pipe circumference is broken away, a section of sheet metal should be placed over the opening to provide a sealing surface for the gasket.

Full Circle Clamp Couplings wider than the 30" widths listed in the catlog are available on special order. If the damage is extensive enough to require a Full Circle wider than 30", the feasibility and economics of replacing the damaged section with new pipe using Rockwell Flexible Couplings rather than repairing it should be considered.

IMPROVISING LARGE O.D. CLAMPS

To fill an emergency need for a large O.D. clamp when none are available, smaller clamps can be joined together to make a multiple band large clamp.

1. Determine exact O.D. of the pipe to be repaired.
2. Select two or three smaller clamps of sizes whose combined O.D. ranges equals the correct O.D. range to fit the damaged pipe.
   A. Example:
   Pipe to be repaired to 20" cast iron 21.60" O.D.
   Use 3 ea. 6" clamps 6.84-7.24 O.D. range
   6.84–7.24
   6.84–7.24
   6.84–7.24
   20.52-21.72 Improvised Clamp O.D. Range
3. It is not necessary to use clamps of the same size, but they should be as close in size as possible.
4. The bridge plate molded into the gasket has a preformed curvature for each size range to facilitate installation. To insure proper sealing the bridge plates must be straightened before installation.

Rockwell

Clamp and Coupling products

Installation Instructions

226,238 and 256 (single band)

1

Clean pipe and mark for position where repair clamp is to be installed for centering over break. Center clamp over damaged area. (Note: Clamp may also be assembled beside break and slid over leak prior to tightening of bolts.)

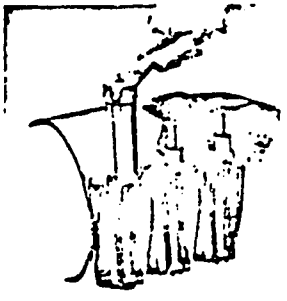
2

Tuck gasket flap in place and mesh lug fingers. Engage center bolt and tighten finger tight.

3

Rotate clamp on pipe in direction indicated by arrow to seat gasket flap smoothly on the pipe.

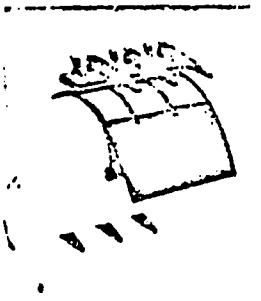
4



Engage remaining bolts and tighten all evenly with normal spanner. Maximum torque 70 Foot Pounds (= 10 mkg).

227, 228, 239 and 257 (multiple band)

1



Clean pipe and mark for position where repair clamp is to be installed for centering over break. Place the boltless half of clamp on pipe with gasket flap at top.

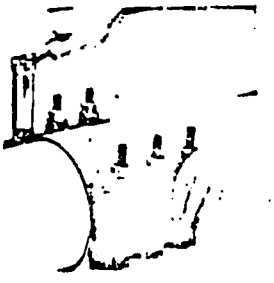
2

Place the half of the clamp containing the bolts with the gasket flap at bottom. Mesh top lug fingers and engage center bolt.

3

Tuck in bottom gasket flap and engage bottom center bolt. Tighten center bolts finger tight.

4



Rotate clamp on pipe in direction as indicated by arrow to seat gasket smoothly on the pipe. Stop rotation when nuts are in tightening position. Tighten center bolts evenly. Equalize gaps between bands. Engage remainder of bolts and tighten evenly with normal spanner. Maximum torque for ⅝-inch bolts: 70 Foot Pounds (= 10 mkg); for ¾-inch bolts: 90 Foot Pounds (= 12.5 mkg).

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September 19, 1981

NOTES

Technical Information: Availability of Cabezales

Information was received today from:

Ing. Jorge Martinez
Sub-Gerente de Ventas
HIDROSTAL, S. A.
Avenida Portada del Sol 722
Urbanización ZARATE
San Juan de Lurigancho
Lima 36
Phone: 812920
Telex: PX-25298 HIDROPE
CABLES: HIDROSTAL/LIMA
Casilla Postal: 5734, Lima 1, Peru

The information was delivered by Ing. Martin García, Supervisor de Ventas.

They produce gear-head-drives using gears imported from the U. S. produced by U. S. Motors. Under their license, they produce the casing in Peru and sell the entire unit, as follows:

Model No.	Maximum Power	Max. RPM	Price (US$)
GP-21	32 HP	3460	$1300
GP-60	60 HP	3460	$2075
GP-100	100 HP	1760	$2525
GP-152	152 HP	1760	$4100

These prices include 6% tax (not certain whether this is sales tax, or if this is the tax on the imported gears). They usually require 30% upon purchase, 70% on delivery.

The principal uses for these cabezales so far has been for agricultural wells. Ing. García indicated that they would fit any of the ESAL wells in Lima. They are called "Cabezales de Engranajes U.S. Motors-HIDROSTAL, 1:1".

At this moment, they have 20 cabezales of 100HP in stock, and 20 of the 152 HP in stock, total 40 which would be useful with ESAL wells.

A copy of the brochure is attached.

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Appendix III

Specifications: HIDROSTAL Gear Head Drives

HIDROSTAL S.A. [illegible] PORTADA DEL SOL [illegible] CARATE
SAN JUAN DE LURIGANCHO LIMA 31 PERU CASILLA POSTAL 5774 LIMA 1 PERU
TELEFONO 81-2300 TELEX PA 25398 HIDROPE CABLES HIDROSTAL LIMA

Hidrostal

Setiembre 16, 1981
DIP-17964

Atención: Sr. Robert Gerzony

Estimados señores:

Por medio de la presente nos es muy grato poner a su disposición nuestro siguiente presupuesto por Cabezales de Engranajes U.S. Motors - Hidrostal, 1:1.

MODELO	POTENCIA MAX. HP	VEL. MAX. RPM		PRECIO UNITARIO	
GP - 21	32	3460	S/.	583,000.00	$1295
GP - 60	60	3460	"	932,800.00	[illegible]
GP - 100	100	1760	"	1'136,000.00	2524
GP - 152	152	1760	"	1'837,300.00	[illegible]

PLAZO DE ENTREGA : Stock, salvo venta previa

FORMA DE PAGO : 30% con el pedido, saldo contra entrega. Nuestros precios son referenciales y facturaremos al precio de lista vigente a la fecha de entrega de la mercadería. El precio incluye impuesto de ley 6%.

VALIDEZ DE OFERTA : 7 días salvo venta previa.

Sin otro particular por el momento y en espera de sus gratas órdenes, los saludamos,

Atentamente,

Jorge Martinez
Sub-Gerente de Ventas

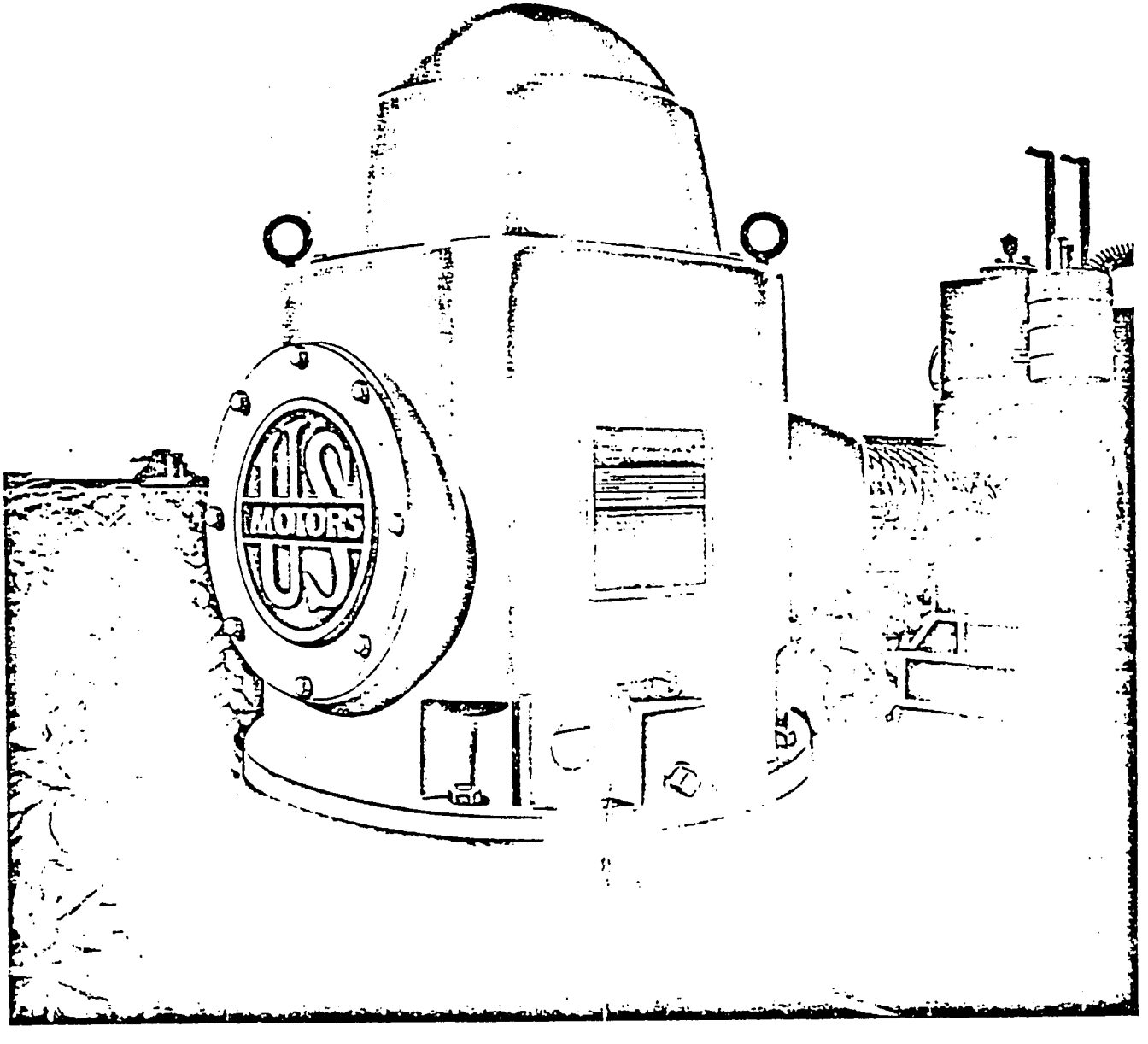
Pedro A. Luksic
Gerente Central

JM/nh

INSCRITA AS 3 F-67 TOMO 154 REG STRO MERCANTIL LIMA

U.S. HOLLOSHAFT

Right-Angle Gear-Drives For Agriculture & Industry



EMERSON

U.S. HOLLOSHAFT RIGHT-ANGLE GEAR DRIVES

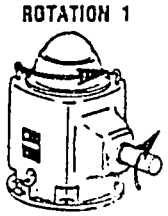
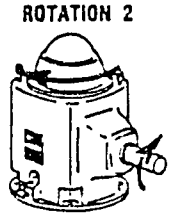
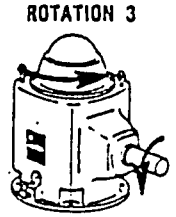
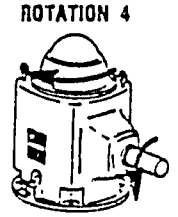
With the U.S. HOLLOSHAFT Gear Drive, U.S. Motors brings more than a half-century of application experience and engineering skill to the task of servicing the needs of irrigators and industry. The purpose of this publication is to help you by providing engineering information to enable you to choose the correct U.S. HOLLOSHAFT Gear Drive for your remote or other-than-electrical prime mover.

GEAR DRIVE SELECTION

The following tables should be used for proper gear drive selection. In order to process orders immediately, supply the following information: Model, ratio, thrust requirement, rotation, coupling bore, flange.

ROTATION TABLE

Rotation 1 is standard — Refer all others to office with application details.

ROTATION 1	ROTATION 2	ROTATION 3	ROTATION 4
			
HORIZONTAL — CW VERTICAL — CCW	HORIZONTAL — CW VERTICAL — CW	HORIZONTAL — CCW VERTICAL — CCW	HORIZONTAL — CCW VERTICAL — CW

MINIMUM THRUST REQUIREMENTS

Spiral bevel gears operating under load exert a separating force along both the axis of the driving gear and the axis of the driven gear. The magnitude of this force depends upon the ratio, hand of spiral and load transmitted. By designing for upthrust on the vertical gear, advantage is taken of this axial thrust to offset part of the normally heavy downthrust caused by the weight of the pump, shafting and hydraulic downthrust. Unless there is a specific downthrust, refer to office with details. New orders will be processed at no charge.

MINIMUM DOWNTHRUSTS TABLE (Values in Pounds) Rotation 1

RATIO	21	40	60	80	100	125	152	200
1:1	788	1352	1625	2060	2575	2255	2706	3610
1:2	1035	1810	—	—	—	2910	3490	4660
2:1	—	384	—	—	—	—	—	—
2:3	983	1692	1231	2350	2935	2395	2880	3830
3:2	313	545	598	800	1000	757	909	1210
3:4	966	1392	628	829	1039	2150	2590	3450
4:3	304	484	1215	1628	2038	736	885	1178
4:5	—	—	638	847	1058	763	916	1221
5:4	—	—	1300	1743	1080	1770	2125	2830
5:6	—	1439	1682	2030	2541	2195	2635	3510
6:5	—	527	474	807	1010	784	940	1255
10:11	—	—	644	2080	2595	2175	2610	3490
11:10	—	—	1431	850	1065	807	970	1292

OTHERS REFER TO ENGINEERING

HORSEPOWER AND THRUST BEARING RATINGS TABLE

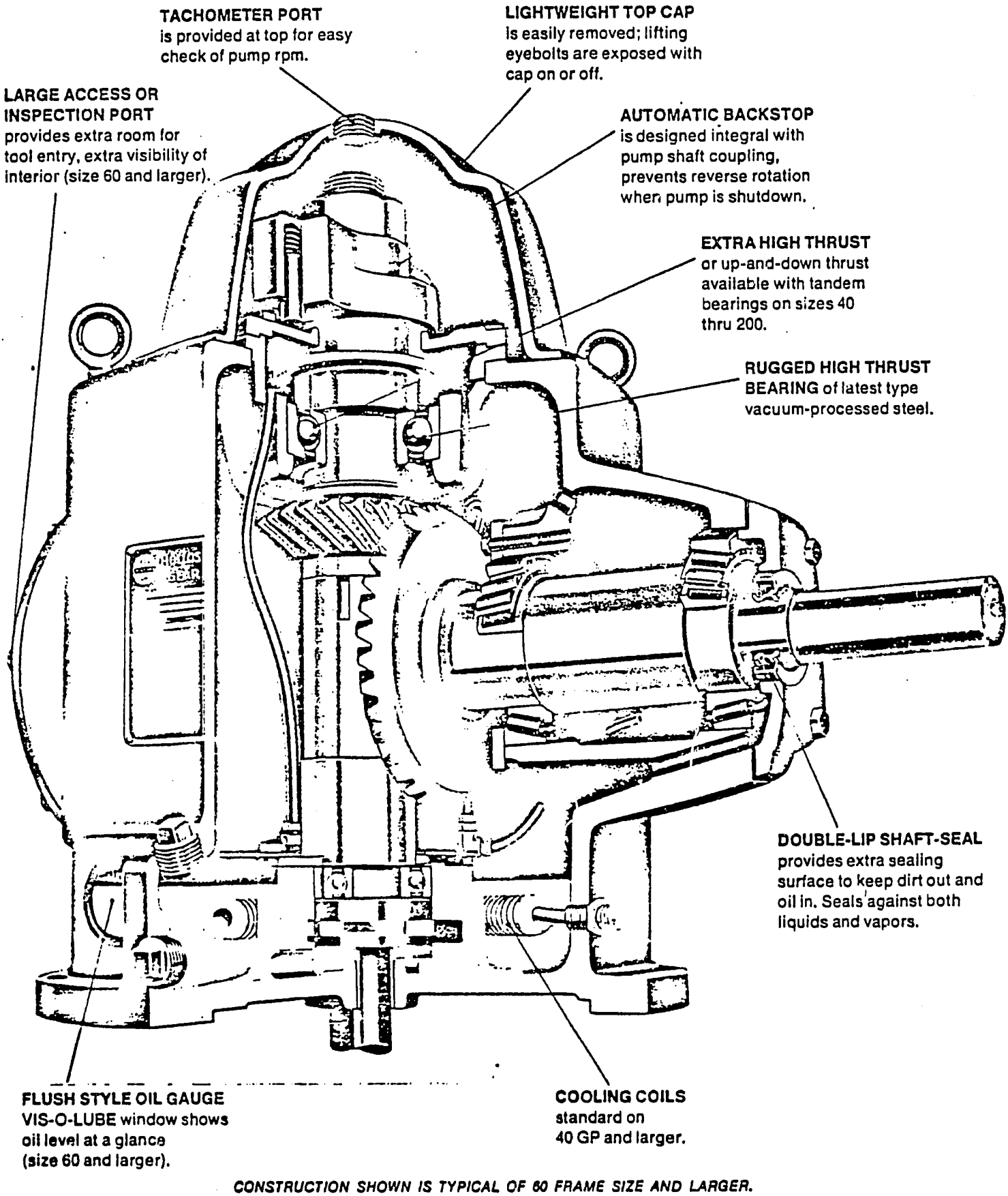
VERTICAL RPM	690	720	870	900	1160	1460	1760	2000	2200	2400	3000	3460	3600
PERCENT HP AT 1760 RPM	52	54	61	66	75	88	100	105	111	116	133	146	150
PERCENT THRUST AT 1760 RPM	137	135	126	122	115	106	100	96	93	90	84	80	79

To obtain horsepower and thrust ratings use SELECTION DATA TABLE and multiply the 1760 rpm rating by the percentage in HORSEPOWER AND THRUST BEARING RATINGS TABLE.

Copyright 1972 EMERSON ELECTRIC CO.

...designed for tough, continuous duty!

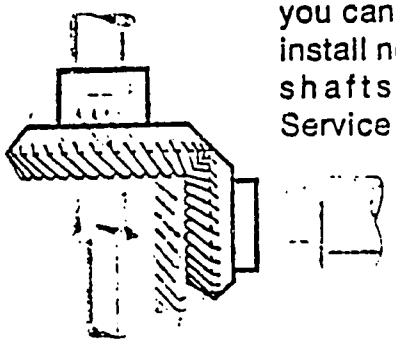
Right-Angle; Compact; Weatherproof; Accessible; Designed for Vertical Turbine Pumps



CONSTRUCTION SHOWN IS TYPICAL OF 60 FRAME SIZE AND LARGER.

WE MAKE OUR OWN GEARS.

Interchangeable Gears



you can change gears . . . install new ratios on same shafts. 1.5 minimum Service Factor at rated hp.

A wide choice of gear ratios is offered in U.S. HOLLOSHAFT Right-Angle Gear-Drives. Added flexibility is provided by interchangeable gears. There is no need to change shafts to provide new pumping speeds or to accommodate a new engine with different output speeds.* Dimensions are etched on all gear-sets to aid in accurate conversion away from the factory.

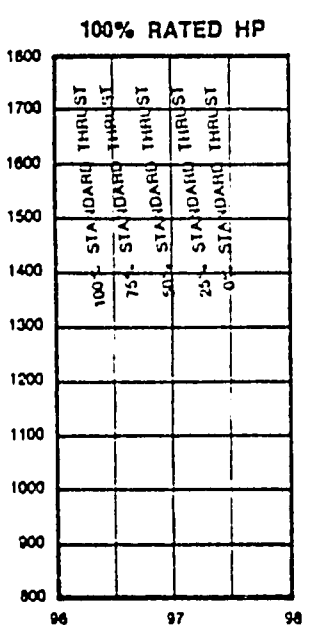
**Except sizes 21 and 40 — 1:2 and 2:1 speed ratios.*

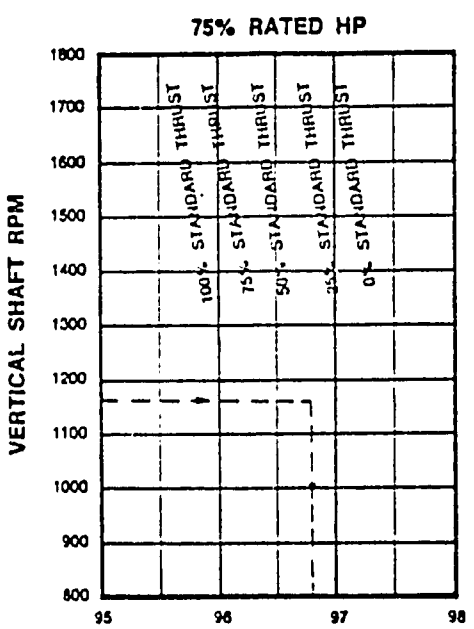
AVERAGE UNIT EFFICIENCY

Each curve represents a percentage of the normal rated horsepower on the SELECTION DATA TABLE.

EXAMPLE: Given GP-100 operating at brake horsepower, 55 at 1160 rpm and 3450 lbs. thrust. The Selection Data Table shows operating horsepower at 74 hp. The percentage load $\frac{55}{74} \times 100 = 74\%$.

Use the 75% LOAD CHART at 50% thrust load = 96.8% efficiency.



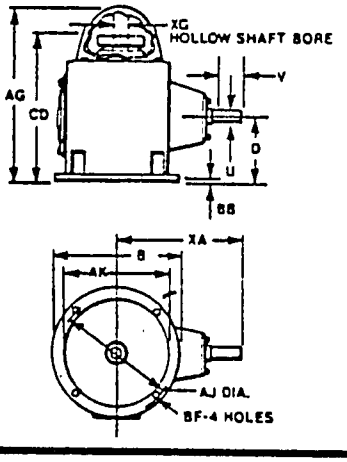


SELECTION DATA TABLE

MODEL	PUMP RPM	HP	THRUST CAP STD	THRUST CAP EHT	RATIOS AND ENGINE SPEED 1:1	10:11	5:6	4:5	3:4	2:3	4:7	1:2	1:3	6:5	11:10	4:3	3:2	2:1	3:1	5:4
21	1160	15	2350	NA	1160	—	—	—	870	773	—	580	—	—	—	1547	1740	—	—	—
	1460	17	2200	NA	1460	—	—	—	1095	974	—	730	—	—	—	1946	2190	—	—	—
	1760	20	2050	NA	1760	—	—	—	1320	1174	—	880	—	—	—	2346	2640	—	—	—
	3460	32	1650	NA	3460	—	—	—	2595	2306	—	1730	—	—	—	—	—	—	—	—
40	1160	30	3550	5520	1160	1055	967	—	870	773	663	580	—	1392	—	1547	1740	2320	3480	—
	1460	35	3300	5088	1460	1309	1217	—	1095	973	834	730	—	1752	—	1947	2190	2920	—	—
	1760	40	3100	4800	1760	1578	1467	—	1320	1173	1006	880	—	2112	—	2347	2640	3520	—	—
	3460	45	2500	—	3460	3145	2883	—	2595	2307	1977	1730	—	—	—	—	—	—	—	—
60	1160	45	4700	6900	1160	1040	967	928	870	773	663	580	387	1392	1276	1547	1740	2320	3480	1450
	1460	53	4350	6360	1460	1314	1217	1168	1095	973	834	730	487	1752	1606	1947	2190	2920	—	1825
	1760	60	4100	6000	1760	1584	1467	1408	1320	1173	1006	880	587	2112	1936	2347	2640	3520	—	2200
	3460	60	3300	NA	3460	3145	2883	2768	2595	2307	1977	1730	—	—	—	—	—	—	—	—
80	960	52	7130	11224	960	873	800	768	720	640	549	480	—	1152	1056	1280	1440	—	—	1200
	1160	60	6750	10580	1160	1040	967	928	870	773	663	580	—	1392	1276	1547	1740	—	—	1450
	1460	70	6250	9750	1460	1314	1217	1168	1095	973	834	730	—	1752	1606	1947	2190	—	—	1825
	1760	80	5850	9200	1760	1584	1467	1408	1320	1173	1006	880	—	2112	1936	2347	2640	—	—	2200
100	960	65	7130	11224	960	873	800	768	720	640	549	480	—	1152	1056	1280	1440	—	—	1200
	1160	74	6750	10580	1160	1040	967	928	870	773	663	580	—	1392	1276	1547	1740	—	—	1450
	1460	89	6250	9750	1460	1314	1217	1168	1095	973	834	730	—	1752	1606	1947	2190	—	—	1825
	1760	100	5850	9200	1760	1584	1467	1408	1320	1173	1006	880	—	2112	1936	2347	2640	—	—	2200
125	960	82	8780	NA	960	873	800	768	720	640	549	480	—	1152	1056	1280	1440	1920	2880	1200
	1160	94	8280	NA	1160	1040	967	928	870	773	663	580	—	1392	1276	1547	1740	2320	3480	1450
	1460	110	7632	NA	1460	1314	1217	1168	1095	973	834	730	—	1752	1606	1947	2190	2920	—	1825
	1760	125	7200	NA	1760	1584	1467	1408	1320	1173	1006	880	—	2112	1936	2347	2640	3520	—	2200
152	960	98	8780	15250	960	873	800	768	720	640	549	480	320	1152	1056	1280	1440	1920	2880	1200
	1160	112	8280	14375	1160	1040	967	928	870	773	663	580	387	1392	1276	1547	1740	2320	3480	1450
	1460	132	7632	13250	1460	1314	1217	1168	1095	973	834	730	487	1752	1606	1947	2190	2920	—	1825
	1760	150	7200	12500	1760	1584	1467	1408	1320	1173	1006	880	587	2112	1936	2347	2640	3520	—	2200
200	960	131	8780	15250	960	873	800	768	720	640	549	480	320	1152	1056	1280	1440	1920	2880	1200
	1160	150	8280	14375	1160	1040	967	928	870	773	663	580	—	1392	1276	1547	1740	—	3480	1450
	1460	175	7632	13250	1460	1314	1217	1168	1095	973	834	730	—	1752	1606	1947	2190	—	—	1825
	1760	200	7200	12500	1760	1584	1467	1408	1320	1173	1006	880	—	2112	1936	2347	2640	—	—	2200

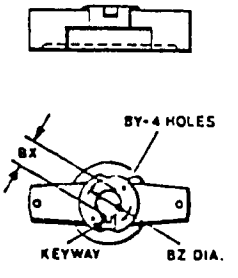
DRIVE DIMENSIONS

All dimensions are in inches



COUPLING DIMENSIONS

All dimensions are in inches



FRAME SIZE	BASIC PART NO.	BX BORE	BY SIZE TAP	BZ DIA. B.C.	SQ. KEY
21	140727	.751	10-32	1 3/8	3/16
	140728	.876	10-32	1 3/8	3/16
	140729	1.001	10-32	1 3/8	1/4
40	140121	1.001	10-32	1 3/8	1/4
	140122	1.188	1/4-20	1 3/4	1/4
	140123	1.251	10-32	1 3/4	1/4
60	144693	1.001	1/4-20	1 3/4	1/4
	139300	1.251	10-32	1 3/4	1/4
	139301	1.188	1/4-20	1 3/4	1/4
	139302	1.501	1/4-20	2 1/8	3/8
80, 100	144698	1.376	1/4-20	1 3/4	5/16
	139308	1.501	1/4-20	2 1/8	3/8
	139309	1.188	1/4-20	1 3/4	1/4
	144697	1.251	1/4-20	1 3/4	1/4
125, 152, 200	139176	1.501	1/4-20	2 1/8	3/8
	139177	1.688	1/4-20	2 1/8	3/8
	139178	1.938	1/4-20	2 1/8	1/2
	144700	1.438	1/4-20	2 1/8	3/8

DIMENSIONS ARE THE SAME FOR 175% EHT AS STANDARD THRUST

FRAME SIZE	D	U	V MIN.	AG	AJ DIA. B.C.	AK	BB	BD BASE DIA.	BF HOLE DIA.	CD	XA	XG	SQ. KEY
21	5 5/16	1 1/8	2 9/16	15 3/8	9 1/8	8 1/4	1/4	10	7/16	12 1/8	11 7/32	1.020	1/4
40†	7	1 1/2	3 15/32	20 1/4	9 1/8	8 1/4	3/16	12	7/16	16 15/16	14 3/8	1.270	3/8
40‡	6	1 1/2	3 15/32	19 1/4	14 3/4	13 1/2	5/16	16 1/2	11/16	15 15/16	14 3/8	1.270	3/8
60	8 3/8	1 1/2	4 9/32	23 1/8	14 3/4	13 1/2	5/16	16 1/2	11/16	19 19/32	16 13/32	1.520	3/8
80	10	1 7/8	4 9/32	27	14 3/4	13 1/2	5/16	16 1/2	11/16	22 11/32	18 3/32	1.520	3/8
100	10	1 7/8	4 9/32	27	14 3/4	13 1/2	5/16	16 1/2	11/16	22 11/32	18 3/32	1.520	3/8
125	12 7/8	2 9/16	4 9/32	33 11/16	18 1/4	13 1/2	5/16	20	11/16	27 15/16	21 9/32	2.020	3/8
152	12 7/8	2 9/16	4 9/32	33 11/16	18 1/4	13 1/2	5/16	20	11/16	27 15/16	21 9/32	2.020	3/8
200	12 7/8	2 9/16	4 9/32	33 11/16	18 1/4	13 1/2	5/16	20	11/16	27 15/16	21 9/32	2.020	3/8

†12 BD 11 1/2 BD

U. S. ELECTRICAL MOTORS DIVISION
EMERSON ELECTRIC CO.
OLD GATE LANE
MILFORD, CONNECTICUT 06460

EMERSON

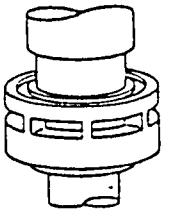
BR 409-16 25M 7/73 LITHO IN U.S.A.

MOTORS

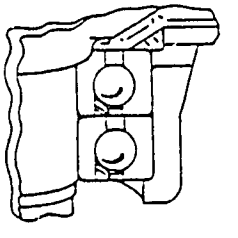
BECAUSE U.S. MOTORS HAS SERVICED THE PUMP INDUSTRY OVER 50 YEARS much experience has been gained in relation to pump applications, and design requirements for long life. U.S. Motors, the recognized leader in the production of vertical pump drives, offers these features for DEPENDABLE, TROUBLE-FREE SERVICE.

VISOLUBE WINDOW makes it easy to check oil level on Model 60 and larger.

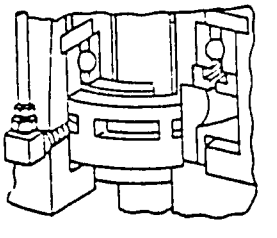
BI-DIRECTIONAL CENTRIFUGAL PUMP on Model 60 and larger. Forces oil through tubes to bearings and gears. On Model 21 and 40 bearings and gears are lubricated by slinger-pump.



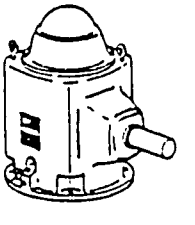
STACKED BEARINGS (Optional) tandem thrust bearings can be mounted for higher thrust ratings or opposed for up and down thrust.



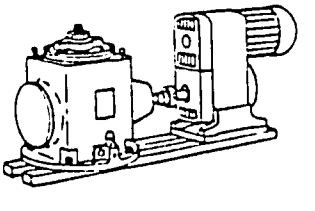
INHERENT UP-THRUST PROTECTION momentary up-thrust sometimes occurs in pump shafts during the starting period. To protect the bearing and gear mesh the lower bearing is locked.



ONE PIECE GEAR BOX (60 Frame & Larger) provides extra rigidity, accurate alignment, and oil tight construction. The advanced features insure reliable gear-life and full protection against environmental hazards.



ALL GEAR DRIVES are tested to insure proper lubrication, gear mesh and quiet operation. This test is performed at half- and full-load to insure quality.



Appendix IV

Specifications and Availability: Plastic Jugs

October 4, 1981

Appendix IV

TECHNICAL DATA: WATER JUG SPECIFICATIONS

PLASTIC WATER CONTAINER SPECIFICATIONS

Local Manufacturers:

BASA
Bakelita y Anexos S.A.
Av. Nugget #131
Altura Km 3, Carr. Central
tel. no. 31-8420

Carlos Koechlin M.
Sub-Gerente de Ventas

Roxana Macha (ChiChi)
Dpto. de Ventas

CESTOR
385 Gregorio VII
tel. no. 81-6622

Plastico Hartinger S.A.
Cuadra 22 de Av. Argentina
tel. no. 23-7775

José Chicama
Dpto. de Ventas

Plastimol S.A.
1108 Prolg. Andahuaylas
tel. no. 72-5100 & 72-6118

Product Specifications:

The above four companies make plastic water containers of various sizes and dimensions. Available of these products is dependant on the time of year and what their factories are currently set up to manufacture. Most of the companies deal with a large line of other products, mostly toys.

CESTOR and BASA have the widest selection of water containers. A sample of a 3 gallon container from each company was obtained. Both are rectangular in shape with a carrying handle and spout at the top. They are well made and excellent for use in an emergency situation for carrying water.

CESTOR has these plastic containers in 1, 2, 3, 5, & 8 gallons. The 3 gallon container retails for S/.1,000 (US$ 2.22)

BASA has these plastic containers in 1 & 3 gallons. The 3 gallon container retails for S/.1,400 (US$ 3.11).

Plastico Hartinger make 3 gallon containers and Plastimol make 1 gallon containers.

Lynch

707

Appendix V

Suggested Modification: Water Storage Tank Specifications

Appendix V

El reporte del Ingeniero Normando Porras sobre el terremoto del 23 de Diciembre de 1972 que destruyó gran parte de la ciudad de Managua (Nicaragua), al referirse a los daños en los reservorios de regulación, indica que en aquellos reservorios en los que la losa del fondo es independiente de las paredes de la columnas y está conectada mediante una junta de expansión con empaque de material plástico y una junta de construcción de dos centímetros de espesor rellenada con flexcel, estas juntas se salieron de su ubicación completamente durante el sismo, provocando fugas de agua en el fondo del tanque, que afectaron a los cimientos.

Siendo que en Lima se utiliza un sistema similar en los reservorios de regulación, convendría hacer notar este riesgo con el objeto de mejorar estas juntas en las normas correspondientes para evitar estas posibles fallas en el caso de un terremoto.