1.2 Superstructure

1.2. SUPERSTRUCTURE

1.2.1 Pump House

(1) Structural System

Design of superstructure is made in accordance with the following structural system.

(a) Layout

The pumping station is divided in two main parts which are the erection bay and the pump/motor bay.

(b) Expansion joint

The pumping station is separated into two blocks by an expansion joint.

(c) Roof

Roof is a reinforced poured-in-place concreted slab which is supported by the framing of reinforced concrete beams and girders.

(d) Crane girder

The crane girder for overhead travelling crane is of reinforced concrete, and is supported by the brackets of columns.

(e) Framing plan

Framing plan of pump house is shown in Fig. No. 4.1.

(2) Design Conditions

(A) Loads

(1) Unit weight of material

Materials	Unit weight
Concrete, plain	2.30 ts/m^3
Concrete, reinforced	2.40 ts/m^3
Mortar	2.00 ts/m^3
Steel	7.80 ts/m^3

(b) Dead Load

Dead load is the self weight of the structure.

(c) Seismic force

Seismic force acting on the structure is calculated by the following formulae:

$$F=\Sigma W.kh$$

where:

F : Seismic load t

ΣW : total dead load

kh : coefficient for horizontal earthquake = 0.15

(B) Factored Loads

The structures and structural members were designed according to the following factored loads: dead D and live L for ultimate strength.

$$U=1.4\ D + 1.7\ L$$

For seismic analysis, including the seismic force E, the most critical conditions of the following combinations were used:

$$U=1.05\ D + 1.275\ L + 1.87\ E$$

$$U=0.9\ D + 1.43\ E$$

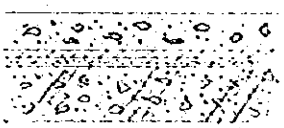
(3) Structural Analysis and Design

The structural analysis was made for each block of the pumping station with the computational program SAP 90.

(A) Loads assumption

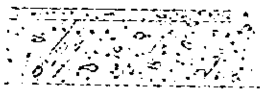
(a) Dead load of roof and floor

a) Roof



- Plain Concrete 10 cm average thickness		230
- 3 ply built-up roofing		20
- Base Mortar	3 cm	60
- Concrete slab	15 cm	<u>360</u>
		670 kgf/m²

b) 2nd floor slab



- Cement mortar	3 cm	60 kgf/m²
- Concrete slab	15 cm	<u>360</u>
		420 kgf/m²

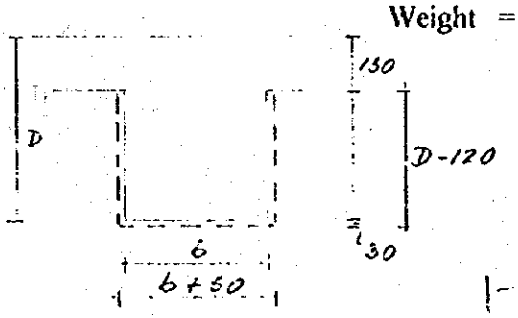
c) Dead load of reinforced concrete walls

W 150	Thick	150 mm	
	- Concrete wall	15 cm	360 kgf/m²
	- Mortar	2 cm	<u>40</u>
			400 kgf/m²

W 200	Thick	200 mm	
	- Concrete wall	20 cm	480 kgf/m²
	- Mortar	2 cm	<u>40</u>
			520 kgf/m²

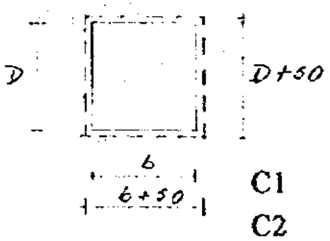
d) Dead load of girder and beam

Weight = 2.4 tf/m³ x (b + 0.005) (D - 0.12) = (tf/m)



Element	b x D	Weight
RG 1	45 cm x 80 cm	2.4 x 0.5 x 0.68 = 0.82 tf/m
RG 2 2G 2 2G 3	40 x 80	2.4 x 0.45 x 0.68 = 0.74
2G 1	50 x 80	2.4 x 0.55 x 0.68 = 0.90
RG-3	70 x 150	2.4 x 0.75 x 1.38 = 2.48
RG4	90 x 130 Ave	2.4 x 0.95 x 1.18 = 2.69
2G 4	100 x 150	2.4 x 1.05 x 1.55 = 3.91 without slab
CG 1	40 x 60	2.4 x 0.45 x 0.48 = 0.52
RB 1 RB 2 2B 1	30 x 70	2.4 x 0.35 x 0.58 = 0.49
2B 2	30 x 60	2.4 x 0.35 x 0.48 = 0.40

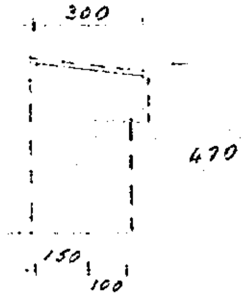
e) Dead load of column



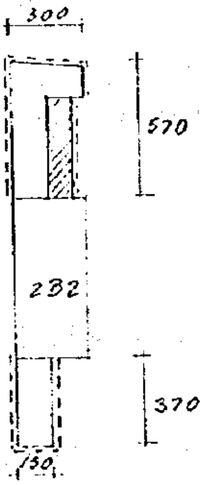
Weight = 2.4 tf/m^3 x (b + 0.05) x (D + 0.05) = tf/m

	b x D	
C1	60 cm x 80 cm	2.4 x 0.65 x 0.85 = 1.33 tf/m
C2	90 x 130	2.4 x 0.95 x 1.35 = 3.08
	90 x 150	2.4 x 0.95 x 1.55 = 3.54

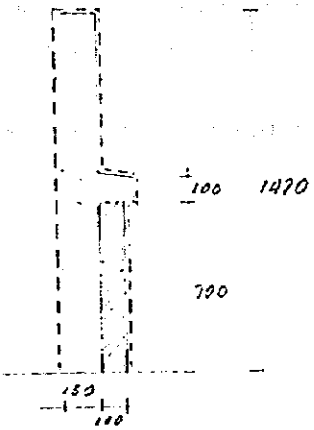
f) Dead weight of parapets



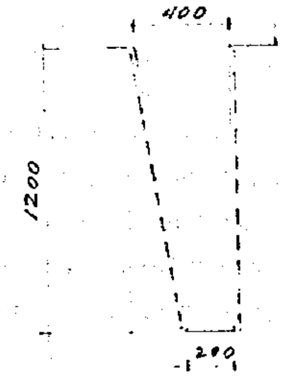
-	Concrete	2.4 x 0.15 x (0.47 + 0.15)	= 0.23
-	Brick	2.0 x 0.10 x 0.32	= 0.07
-	Finish	2.0 x 0.03 x 1.24	= 0.08
			0.38 tf/m



-	Concrete	2.4 x 0.15 x (0.57 + 0.15)	= 0.26
-	Brick	2.0 x 0.10 x 0.42	= 0.09
-	Finish	2.0 x 0.03 x 1.44	= 0.09
-	Concrete	2.4 x 0.15 x 0.37	= 0.13
-	Finish	2.0 x 0.03 x 0.95	= 0.06
			0.63 tf/m



-	Concrete	2.4 x 0.15 x 1.47	= 0.53
		2.4 x 0.10 x 0.15	= 0.04
-	Brick	2.0 x 0.10 x 0.70	= 0.14
-	Finish	2.0 x 0.03 x 3.24	= 0.20
			0.91 tf/m



-	Concrete	2.4 x 1.20 x $\frac{(0.40 + 0.20)}{2}$	= 0.86 tf/m
-	Finish	2.4 x 0.03 x 2.0	= 0.15
			1.01 tf/m

(b) Live load

Roof	180 kgf/m^2
2nd floor slab	300 kgf/m^2

(B) Structural Analysis

The structural three dimensional analysis for each block that conforms the pump house superstructure, was made with the computer program SAP90.

(a) Block No. 1

The block No. 1 is a building of one floor with three spans longitudinally and one transversally.

The roof slab is supported on beams and girders and all of them supported on columns.

The structural model has 32 joints, 26 frame type elements and 15 shell bending type elements.

Because of symmetry in both directions the structure was studied for the following load combinations:

1. 1.4 D + 1.7 L
2. 1.05 D + 1.275 L + 1.4 E Y
3. 1.05 D + 1.275 L + 1.4 E X
4. 0.9 D + 1.43 E Y
5. 0.9 D + 1.43 E X

The structural model is shown in Figure B1-1, the joints in Figure B1-2, frame elements in Figure B1-3, shell type elements in Figure B1-4, joints displacements for load combination No. 1 in Figure B1-5, joint displacements for load combination No. 2 in Figure B1-6, joint displacement for load combination No.4 in Figure B1-7, bending moments for load combination No.1 in Figure B1-8 and shear forces for load combination No.1 in Figure B1-9.

The structural design was made by the computer program SAPCON, a postprocessor program of SAP90, for reinforced concrete design.

The concrete design was made in accordance to the ACI 318 - 89 Code.

The computer autputs for the estructural analysis and design are in a separate appendix.

(b) Block No. 2

The block No.2 is an asymmetric building with four spans longitudinally and where one span has two floors. One and span is part of the maintenance pump house block.

The roof slab is supported on beams and girders and all of them on columns.

The maintenance block has a bridge crane with a capacity of 32tf supported on rails on top of concrete girders of 1.0 x 1.5 m. The main columns are 0.9 x 1.5 m in section.

The structural model has 96 joints, 139 frame type elements and 30 shell bending type elements.

Due to its lack of symmetry the structure was studied for the following load combinations:

1. 1.4 D + 1.7 L
2. 1.05 D + 1.275 L + 1.4 E Y
3. 1.05 D + 1.275 L + 1.4 E X
4. 0.9 D + 1.43 E Y
5. 0.9 D + 1.43 E X
6. 1.05 D + 1.275 L - 1.4 E Y
7. 1.05 D + 1.275 L - 1.4 E X
8. 0.9 D - 1.43 E Y
9. 0.9 D - 1.43 Sismo X.

The structural model is shown in figure B2-1, the joints in Figure B2-2, the frame type elements in Figure B2-3, the shell type elements in Figure B2-4, joints displacements for load combinations No.1, No.2, No.3, No.6 and No.7 in Figures B2-5, B2-6, B2-7, B2-8, B2-9, bending and shear for load combination No.1 in Figures B2-10 and B2-11.

The structural design of the frame type reinforced concrete elements beams and columns was made by the computer program SAPCON.

The concrete design was made in accordance to the ACI 318 -89 Code.

The computer out puts for the estructural analysis and design are in a separate appendix.

(C) Check the assumed slab depth

The minimum depth of slabs in two directions shall be computed by:

$$h = \frac{Ln\,(800 + fy / 1.5)}{36{,}000 + 5{,}000\,\beta\ [\alpha m - 0.5(1-\beta s)(1+1/\beta)}$$

where:

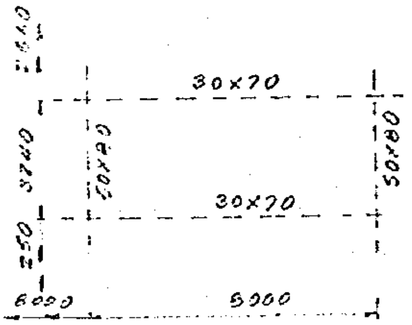
Ln : larger clear span

fy : yield strength of reinforcement

β : relation of long to short spans

αm : average value of α

βs : ratio of continuous edges to panel perimeter



$Ln = 800 - 2 \times 25$

$= 750$ cm

$Lc = 3.24 - 2 \times 15$

$= 294$ cm

$$\beta = \frac{750}{294} = 2.55$$

$$I_1 = \frac{1}{12}\, 50 \times 80^3 = 2{,}133{,}333.3 \ \ cm^4$$

$$I_2 = \frac{1}{12} 30 \times 70^3 = 857{,}500 \quad cm^4$$

$$I_{s1} = \frac{1}{12} 800 \times 15^3 = 225{,}000 \quad cm^4$$

$$I_{s2} = \frac{1}{12} 295 \times 15^3 = 82{,}969 \quad cm^4$$

$$I_{s3} = \frac{1}{12} 287 \times 15^3 = 80{,}719 \quad cm^4$$

$$\alpha_1 = \frac{2{,}133{,}333}{225000} = 9.48$$

$$\alpha_2 = \frac{857{,}500}{82{,}969} = 10.36$$

$$\alpha_3 = \frac{857{,}500}{80{,}719} = 10.62$$

$$\alpha_m = \frac{9.48 + 10.36 + 10.62}{3} = 10.15$$

$$h = \frac{7{,}500\,(800 + 420/1.5)}{36{,}000 + 5{,}000 \times 2.55\,[10.15 - 0.5\,(1-1)(1+1/2.55)]} = 49 \text{ mm}$$

but shall not be less than

$$h = \frac{\ln\,(800 + fy/1.5)}{36{,}000 + 5{,}000\,\beta\,(1 + \beta\, s)}$$

$$= \frac{7{,}500(800+420/1.5)}{36{,}000+5{,}000 \times 2.55(1+1)} = 132 \; mm$$

and does not need to be larger than

$$h = \frac{\ln\,(800 + fy/1.5)}{36{,}000}$$

$$= \frac{7500(800+420/1.5)}{36000}$$

$$= 225 \text{ mm}$$

The assumed depth was 150 mm which is between the limits defined, so it is adequate.

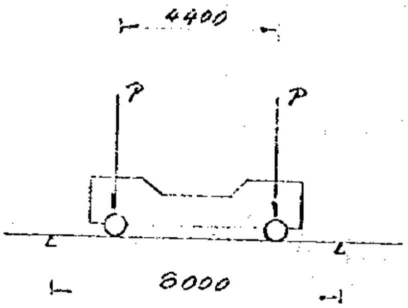
$$132 < \underline{150} < 225 \qquad \underline{\text{OK}}$$

(D) Crane Girder Analysis

(a) Crane load and reaction

Loading conditions

Crane self weight	24 tf
Crane capacity	32 tf
Maximum wheel load	22 tf
Crane span	10.5 m
Total of wheels	4 nos
Vertical impact factor	1.2
Horizontal impact factor	
- for across the rail	0.1
- for along the rail	0.15



$P = 22 \times 1.2 = 26.4$ tf

$a = 4.40$ m

$l = 8.0$ m

$$\text{Mmax} = \frac{P}{8l}(2l-a)^2$$

$$= \frac{26.4}{8 \times 8.0}(2 \times 8.0-4.4)^2 \;= 55.506\; tf\text{ - }m$$

$$Q \quad = P \quad = 26.4 \text{ tf}$$

$$\text{Qmax} = P\left(1+\frac{l-a}{l}\right)$$

$$= 26.\,4\left(1+\frac{8.0-4.4}{8.0}\right) \; 38.28 \text{ tf}$$

(b) Check the Girder depth

Depth required

$$d > \frac{l}{\sqrt{\frac{Cc}{\alpha}\cdot\frac{b}{Wo}}}$$

Ref. Japanese Code of Practice

where:

Cc : 6 kg/cm^2 for rectangular section

α : 1/8 for simple supported beam

l : 800 cm

d : required depth

Wo : average uniform load on girder

$$\text{Wo} = 39.1 + \frac{38280}{400} = 134.8\; kg/cm$$

$$\sqrt{\frac{Cc}{\alpha}\cdot\frac{b}{Wo}} = \sqrt{\frac{6}{1/8}\cdot\frac{100}{134.8}} = 5.967\,; d > \frac{800}{5.976} = 134\,cm$$

Assumed 150 cm

(c) Check the Deflection

de = d1 + d2

where:

de : inmediate deflection
d1 : deflection by crane load
d2 : deflection by girder dead load

The effective moment of inertia according to the code.

$$Ie = (\frac{Mcr}{Ma})^3\ Ig + \left[1 - (\frac{Mcr}{Ma})^3\right] Icr < Ig$$

where:

$$Mcr = \frac{fr}{yt}\ Ig$$

$$fr = 2\sqrt{f'c} = 2\sqrt{210} = 29.0\ kgf / cm^2$$

$$Ig = 100 \text{ x } \frac{150^3}{12} = 0.28125 \text{ x } 10^8\ cm^4$$

$$yt = \frac{150}{2} = 75cm$$

$$Mcr = \frac{29}{75} 0.28125 \text{ x } 10^8 = 108.75\ tf - m$$

$$Md = \frac{Wl^2}{8} = 3.91 \text{ x } \frac{8.0^2}{8} = 31.28\ tf - m$$

Live load is considered to be 50% sustained.

Ma = Md +0.5 Ml

Ml = 55.506 tf-m (See page 10)

Ma = 31.28 + 0.5 x 55.506 = 59.03 tf - m

$$Ec = W^{1.5}\ 0.14\sqrt{f'c}$$

$$= 2300^{1.5}\ 0.14\sqrt{210} = 223{,}784.2\ kgf\ /\ cm^2$$

$$n = \frac{Es}{Ec} = \frac{2.039}{0.222378} = 9.11$$

Moment of inertia of cracked section Icr

$$B = \frac{b}{n\,As}\ ;\ As \text{ assumed } = 0.0033\ bd$$

$$As = 0.0033 \times 100 \times 144 = 47.52\ cm^2$$

$$B = \frac{100}{9.11 \times 47.52} = 0.231$$

$$r = \frac{(n-1)}{n\,As}A's \qquad A's = 0.001 \times 100 \times 144 = 14.4\ cm^2$$

$$= \frac{(9.11-1)\ 14.4}{9.11 \times 47.52} = 0.27$$

$$a = \left[\sqrt{2d\,B\left(1+r\frac{d'}{d}\right)+\left(1+r\right)^2} - \left(1+r\right)\right]\frac{1}{B}$$

$$= \left[\sqrt{2 \times 144 \times 0.231\left(1+0.27\text{x}\frac{6}{144}\right)+\left(1+0.27\right)^2} - 1.27\right]\frac{1}{0.231}$$

$$= 30.433\ \text{ cm}$$

$$Icr = \frac{6a^3}{3} + n\ As\,(d-a)^2 + (n-1)\ A's\,(a-d')^2$$

$$= \frac{100}{3} \times\ 30.433^3 + 9.11 \times 47.52\ (144 - 30.433)^2$$

$$+ (9.11 - 1)\ 14.4\ (30.433 - 6)^2$$

$$= 939535.17 + 5{,}583{,}404.81 + 69{,}716.72 = 6{,}592.66\text{x}10^3$$

$$\frac{Ig}{Icr} = \frac{28{,}125 \times 10^3}{6{,}592.66 \times 10^3} = 4.266$$

$$\frac{Mcr}{Md} = \frac{108.75}{31.28} = 3.477 \quad > 1.0$$

then (Ie)d = Ig

$$\left(\frac{Mcr}{Ma}\right)^3 = \left(\frac{108.75}{59.03}\right)^3 = 6.253$$

$$Ie = \left(\frac{Mcr}{Ma}\right)^3 Ig + \left[1 - \left(\frac{Mcr}{Ma}\right)^3\right] Icr$$

$$= 6.253 \times 0.28125 \times 10^8 + (1 - 6.253) \times 6{,}592.66 \times 10^3$$

$$= 141{,}234.38 \times 10^3 \text{ cm}^4 = 1.4123 \times 10^8$$

Ie > Ig

then take Ig

The inmediate deflection shall be:

$$\delta e = \frac{5}{48} k \frac{Ma\ l^2}{Ec\ Ic}$$

where, k =1.0

$$\delta e = \frac{5}{48} \times 1.0 \times \frac{59.03 \times 800^2 \times 10^2}{223{,}784.2 \times 28{,}125{,}000}$$

$$= 0.0625\text{cm}$$

the long term deflection

$$\delta t = \delta e . \lambda = \frac{\delta e\ \xi}{1 + 50\rho}$$

where:

ξ = 2.0 for more than five years

$$\lambda = \frac{2.0}{1 + 50 \text{ x } 0.001} = 1.905$$

$$\delta t = 1.905 \text{ x } 0.0625 = 0.119 \text{ cm}$$

$$\frac{\delta t}{l} = \frac{0.119}{800} = \frac{1}{6{,}722} < \frac{1}{400} \quad \underline{\text{OK}}$$

according to the Japanese Code of Practice.

$$\delta u = \frac{\Psi}{\alpha y} \delta c$$

where:

$\frac{\Psi}{\alpha y}$ = increasing ratio of long term deflection = 7.5 for outside span

δc = 0.0625 cm

δu = 0.0625 x 7.5 = 0.47 cm $> \delta t$

$$\frac{\delta u}{l} = \frac{0.47}{800} = \frac{1}{1{,}702} \leq \frac{1}{400} \quad \underline{\text{OK}}$$

The inmediate and long term deflections are loss tham the allowable.

d) Bracket design

Loading conditions

- Crane self weight	24 tf
- Crane capacity	32 tf
- Total of wheels	4 nos
- Vertical impact factor	1.2
- Horizontal impact factor	
• Transversal	0.1
• Longitudinal	0.15

1) Compute the factored shear force Vu

$$Vu = 1.4\,D + 1.7\,L$$

$$= 1.4\text{x}\ \frac{24}{4} + 1.7\text{ x }\frac{32}{2} = 35.6\text{ t} \qquad 35.6\text{ tf per wheel}$$

2) Compute the shear by friction reinforcement area Avf

$$Avf = \frac{Vu}{\Phi\ fy\ \mu}$$

where,

Φ : stress reduction factor

fy : yield strength of reinforcement

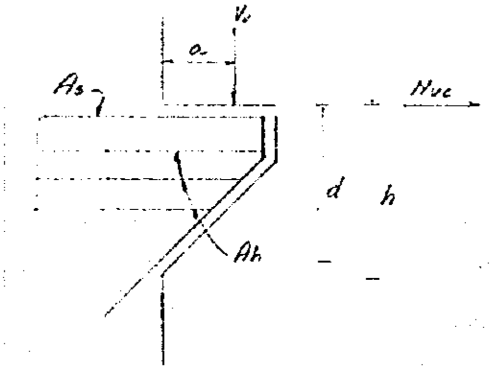
μ : friction coefficient = 1.4

$$Avf = \frac{35600\text{ x }2}{0.85\text{ x }4200\text{ x }1.4} = 14.3\text{ cm}^2$$

3) Compute the reinforcement to resist moment Af

$$Af = \frac{Mu}{\Phi\ fy\ Z} \qquad Z = 0.9\,d$$

$$Mu = Vu\ a + Nuc\,(h\text{-}d)$$



where:

h : total depth

d : effective depth

Nuc : tension factored force

a : shear length

Mu : factored moment

$$Nuc = 0.1\text{ x }35.6\text{ x }2 = 7.12\text{ t}$$

$$Mu = 35.6\text{ x }2\text{ x }0.45 + 7.12\,(2.10 - 1.95)$$

$$= 33.11\text{ t}f\text{- m}$$

$$Af = \frac{3,311,000}{0.85 \times 4,200 \times 0.9 \times 195} = 5.3 \text{ cm}^2$$

4) Compute the tensile force reinforcement An

$$An = \frac{Nuc}{\Phi \, fy}$$

$$= \frac{7,120}{0.85 \times 4,200} = 2.0 \text{ cm}^2$$

5) Compute the primary tension reinforcement As

$As \geq Af + An$

whichever is greater

$As \geq \frac{2}{3} Avf + An$

$As \geq 5.3 + 2.0 = 7.3 \text{ cm}^2$

$As \geq \frac{2}{3} \times 14.3 + 2.0 = \underline{11.5 \text{ cm}^2}$

$$\rho min = 0.04 \frac{f'c}{fy} = 0.04 \times \frac{210}{4200} = 0.002$$

$Asmin = 0.002 \times 90 \times 195 = 35.1 \text{ cm}^2 > 11.5$ 8 Φ 25

6) Compute the reinforcement for parallel shear Ah

$Ah = 0.5 (As - An)$

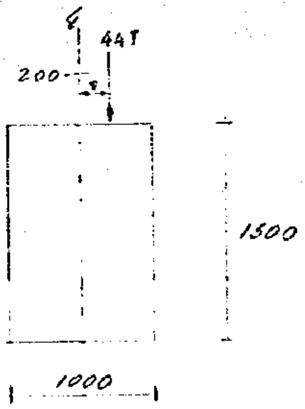
$= 0.5 (35.1 - 2.0) = 16.6 \text{ cm}^2$ 8 Est Φ 12 (18.1 cm^2)

Check: $As + Ah \geq Avf + An + Af$

$35.1 + 16.6 \geq 14.3 + 2.0 + 5.3$

$51.7 \geq 21.6$ <u>OK</u>

(e) Check the crane girder to torsion



$$Tu = (1.4 \times 6 + 1.7 \times 16)\, 0.2$$

$$= 7.12 \text{ t.m}$$

if $Tu < \Phi (0.13 \sqrt{f'c}\ \Sigma x^2 y)$

the torsion effect may be neslected

$$\Phi (0.13 \sqrt{fc'}\ \Sigma x^2 y) = 0.85 (0.13 \sqrt{210} \times 100^2 \times 150)$$

$$= 2{,}401{,}946 \text{ kgf- cm}$$

$$= 24.02 \text{ tf- m} > 7.12$$

then torsion is neslected

(E) Slab reinforcement

From the structural analysis the maximum bending moment for the slab element No.4 is 1,545.4 kg - m at joint No. 27 for load combination No. 1.

$$Mu = 154{,}540 \text{ kgf- cm}$$

$$kn = \frac{154{,}540}{0.9 \times 210 \times 100 \times 12^2} = 0.0568$$

$$\rho = 0.00295 < 0.0033 = \frac{14}{fy}$$

Check with coefficient for one single direction.

$$M_{(-)} = \frac{W\, l\, n^2}{10} \qquad \frac{ln}{lc} = \frac{7.5}{2.94} = 2.55 > 2.0$$

$$WD = 670 \text{ kgf/m}^2$$

$$WL = 180 \text{ kgf/m}^2$$

$Wu = 1.4 \times 670 + 1.7 \times 180$

$= 1,244\ kgf/m^2/m$

$ln_1 = 3.24 - 0.15 \times 2 = 2.94\ m$

$ln_2 = 2.66 - (0.15 + 0.20) = 2.31\ m$

$$ln = \frac{2.94 + 2.31}{2} = 2.625\ m$$

$$Mu = \frac{1244 \times}{10}\ 2.625^2 = 857.2\ \ kg - m$$

$$kn = \frac{Mu}{\Phi f'c\, b\, d^2} = \frac{85720}{0.9 \times 210 \times 100 \times 12^2} = 0.0314$$

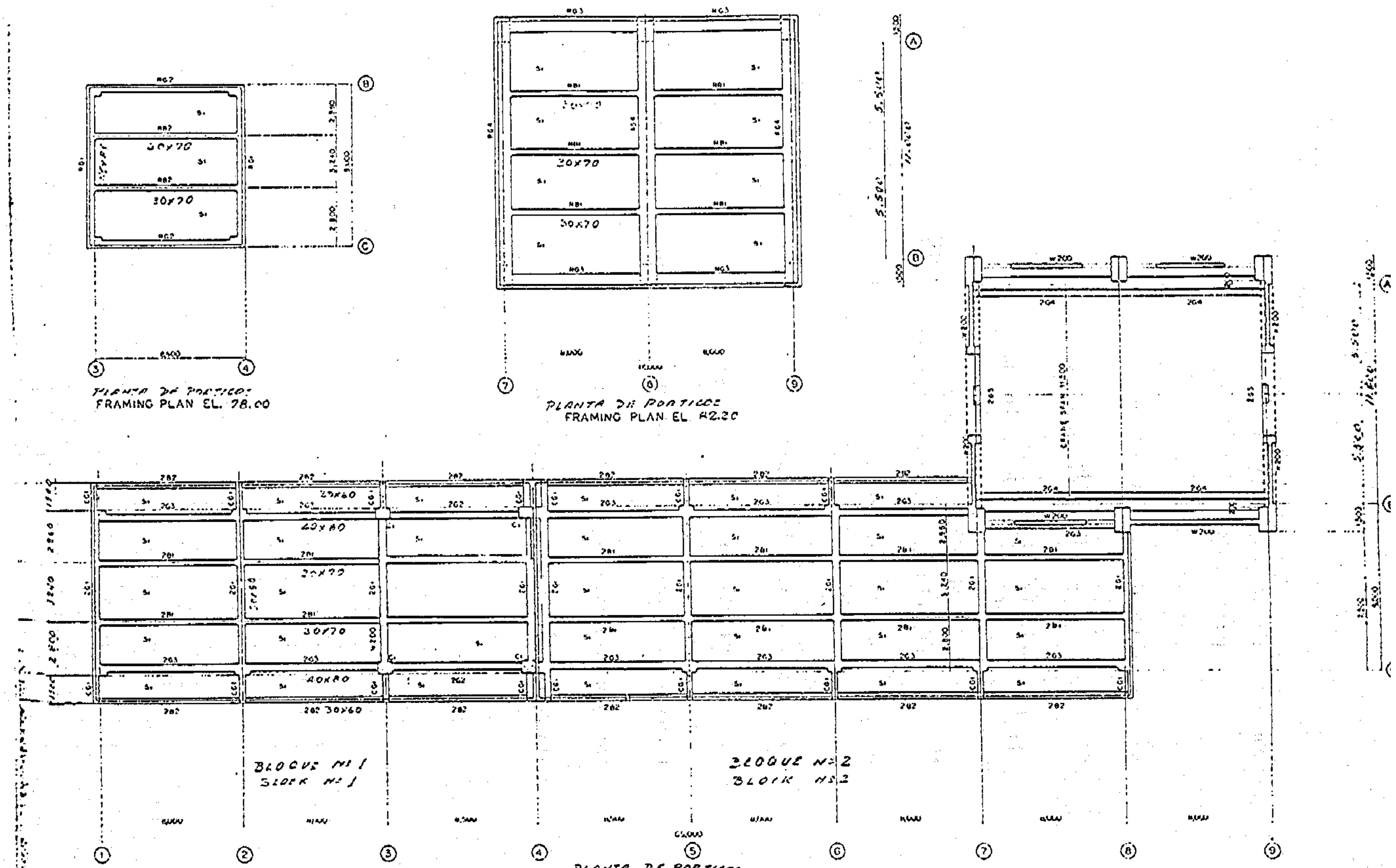
$\rho = 0.0016 < 0.0033$

So assumed the minimum reinforcement

$As = 0.0033 \times 100 \times 12 = 3.96\ cm^2$

For positive reinforcement	5 Φ 10	bottom
For negative reinforcement	5 Φ 12	top

The distribution reinforcement assumed the same.



PLANTA DE PORTICOS
FRAMING PLAN EL. 74.80

FIG. 4.1

1-7-20

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SUPERESTRUCTURA BLOQUE 1 - ANALISIS TRIDIMENSIONAL
SYSTEM
L=4
:
JOINTS
1  X=10.2  Y=0.0  Z=0.0
2          Y=8.0
3          Y=16.0
4          Y=24.1
5  X=1.8   Y=0.0
6          Y=8.0
7          Y=16.0
8          Y=24.1
9  X=12.0  Y=0.0   Z=4.5
10         Y=8.0
11         Y=16.0
12         Y=24.1
13 X=10.2  Y=0.0
14         Y=8.0
15         Y=16.0
16         Y=24.1
17 X=7.7   Y=0.0
18         Y=8.0
19         Y=16.0
20         Y=24.1
21 X=4.46  Y=0.0
22         Y=8.0
23         Y=16.0
24         Y=24.1
25 X=1.8   Y=0.0
26         Y=8.0
27         Y=16.0
28         Y=24.1
29 X=0.0   Y=0.0
30         Y=8.0
31         Y=16.0
32         Y=24.1
:
RESTRAINTS
1,8,1  R=1,1,1,1,1,1
:
POTENTIAL
9,32,1  P=180,180           :Unidades kg / m2
:
FRAME
NM=7  X=0,0,0,0.15   Y=0,0,0.15,0   Z=-1.0
1 SH=R  T=0.6,0.3  E=2.1E9  W=1030         :carga muerta
2 SH=R  T=0.7,0.3                 W=490    :carga muerta
3 SH=R  T=0.8,0.4                 W=740    :carga muerta
4 SH=R  T=0.8,0.5                 W=900    :carga muerta
5 SH=R  T=0.8.0.5                 W=1340   :carga muerta
6 SH=R  T=0.6,0.8                 W=1330   :carga muerta
7 SH=R  T=0.6.0.4                 W=520    :carga muerta
C COLUMNAS
1,1,13   M=6  RE=0,0.8  G=3,1,1,1  LP=2,0
5.5.25   M=6  RE=0,0.8  G=3,1,1,1  LP=2.0
C VIGAS
9,9,10    M=1 RE=0.25,0.25 RZ=0.5 LP=3.0 G=2,1,1,1
12,13,14 M=3 RE=0.25,0.25 RZ=0.5 LP=3.0 G=2,1,1,1
15,17,18 M=2 RE=0.25,0.25 RZ=0.5 LP=3,0 G=2,1,1,1
18,21,22 M=2 RE=0.25,0.25 RZ=0.5 LP=3.0 G=2,1,1,1
21,25,26 M=3 RE=0.25,0.25 RZ=0.5 LP=3.0 G=2,1,1,1
24,29,30 M=1 RE=0.25,0.25 RZ=0.5 LP=3,0 G=2,1,1,1
27,9,13  M=7 RE=0.15,0.15 RZ=0.5 LP=2.0
28,13,17 M=5 RE=0.15,0.15 RZ=0.5 LP=2.0 G=2,1,4,4
31,25,29 M=7 RE=0.15,0.15 RZ=0.5 LP=2.0
```

```
32.10.14 M=7 RE=0.15.0.15 RZ=0.5 LP=2.0
33.14.18 M=4 RE=0.15.0.15 RZ=0.5 LP=2.0 G=2.1.4.4
36.26.30 M=7 RE=0.15.0.15 RZ=0.5 LP=2.0
37.11.15 M=7 RE=0.15.0.15 RZ=0.5 LP=2.0
38.15.19 M=4 RE=0.15.0.15 RZ=0.5 LP=2.0 G=2.1.4.4
41.27.31 M=7 RE=0.15.0.15 RZ=0.5 LP=2.0
42.12.16 M=7 RE=0.15,0.15 RZ=0.5 LP=2.0
43.16.20 M=4 RE=0.15.0.15 RZ=0.5 LP=2.0 G=2.1.4.4
46.28.32 M=7 RE=0.15,0.15 RZ=0.5 LP=2.0
:
SHELL
NM=1  X=0.0.0,0.15  Y=0.0.0.15,0  Z=-1.0  P=0,-1.0
1  E=2.1E9  U=0.15  W=3340
1 JQ=10,14.9.13  ETYPE=2  M=1  TH=0.15.0.15  LP=0
2 JQ=11.15.10.14
3 JQ=12.16,11.15
4 JQ=14,18,13,17
5 JQ=15,19,14.18
6 JQ=16.20,15,19
7 JQ=18,22,17.21
8 JQ=19.23.18.22
9 JQ=20.24.19.23
10 JQ=22,26.21.25
11 JQ=23.27.22.26
12 JQ=24,28.23.27
13 JQ=26,30,25,29
14 JQ=27,31.26.30
15 JQ=28,32.27.31
:
COMBO
1 C=1.4.1.7                :1.4 CM + 1.7 CV
2 C=1.05.1.275.1.40        :1.05 CM + 1.275 CV + 1.4 SY
3 C=1.05.1.275,0.1.40      :1.05 CM + 1.275 CV + 0 SY + 1.4 SX
4 C=0.9,0.1.43             :0.9 CM + 0 CV + 1.43 SY
5 C=0.9,0.0,1.43           :0.9 CM + 0 CV + 0 SY + 1.43 SX
:

END
```

1.2.2 Generator House

(1) STRUCTURAL SYSTEM

The structure is a tridimensions frame conformed by beams and columns. The roof is a reinforced concrete slab supported on beams.

(2) DESIGN CONDITIONS

(A) Loads

(a) Unit weight of materials

Materials	Unit Weight
Concrete, plain	2.30 tf/m^3
Concrete, reinforced	2.40 tf/m^3
Mortar	2.00 tf/m^3
Steel	7.80 tf/m^3

(b) Dead Load

Dead load is the structure self weight.

(c) Seismic Force

Seismic force acting on the structure was computed by the following formulae:

$$F = \Sigma W \cdot kh$$

where:

F = seismic load
ΣW = total dead load
kh = coefficient of horizontal earthquake = 0.15

(B) Factored Loads

The structure and its members were analyzed according to the following factored loads: dead load D and live load L for ultimate strength design.

$$U = 1.4\,D + 1.7\,L$$

Including seismic force E.

$$U = 1.05\,D + 1.275\,L + 1.87\,E$$

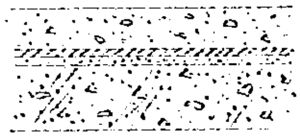
$$U = 0.9\,D + 1.43\,E$$

(3) STRUCTURAL ANALYSIS AND DESIGN

The structural analysis was made with the computer program SAP90 and the design with the program SAPCON.

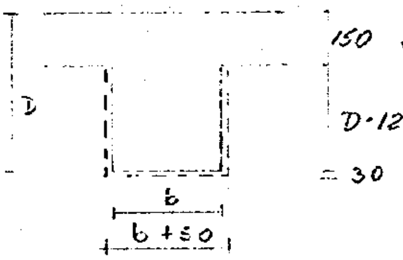
(A) Load Assumption

(a) Roof dead load



- Concrete 8 cm thick	184 kgf/m²
- 3 ply built-up roofing	20 "
- Base mortar 3 cm	60 "
- Concrete slab 15 cm thick	360 "
	624 kgf/m²

(b) Dead load of beams and columns



Weight $= 2.4\,(b + 0.05)\,(D - 0.12)$

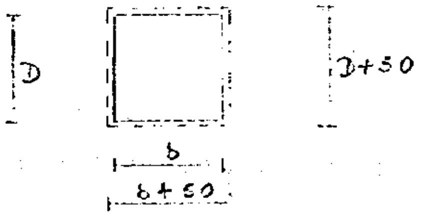
$= 2.4 \times 0.45 \times 0.48$

$= 0.52$ tf/m

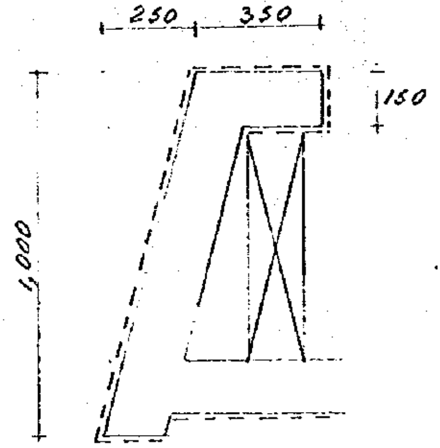
Weight $= 2.4\,(b + 0.05)\,(D + 0.05)$

$= 2.4 \times 0.65 \times 0.65$

$= 1.01$ tf/m



(c) Parapets dead weight



- Concrete	2.4 x 0.15 x 1.03	=	0.47	tf/m
- Concrete block	2.0 x 0.2 x 0.4	=	0.16	"
- Finish	2.0 x 0.03 x 16	=	0.10	"
			0.73	tf/m

Roof live load 180 kg/m^2

(B) Structural Analysis and Reinforcement

The structural model for the analysis has 10 joints, 11 frame type elements and 2 shell bending type elements.

Enclosed are the computer outputs for the structural analysis and the concrete design.

(C) Foundation Design

The foundation allowable bearing capacity was assumed as 15 tf/m^2

For seismic analysis was accepted and increment of 30%.

For plinth design.

P_u = 21.6 T   P = 14.4 T

M_{u1} = 1.06 T-M M_1 = 0.91 T-M

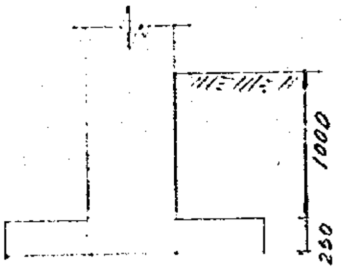
M_{u2} = 4.47 T-M M_2 = 2.98 T-M

Including seismic force.

P_s = 17.97 T

M_1 = 7.31 T-M

M_2 = 3.43 T-M



- backfill 1.0 x 1.7 =1.70 tf/m²
- concrete 0.25 x 2.4 = 0.60

2.30 tf/m²

- qa = . 15 - 2.30 = 12.70 tf/m²

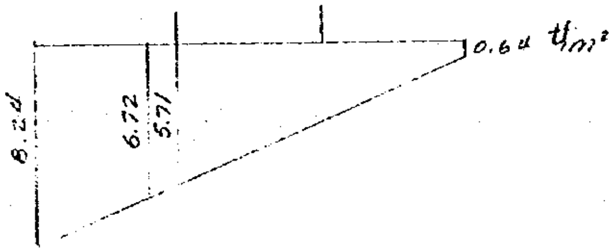
si b x h = 1.8 x 1.8 m

$$\sigma = \frac{14.40}{1.8^2} \pm \frac{(0.71 + 2.98)6}{1.8^3} = 4.44 \pm 3.80 \begin{cases} 8.24 \text{ tf/m}^2 \\ 0.64 \text{ tf/m}^2 \end{cases}$$

σ = 8.24 < 12.70 OK

$$\sigma_s = \frac{17.97}{1.8^2} \pm \frac{(7.31 + 3.43)6}{1.8^3} = 5.55 \pm 11.05 = 16.6 \text{ tf/m}^2$$

σ_s = 16.6 ≈ 12.70 x 1.3 OK.



Si d = 20 cm

Check for shear

$$V = 6.79 \frac{(1.8 + 0.8)}{2} 0.5 = 4.41 \text{ tf}$$

$$vc = \frac{Vu}{\phi bd} < 1.06 \sqrt{f'c}$$

$$vc = \frac{4410 \times 1.5}{0.85 \times 80 \times 20} = 4.86 \text{ kgf/cm}^2 < 15.36 \text{ OK}$$

Compute the reinforcement.

$$M \;=\; 5.71 \times \frac{0.6^2}{2} + 2.53 \times \frac{0.6^2}{3}$$

$$\;=\; 1.33 \text{ T-M/M}$$

$$kn \;=\; \frac{Mu}{\phi f'c\, bd^2} = \frac{133{,}000 \times 1.5}{0.9 \times 210 \times 100 \times 20^2} \;=\; 0.0264$$

$$\rho \;=\; 0.00135 \;<\; \rho\text{min}$$

Asmin = 0.0033 x 100 x 20 = 6.6 cm^2/m

1 Ø 12 @ 150 each direction.

1.3 Utility

SEVERINO PUMPING STATION

CONDUCTOR CALCULATION

1. LIGHTING PANEL "A"

TOTAL (VA) LOAD = 37,680 VA

$$I = \frac{37{,}680 \text{ VA}}{\sqrt{3} \text{ x } 220 \text{ V}}$$

$= 98.9$ Amp

From "CABLEC" Catalog, we need a 2 x (4 x 4 AWG) cable
or 4C x 22 mm^2 x 2 cable

Voltage drop:

$$\Delta V\ (\%) = K \text{ x } KVA \text{ x } L\ (m)$$

(See next table)

$$K_{220} = K_{440}\left(\frac{440}{220}\right)^2 = K_{440} \text{ x } 4$$

$$\Delta V\ (\%) = \frac{4.69}{2} \text{ x } 10^{-4} \text{ x } 4 \text{ x } 37.68 \text{ KVA x } 26 \text{ m}$$

$= 0.92\ \%$ (The 4 AWG conductor is OK)

2. LIGHTING PANEL "B"

Total (VA) load = 14,240 VA

$$I = \frac{14{,}240 \text{ VA}}{\sqrt{3} \text{ x } 220 \text{ V}} = 37.4 \text{ Amp.}$$

From "CABLEC" Catalog, conductor 4 x 4 AWG Cable or
4C x 22 mm^2 Cable

DESCRIPCION TRABAJO FACTORES PARA CALCULO DE REGULACION DE REDES AEREAS Y SUBTERRANEAS

TENSION: 440V - Sistema Trifásico
60 Hz

COS ϕ: 0.9

UNIDADES: % /KVA-METRO

CALIBRE AWG MCM / mm²	CONDUCTORES DE ALUMINIO (Aislamiento termoplástico)		CONDUCTORES DE COBRE (Aislamiento Termoplástico)	
	AEREO (20°C)	SUBTERRANEO (30°C)	AEREO (20°C)	SUBTERRANEO (THW 75°C)
8 / 8,37			$12,8 \times 10^{-4}$	$12,16 \times 10^{-4}$
6 / 13,30	$10,38 \times 10^{-4}$		$7,94 \times 10^{-4}$	$7,63 \times 10^{-4}$
4 / 21,15	$7,21 \times 10^{-4}$		$4,69 \times 10^{-4}$	$4,38 \times 10^{-4}$
2 / 33,63	$4,8 \times 10^{-4}$		$3,22 \times 10^{-4}$	$2,82 \times 10^{-4}$
1 / 42,41	$3,94 \times 10^{-4}$		$2,7 \times 10^{-4}$	$2,3 \times 10^{-4}$
1/0 / 53,48	$3,26 \times 10^{-4}$		$2,27 \times 10^{-4}$	$1,83 \times 10^{-4}$
2/0 / 67,43	$2,71 \times 10^{-4}$		$1,94 \times 10^{-4}$	$1,5 \times 10^{-4}$
3/0 / 85,03	$2,28 \times 10^{-4}$		$1,66 \times 10^{-4}$	$1,26 \times 10^{-4}$
4/0 / 107,2	$1,93 \times 10^{-4}$		$1,44 \times 10^{-4}$	$1,05 \times 10^{-4}$
250 / 126,7				$0,75 \times 10^{-4}$
300 / 152				$0,66 \times 10^{-4}$
350 / 177,4				$0,59 \times 10^{-4}$
400 / 202,7				$0,54 \times 10^{-4}$
500 / 253,10				$0,47 \times 10^{-4}$
1000				$0,2755 \times 10^{-4}$

$$\Delta V(\%) = K \times KVA \times L(m)$$

$$K = \frac{R\cos\phi + X\,\mathrm{sen}\,\phi}{10\,(V)^2}$$

$$K_{440} = K_{208}\left(\frac{208}{440}\right)^2$$

$$\boxed{K_{440} = K_{208} \times (0.22)}$$

$$K_{480} = K_{440} \times \left(\frac{440}{480}\right)^2$$

INGETEC S.A. INGENIEROS CONSULTORES	Preparado	Revisado	Fecha	
	A.M.G.		VII-23-90	Hoja 1 de 1

Voltage drop

$$\Delta V (\%) = 4.69 \times 10^{-4} \times 4 \times 14.24 \text{ KVA} \times 27 \text{ m}$$

$$= 0.7 \% \quad \text{(The AWG Conductor is OK)}$$

3. LIGHTING PANEL "C"

Total (VA) load = 4,500 VA

$$I = \frac{4{,}500 \text{ VA}}{\sqrt{3} \times 220 \text{ V}} = 11.8 \text{ Amp.}$$

From "CABLEC" Catalog, conductor 4 x 14 AWG

but shall use 4 x 12 AWG Cable

or 4C x 3.5 mm^2 Cable

Voltage drop:

$$\Delta V (\%) = 30.4 \times 10^{-4} \times 4 \times 4.5 \text{ KVA} \times 7 \text{ m}$$

$$= 0.38 \% \quad \text{(The 12 AWG conductor is OK)}$$

4. OUTDOOR LIGHTING

400W Mercury luminaires: (450 VA each)

Voltage drop:

$$\Sigma \text{KVA} \times l \quad = \text{KVA virtual} \times l_5$$

$$\text{KVAvirt.} \quad = \frac{10 \times 450 \ + \ 23 \times 450 \ + \ 41 \times 450 \ + \ 59 \times 450 \ + \ 81 \times 450}{81}$$

$$= \frac{450 \times 214}{81} \ = \ 1{,}189 \text{ VA}$$

For 10 AWG conductor:

$$K \qquad = \left(\frac{440}{220} \times \sqrt{3}\right)^2 \ = \ 12$$

$$\Delta V\,(\%) \quad = 18.37 \times 10^{-4} \times 12 \times 1.19 \text{ KVA} \times 81 \text{ m}$$

= 2.12 % (the 10 AWG conductor is OK)

Then, it shall be used: 2 x 10 AWG Cable
or 2C x 5.5 mm^2 Cable

SEVERINO PUMPING STATION

LIGHTING DESIGN

Lighting system is designed to obtain the functional and economical features as well as easy maintenance. From these points, locations of lighting fixtures and arrangement of circuit are determined adequately for both normal use system and the emergency system required in the pump station.

1. CONTROL ROOM

- Illumination level: 500 lux
- Area: 10.7 x 8.1 = 86.7 m^2
- Mounting height = 3.40 m
- Luminaire, Type D-1: Ceiling flush mounted fluorescent light with acrylic cover, 40 W x 2 (see drawings)

The minimum recommended illumination level, agree with the IES, Illuminating Engineering Society, for Central Station Indoor Locations, in the case of Control Rooms, vertical face of switchboards (Single or Section of duplex facing operator) for Type A-Large centralized control room at 66 inches above floor is 500 lux.

Type B-Ordinary control room at 66 inches above floor is 300 lux.

We shall use, 500 lux at 66" above floor, then:

$$\text{Room Ratio} = \frac{\text{Width x Length}}{\text{Work plane to mountain height (Width + Length)}} \, *$$

$$= \frac{8.1 \times 10.7}{(3.40 - 1.67)\ (8.1 + 10.7)}$$

$$= 2.66$$

* From: IES LIGHTING HANDBOOK
WESTINGHOUSE LIGHTING HANDBOOK (Westinghouse Electric Co. USA 1978).

For: Ceiling reflectance 80%
Walls reflectance 50%
Floor reflectance 10%

We get from tables for the above luminaire the COEFFICIENT OF UTILIZATION (CU);
CU = 0.6, and
Maintenance Factor = 0.7

Then:

$$\text{Required Lumens} = \frac{\text{Desired Illumination x Area}}{\text{Coefficient of Utilization x Maintenance Factor}}$$

$$= \frac{500 \times 86.70}{0.6 \times 0.7}$$

$$= 103{,}214 \text{ lumens}$$

$$\text{Number of lamp} = \frac{\text{Required Lamp Lumens}}{\text{Rated Initial Lamp Lumens **}}$$

** From OSRAM Catalog for 40W Lamp, 1.2 m length, cool white, 38 mm bulb diameter: 3000 lumens.

$$\text{Number of lamps} = \frac{103{,}214}{3{,}000} =$$

$$= 34.4 \quad (35)$$

Number of luminaires = 18 luminaire of 40 W x 2

2. OFFICE ROOM

- Illumination Level : 200 lux
- Area = 7.2 x 6.3 = 45.36 m^2
- Mounting height = 3.0 m
- Luminaire, Type D-1, 40 W x 2

$$RR = \frac{6.30 \times 7.20}{(3.0 - 0.76)(6.3 + 7.2)} =$$

$$= 1.5$$

From tables:

Maintenance factor = 0.7
Coefficient of utilization = 0.45

$$\text{Required lumens} = \frac{200 \times 45.36}{0.45 \times 0.7}$$

$$= 28{,}800 \text{ lumens}$$

$$\text{Number of lamps} = \frac{28{,}800}{3{,}000} =$$

$$= 9.6 \text{ (use 10)}$$

Number of luminaires = 5 (Use 6 for a better arrangement) 6 luminaire 40W x 2

3. CONFERENCE ROOM

- Illumination level : 200 lux
- Area = 5.3 x 6.2 = 32.86 m^2
- Mounting height = 3.0 m
- Luminaire, Type D-1, 40 W x 2

$$RR = \frac{5.3 \times 6.2}{(3.0 - 0.76)\ (5.3 + 6.2)}$$

$$= 1.28$$

From tables:

Maintenance factor = 0.7
Coefficient of utilization = 0.42

Required lumens $= \dfrac{200 \times 32.86}{0.42 \times 0.7}$

= 22,345 lumens

Number of lamps $= \dfrac{22,354}{3,000} =$

= 7.5 (use 8)

Number of luminaires = 4 luminaire 40 W x 2

4. MANAGER ROOM

- Illumination level : 200 lux
- Area = 3.6 x 5.4 = 19.44 m^2
- Mounting height = 3.0 m
- Luminaire, type D-1, 40 W x 2

$$RR = \frac{3.6 \times 5.4}{(3.0 - 0.76)(3.6 + 5.4)} =$$

= 0.96

From tables:

Maintenance factor = 0.7
Coefficient of utilization = 0.43

Required lumens $= \dfrac{200 \times 19.44}{0.43 \times 0.7}$

= 12,917 lumens

Number of lamps $= \dfrac{12,917}{3,000} = 4.3$ (use 4)

Number of luminaires = 2 luminaire 40 W x 2

1-3-7

5. STORAGE ROOM

- Illumination level : 200 lux
- Area = 4.6 x 14.0 = 64.4 m^2
- Mounting high = 3.5 m
- Luminaire, type A-2, pipe pendant fluorescent light, 40 W x 1 (see drawings)

$$RR = \frac{4.6 \times 14.0}{(3.5 - 0.76)(4.6 + 14.0)} =$$

$$= 1.26$$

From tables:

Maintenance factor = 0.7
Coefficient of utilization = 0.532

$$\text{Required lumens} = \frac{200 \times 64.4}{0.532 \times 0.7}$$

$$= 30{,}263 \text{ lumens}$$

$$\text{Number of lamps} = \frac{30{,}263}{3{,}000} = 10.08 \text{ (use 10) luminaire 40 W x 1}$$

6. LOW TENSION SWITCHGEAR ROOM AND HIGH TENSION SWITCHGEAR ROOM

- Illumination level; Front of panels: 200 lux
  Rear of switchboard panels: 100 lux
- Area front of panels = 2.3 x 24.4 = 56.12 m^2
- Mounting height = 3.5 m
- Luminaire, type A-1, pipe pendant fluorescent light 40 W x 2 (see drawings)

$$RR = \frac{2.3 \times 24.4}{(3.5 - 0.76)(2..3 + 24.4)} =$$

$$= 0.77$$

From tables:

Maintenance factor = 0.8
Coefficient of utilization = 0.38

$$\text{Required lumens} = \frac{200 \times 56.12}{0.38 \times 0.8}$$

$$= 36{,}921$$

$$\text{Number of lamps} = \frac{36{,}921}{3{,}000} = 12.3 \text{ (use 12)}$$

Number of luminaires = 6 luminaire 40 W x 2

- Area rear of panels = 2.3 x 24.4 = 56.12 m^2
- Mounting height = 3.5 m
- Luminaire, type A-2, 40 W x 1

$$RR = \frac{2.3 \times 24.4}{(3.5 - 0.76)(2..3 + 24.4)} =$$

$$= 0.77$$

From tables:

Maintenance factor = 0.8
Coefficient of utilization = 0.38

$$\text{Required lumens} = \frac{100 \times 56.12}{0.38 \times 0.8}$$

$$= 18{,}461$$

$$\text{Number of lamps} = \frac{18{,}461}{3{,}000} = 6.15 \text{ (use 6)}$$

Number of luminaires = 6 luminaire 40 W x 1

7. REPAIR SHOP

- Illumination level : 250 lux
- Area repair shop (1) = Area repair shop (2) = 6.0 x 6.2 = 37.2 m^2
- Mounting height = 3.5 m
- Luminaire, type A-1, 40 W x 2

$$RR = \frac{6.0 \times 6.2}{(3.5 - 0.76)(6.0 + 6.2)} =$$

$$= 1.11$$

From tables:

Maintenance factor = 0.8
Coefficient of utilization = 0.491

$$\text{Required lumens} = \frac{250 \times 37.2}{0.491 \times 0.8}$$

$$= 23{,}676$$

$$\text{Number of lamps} = \frac{23{,}676}{3{,}000}$$

= 7.9 (use 8)

Number of luminaires = 4 luminaire 40 W x 2

8. MOTOR FLOOR

- Illumination level : 200 lux
- Area = 10 x 47 = 470 m^2
- Mounting height = 18 m
- Luminaire, type G, Pipe pendant mercury light with open industrial dome reflector, 400 W x 1 (See drawings).

$$RR = \frac{10 \times 47}{(18 - 0.76)(10 + 47)} =$$

$$= 0.478$$

From tables:

Maintenance factor = 0.55
Coefficient of utilization = 0.31

$$\text{Required lumens} = \frac{200 \times 470}{0.31 \times 0.55}$$

$$= 511{,}320$$

$$\text{Number of lamps} = \frac{551{,}320}{23{,}000\ *}$$

= 23.9 (use 24) luminaire 400W x 1

* From OSRAM catalog.

9. PLATFORM

- Illumination level : 250 lux
- Area = 7.1 x 11.0 = 78.1 m^2
- Mounting height = 10.4 m
- Luminaire, type G, 400 W x 1 mercury light

$$RR = \frac{7.1 \times 11.0}{(10.4 - 0.76)(7.1 + 11.0)}$$

$$= 0.448$$

From tables:

Maintenance factor = 0.55
Coefficient of utilization = 0.29

$$\text{Required lumens} = \frac{250 \times 78.1}{0.29 \times 0.55}$$

$$= 122{,}414$$

$$\text{Number of lamps} = \frac{122{,}414}{23{,}000} = 5.3 \text{ (use 6)}$$

Number of luminaires = 6 luminaire 400 W x 1

10. ERECTION BAY

- Illumination level : 250 lux
- Area = 6.8 x 11.0 = 74.8 m^2
- Mounting height = 25.4 m
- Luminaire, type G, 400 W x 1 mercury light

$$RR = \frac{6.8 \times 1.1}{(25.4 - 0.76)(6.8 + 11.0)}$$

$$= 0.17$$

From the tables is not possible to get by interpolation the coefficient of utilization because the Room Ratio is too low. So, because this area is very similar to the Platform area, shall use also 6 luminaires, mercury light 400 W x 1.

11. 138 KV SWITCHYARD

- Illumination level: 20 lux
- Luminaire, type H, Mercury light pole mounted, 400W x 1
- Pole height: 8.0 m Mounting height, (see drawings)
- Bracket length: 1.2 m

The luminaire layout in the switchyard is:

We are going to calculate the spacing, the coefficient of utilization and the uniformity.

The equation for average illumination is:

$$fc = \frac{(LL)\,(MF)\,(CU)}{(W) \times (S)}$$

fc = Illumination in lux

LL = Rated initial lamp lumens

MF = Maintenance factor

CU = Coefficient of utilization

W = Street width

S = Spacing of luminaires

Where:

fc = 20 lux

LL = 23,000 lumens*

MF = 0.7

W = 26 m

* From OSRAM catalog for 400W mercury light.

Ratio - Street side (SS)

$$\frac{\text{Transverse distance}}{\text{Mounting height}} = \frac{26 - 1.2}{8} = 3.1$$

1-3-13

Ratio-House Side (HS)

$$\frac{\text{Transverse distance}}{\text{Mounting height}} = \frac{1.20}{8} = 0.15$$

From the utilization curve (see next page "The Photometric Data for Roadway Lighting Luminaires" that we assume for the luminaire.

Then:

Ratio 3.1 street side, corresponds to CU = 58%

Ratio 0.15, house side, corresponds to CU = 2%

Total CU = 60%

The spacing $S = \frac{(LL)(MF)(CU)}{(fc)(W)}$

$$= \frac{23.000 \times 0.7 \times 0.6}{20 x 26}$$

$$= 18.6 \text{ m}$$

The uniformity

The uniformity of illumination is expressed in terms of a ratio of:

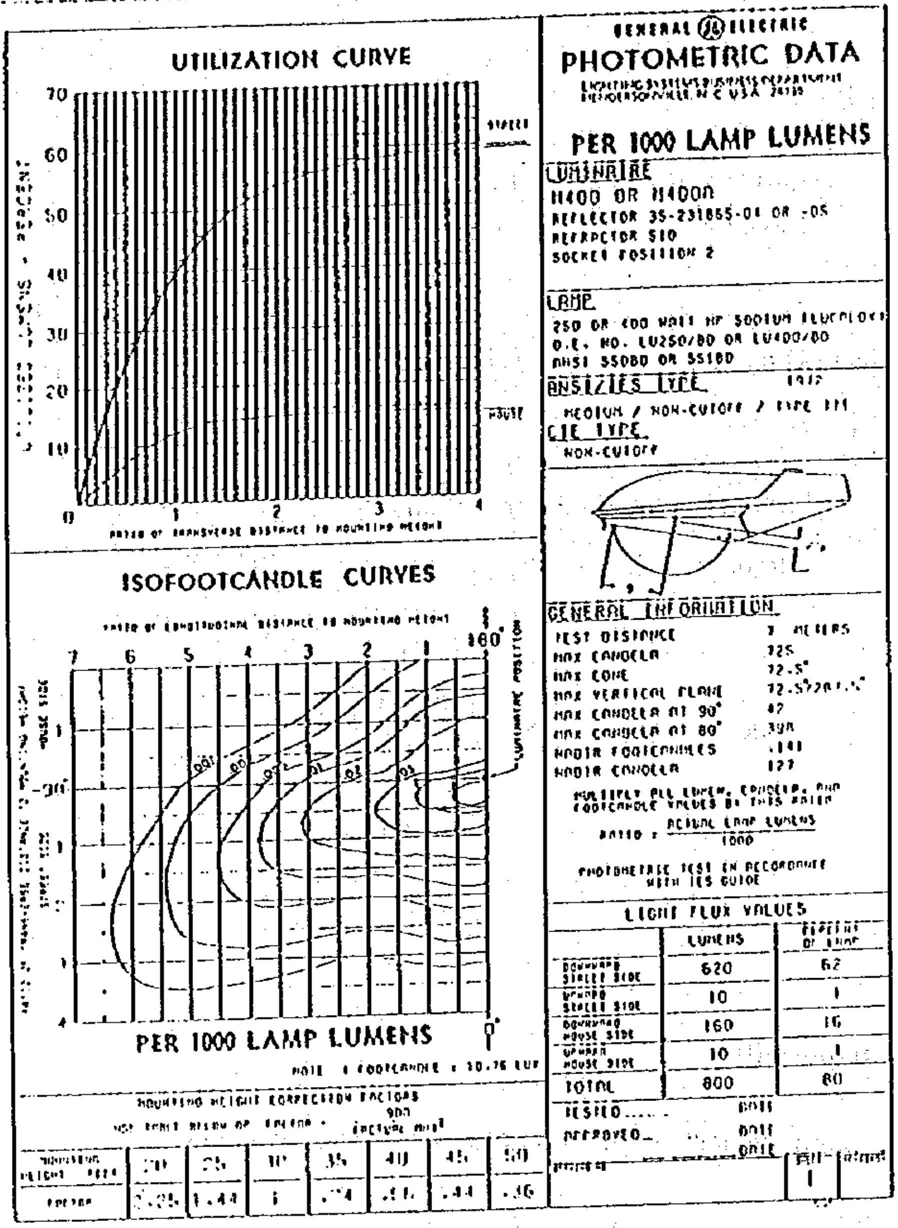
$$\text{Uniformity} = \frac{\text{Average fc}}{\text{Minimum fc}}$$

The minimum value of the illumination can be found by studying the isofootcandle diagram and taking into account all luminaires that are contributing significant amounts of light.

Illumination contributions will be considered from luminaires labeled A, B, C and D as shown above in the figure. Prints on the switchyard labeled P_1, P_2, P_3, P_4 and P_5 will be checked for a minimum footcandle (lux) value.

First, determine both transverse and longitudinal ratios of distance -to- mounting height relative to each of the luminaires.

1-3-14



GENERAL ELECTRIC

PHOTOMETRIC DATA

LIGHTING SYSTEMS BUSINESS DEPARTMENT
HENDERSONVILLE, N.C. USA 28739

PER 1000 LAMP LUMENS

LUMINAIRE

M400 OR M400A
REFLECTOR 35-231855-01 OR -05
REFRACTOR 510
SOCKET POSITION 2

LAMP

250 OR 400 WATT HP SODIUM LUCALOX
G.E. NO. LU250/BD OR LU400/BD
ANSI S50BD OR S51BD

ANSI/IES TYPE 1972
MEDIUM / NON-CUTOFF / TYPE III

CIE TYPE
NON-CUTOFF

GENERAL INFORMATION

TEST DISTANCE	7 METERS
MAX CANDELA	725
MAX CONE	72.5°
MAX VERTICAL PLANE	72.5°/20.5°
MAX CANDELA AT 90°	47
MAX CANDELA AT 80°	398
NADIR FOOTCANDLES	.141
NADIR CANDELA	127

MULTIPLY ALL LUMEN, CANDELA, AND FOOTCANDLE VALUES BY THIS RATIO

$$\text{RATIO} = \frac{\text{ACTUAL LAMP LUMENS}}{1000}$$

PHOTOMETRIC TEST IN ACCORDANCE WITH IES GUIDE

LIGHT FLUX VALUES

	LUMENS	PERCENT OF LAMP
DOWNWARD STREET SIDE	620	62
UPWARD STREET SIDE	10	1
DOWNWARD HOUSE SIDE	160	16
UPWARD HOUSE SIDE	10	1
TOTAL	800	80

TESTED ...... DATE

APPROVED ...... DATE

DATE

SHT 1

MOUNTING HEIGHT CORRECTION FACTORS

$$\text{USE CURVE BELOW OR FACTOR} = \frac{900}{(\text{ACTUAL MH})^2}$$

MOUNTING HEIGHT FEET	20	25	30	35	40	45	50
FACTOR	2.25	1.44	1	.74	.56	.44	.36

Fig. 5

The light contributed by each fixture is cumulative at the point in question.

In the above chart, using the Distance/Mounting height ratios tabulated as coordinates, corresponding illumination values can now be read from the isofootcandle curve and are also tabulated in the chart.

CONTRIBUTING LUMINAIRES	DISTANCE/MOUNTING HEIGHT RATIOS FOR TEST POINTS										ILLUMINATION AT TEST POINTS				
	TRANSVERSE RATIO					LONGITUDINAL RATIO									
	P_1	P_2	P_3	P_4	P_5	P_1	P_2	P_3	P_4	P_5	P_1	P_2	P_3	P_4	P_5
A	-0.15	3.1	3.1	3.1	1.5	1.12	1.12	2.35	0	1.12	0.1	.0011	.0008	.001	.015
B	-0.15	3.1	3.1	3.1	1.5	1.12	1.12	0	2.35	1.12	0.1	.0011	.001	.0008	.015
C	3.1	-0.15	-0.15	-0.15	1.5	1.7	1.75	2.9	0.5	1.75	.0008	.07	.012	.2	.015
D	3.1	-0.15	-0.15	-0.15	1.5	2.3	2.25	1.1	3.4	2.25	.0008	.022	.05	.006	0.13
						TOTALS					.2016	.0942	.0638	.2078	.058

Note: Negative transverse ratios signify "House Side".

The lowest total footcandle value is chosen from the chart. This value is 0.058 and is located at P5, then:

FCmin = (fc) (LF) (MF) (CF)

Fcmin = Minimum point footcandles

fc = Total value from the chart

LF = Lamp factor

MF = Maintenance factor

CF = Mounting height correction factor

Where:

fc = 0.058 footcandles

Mf = 0.7

LF : because the values on the photometric curve have been adjusted to represent a lamp producing 1,000 lumens inside the luminaire, so we have the ratio:

$$LF = \frac{\text{Actual Lamp Lumens}}{1,000} = \frac{23,000}{1,000} = 23$$

1-3-16

CF : Also the values on the photometric curve are for a mounting height of 30 feet.

$$CF = \frac{900}{(\text{Actual MH})^2} = \frac{900}{(8/0.3048)^2} = 1.306$$

$$FCmin = 0.058 \times 23 \times 0.7 \times 1.306$$

$$= 1.22 \text{ footcandle}$$

$$1 \text{ footcandle} = 10.76 \text{ lux}$$

$$FCmin = 1.22 \times 10.76$$

$$= 13.13 \text{ lux}$$

Then:

$$\text{Uniformity} = \frac{20 \text{ lux}}{13.13 \text{ lux}}$$

$$= 1.52$$

12. MAIN TRANSFORMERS YARD

- Illumination level : 20 lux
- Luminaire, type H, Mercury light pole mounted, 400W x 1
- Pole height: 8.0 m, Mounting height (See drawings)
- Bracket length: 1.2 m

The luminaire layout in the transformers yard is:

Ratio - Street Side (SS) $= \dfrac{15 - 1.2}{8} = 1.725$

Ratio - House Side(HS) $= \dfrac{1.20}{8} = 0.15$

Maintenance Factor = 0.7, and from the "utilization curve"

Ratio 1.725 (SS), corresponds to CU = 52%

Ratio 0.15 (HS), corresponds to CU = <u>2 %</u>

Total CU = 54%

The spacing:

$$S = \frac{(LL)(MF)(CU)}{(fc)(W)}$$

Then:

$$= \frac{23{,}000 \times 0.7 \times 0.54}{20 \times 16}$$

=27 m (20 m is OK.)

The uniformity: (using the isofootcandle curve of the photometric data)

CONTRIBUTING LUMINAIRES	DISTANCE/MOUNTING HEIGHT RATIOS FOR TEST POINTS								ILLUMINATION OF TEST POINTS			
	TRANSVERSE RATIO				LONGITUDINAL RATIO							
	P_1	P_2	P_3	P_4	P_1	P_2	P_3	P_4	P_1	P_2	P_3	P_4
A	-0.15	1.75	1.75	1.75	3.8	0	2.5	3.8	0.004	0.01	0.008	0.007
B	-0.15	1.75	1.75	1.75	1.25	2.5	0	1.25	0.05	0.008	0.01	0.009
C	-0.15	1.75	1.75	1.75	1.25	5	2.5	1.25	0.05	0.003	0.008	0.009
							TOTALS		0.104	0.021	0.026	0.025

FCmin = (fc) (LF) (MF) (CF)

fc = 0.021

LF $= \dfrac{23{,}000}{1{,}000} = 23$

1-3-18

MF $= 0.7$

CF $= \dfrac{900}{(8/0.3048)^2} = 1.306$

Fcmin $= 0.021 \times 23 \times 0.7 \times 1.306$

$= 0.442$ footcandles

FCmin $= 0.442 \times 10.76$

$= 4.76$ lux

Then:

$$\text{Uniformity} = \frac{20 \text{ lux}}{4.76 \text{ lux}}$$

$$= 4.2$$

1-3-19

SEVERINO PUMPING STATION

EARTHING SYSTEM

1. SHORT CIRCUIT CALCULATION

From information supplied by INECEL (Instituto Ecuatoriano de Electrificación) from their load flow and short circuit studies, done in September 1994 for the horizontal year of 2010; in which the Daule-Peripa power house was included in maximum demand condition.

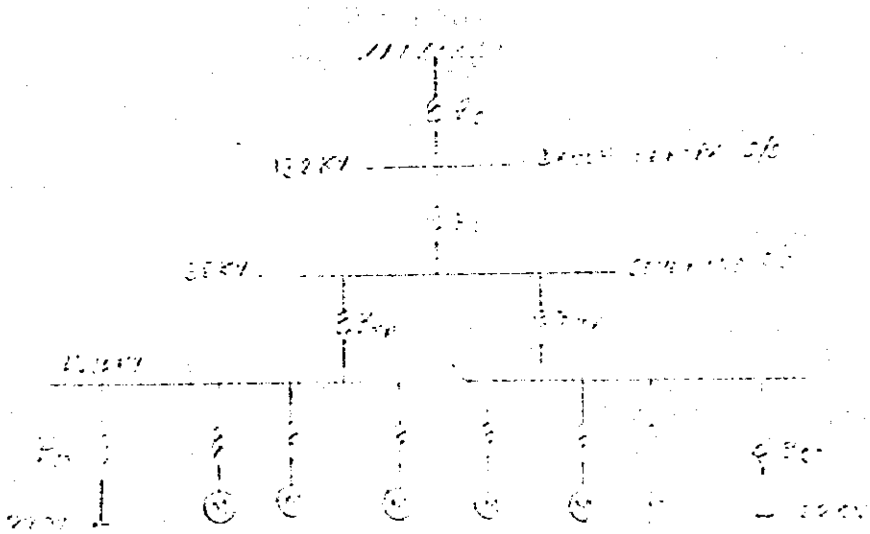
The values given by INECEL for a short-circuit in the 138 kV bus at Daule-Peripa substation are:

$Z_1 = 0.0878^{\cdot} \underline{|84.56°}$ and

$Z_0 = 0.0456^{\cdot} \underline{|88.05°}$

in a 100 MVA base and 138 KV base system.

The one line diagram of this Project is the following:



1-3-20

a) System impedance

$$Zs = 0.0878 \underline{\angle 84.56^\circ}$$

$$Zs = 0.00832 + j\,0.0874$$

b) Transmission line

- 138 KV
- 32 km
- Conductor: Oriole, 336.4 MCM, 170 mm^2, 18.83 mm diam.

$$GMD = \sqrt[3]{6.135 \times 6.135 \times 4.0}$$

$$= 5.32 \text{ m}$$

$$X_L = Xa + Xd$$

$$= (0.445 + 0.346) \text{ ohm/mile}$$

$$= 0.791 \text{ ohm/mile}$$

$$= 0.491 \text{ ohm/km}$$

$$X_L = j\,15.712 \text{ ohm} \quad ; \qquad z(pu) = \frac{z\,(ohm) \times KVA_B}{(KV_B)^2 \times 1000}$$

$$X_L\,pu = \frac{15.712 \times 100.000}{(138)^2 \times 1000}$$

$$X_L\,pu = j\,0.082$$

c. Main transformers

- 10 MVA , 138/4.16 KV
- $X_{TR} = 10\%$

$$X_{TR} = j\,0.1 \times \frac{100}{10}$$

$$X_{TR} = j\,1.0\,(pu)$$

1-3-21

d) Service transformers

- 300 kva , 4160 - 220/127 V
- $X_{ST} = 5\%$

$$X_{ST} = j\,0.05 \times \frac{100}{0.3}$$
$$= j\,16.7\ (pu)$$

e) Motors

- 2400 kW, 3217 HP, 4.16 KV
- $Xd'' = 20\%$

$X_M = 1.5\ Xd''$

(The capacity of the motor shall be the power in HP)

KVA = (1.0) x (HP)

$$X_M = 1.5 \times 0.2 \times \frac{100}{3.217}$$

$$X_M = j\,9{,}325\ (pu)$$

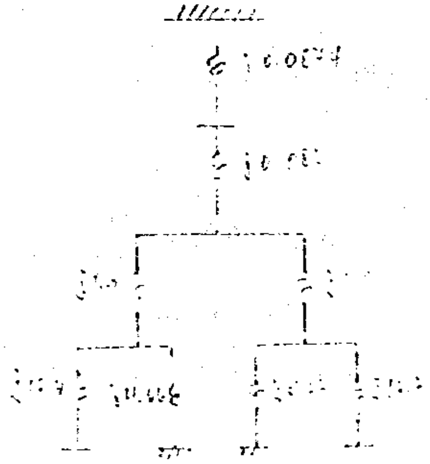
The motors shall operate three in one bus and two in the other bus. One motor always will be in stand-by.

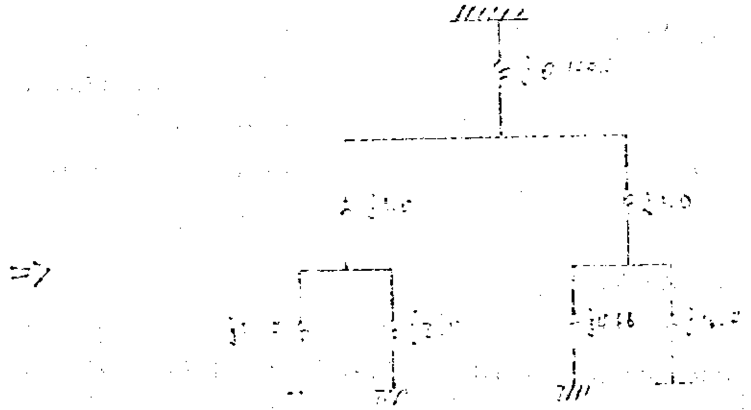
Then:

$$X_{M1} = j\,\frac{9.325}{3}$$
$$X_{M1} = j\,3.111\ (pu)$$
$$X_{M2} = j\,\frac{9.325}{2}$$
$$X_{M2} = j\,4.66\ (pu)$$

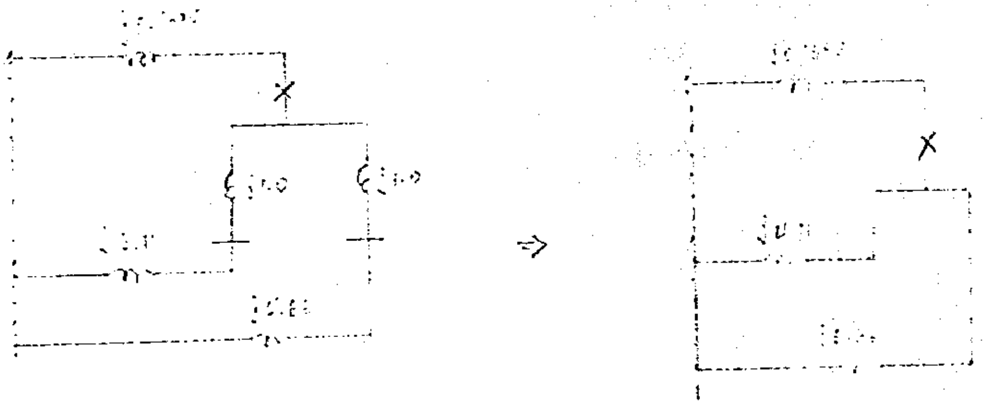
1-3-22

Then, the reactances diagram:

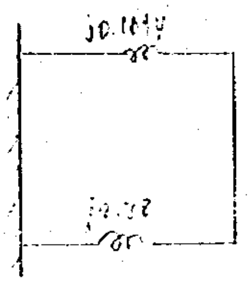




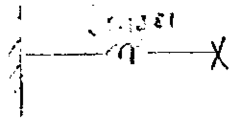
1.1 Short-circuit on Severino s/s in 138 KV Bus



1-3-23



$$Xeq = \frac{4.11 \text{ x } 5.66}{4.11 + 5.66} = 2.38$$



$$Xeq = \frac{2.38 \text{ x } 0.1694}{2.38 + 0.1694} = 0.1581$$

$$\text{MVA sc } 3\Phi = \frac{100.0}{0.1581} = 632.5 \text{ MVA}$$

$$\text{I sc } 3\Phi = \frac{1.0}{0.1581} = 6.325 \text{ (pu)}$$

$$\text{I (AMP)} = \text{I (pu) x } I_B$$

$$I_B = \frac{MVA_B}{\sqrt{3}\, KV_B}$$

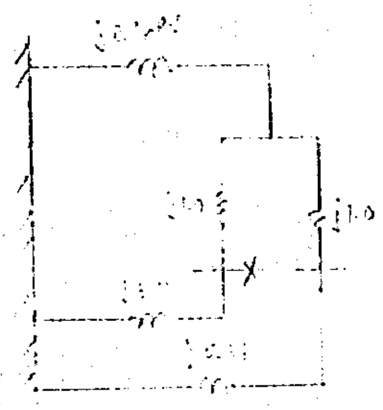
$$\text{I(AMP)} = 6.33 \text{ x } \frac{100.000}{\sqrt{3} \text{ x } 138}$$

$$= 2646 \text{ Amp}$$

$$I_{138kV} = 2.6 \text{ KA //}$$

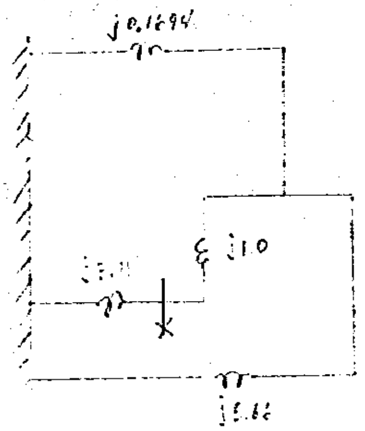
1.2 Short-circuit on 4.16 KV Bus

The reactances diagram shall be:



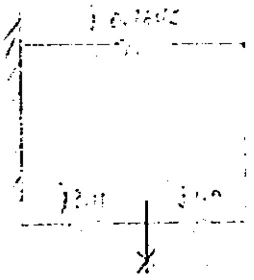
1-3-24

⇒

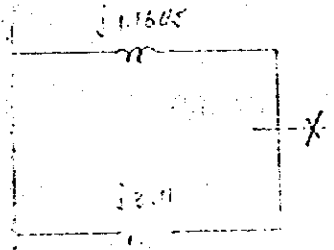


$$X_{eq} = \frac{5.66 \times 0.1694}{5.66 \times 0.1694} = j\,0.1645 \qquad X_{eq} = \frac{3.11 \times 1.1645}{3.11 + 1.1645} = j\,0.847$$

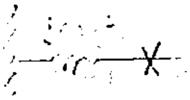
⇒



⇒



⇒



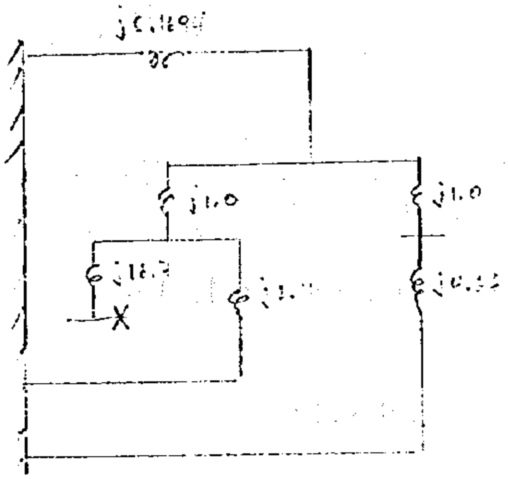
$$\text{MVA sc } 3\Phi = \frac{100.0}{0.847} = 118.1 \text{ MVA}$$

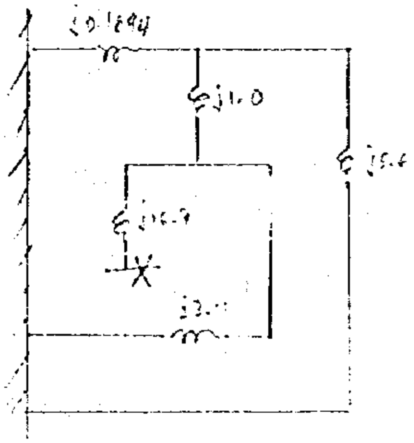
$$\text{I sc } 3\Phi = \frac{1.0}{0.847} = 1.18 \text{ (pu)}$$

$$\text{I (AMP)} = 1.18\,\frac{100.000}{\sqrt{3} \times 4.16} = 16.377 \text{ Amp} \approx 16.4 \text{ KA } //$$

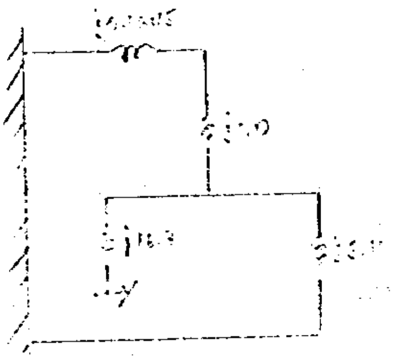
1-3-25

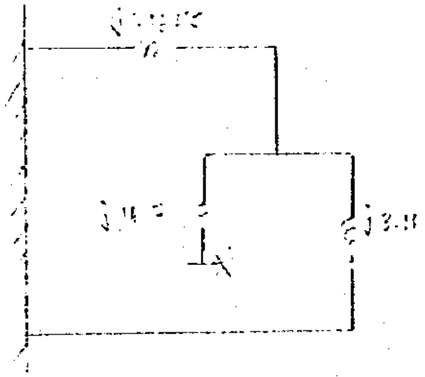
1.3 Short-circuit on 220 V Bus



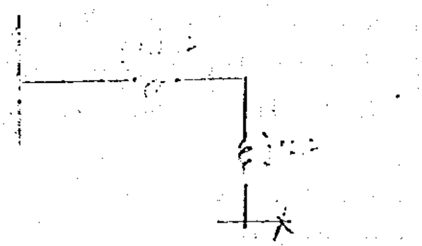


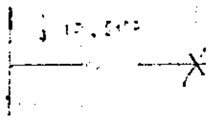
$$X_{eq} = \frac{5.66 \times 0.1694}{5.66 + 0.1694} = 0.1645$$





$$X_{eq} = \frac{3.11 \times 1.1645}{3.11 + 1.1645} = 0.847$$





1-3-76

$$\text{MVA sc } 3\Phi = \frac{100.0}{17.547} = 5.47 \text{ MVA}$$

$$\text{I sc } 3\Phi = \frac{1}{17.547} = 0.057$$

$$\text{I (AMP)} = 0.057 \, \frac{100.000}{\sqrt{3} \times 0.22} = 14.956 \text{ A} \approx 15 \text{ KA} \; //$$

Then, the maximum short-circuit current is on the 4.16 KV bus.

2. GROUNDING MESH CALCULATION

From: ANSI/IEEE STD 80 - 1986 (IEEE 80 GUIDE)

"IEEE GUIDE PR SAFETY IN AC
SUBSTATION GROUNDING"

The SVERAK formula:

$$A\,(\text{mm}^2) = I \times \sqrt{\frac{\dfrac{tc\ \alpha r\ \rho r \times 10^4}{TCAP}}{\ln\left(1 + \dfrac{Tm - Ta}{Ko + Ta}\right)}}$$

Where:

I = rms current in KA
A = Conductor cross section area in mm^2
Tm = Max. allowable temperature in welded connections (°C)
Ta = Ambient temperature (°C)
Tr = Reference temperature for materials constants (°C)
αr = Thermal coefficient of resistivity at Tr temperature
ρr = Resistivity of mesh conductor at Tr temperature (μohm/cm^3)
Ko = $1/\alpha_0$; o $(1/\alpha_r)$ - Tr
α_0 = Thermal coefficient of resistivity at 0°C
tc = Time that the current is following (sec)
TCAP= Thermal capacity factor (J/cm^3/°C)

Then:

I = 16.4 KA (on 4.16 KV bus)
Tm = 450 °C (Std. 80 pg. 69)
Ta = 40 °C
Tr = 20 °C
αr = 0.00381 to 20°C (Table 1 IEEE for Commercial Hard Drawn Copper Wire 97% conductivity)
ρr = 1.7774 at 20°C
Ko = $242\ ;\ \frac{1}{0.00381} - 20$
tc = 1.0 sec
TCAP = 3.422

$$A\ mm^2 = 16.4 \times \sqrt{\frac{\frac{1.0 \times 0.00381 \times 1.7774 \times 10^4}{3{,}422}}{\ln\left(1 + \frac{450\ - 40}{242 \times 40}\right)}}$$

$$= 16.4 \sqrt{\frac{19.79}{\ln\ 2{,}4539}} \quad = \quad 16.4 \sqrt{22.05}$$

A = 77 mm² 85 mm² is 3/0 AWG
Use 4/0 AWG or 100 mm² //

- Verification with Ordendonk formula:

$$A\ (KCM) = I \Big/ \sqrt{\frac{1}{33s} \lg_{10}\left(1 + \frac{Tm\ -\ Ta}{234\ +\ Ta}\right)}$$

$$= 16.4 \Big/ \sqrt{\frac{1}{33 \times 1.0} \lg_{10}\left(1 + \frac{450\ -\ 40}{234\ +\ 40}\right)}$$

$$= 16.4 \Big/ \sqrt{\frac{\lg_{10} 2.4964}{33.0}} \quad = \quad \frac{16.4}{0.10973}$$

1-3-79

A (KCM) = 149.5 KCM il
1 MCM = 0.50671 mm^2
A = 75.7 mm^2 Use 4/0 AWG or 100 mm^2

Note: The compression connectors we assume have the same temperature rise than the welded connections.

3 GROUNDING MESH RESISTANCE

$$r = \sqrt{\frac{A}{\pi}} \quad \text{and} \quad R = \frac{\rho}{2\pi r} + \frac{\rho}{L}$$

From: "Cálculo de Sistemas de Tierra" (Grounding Systems Calculation)
CFE, Mexico.

Where

r = Radius of the equivalent conduction semisphere (m)
A = Total external area of the mesh (m^2)
R = Resistance of the mesh ground connection(ohms)
ρ = Resistivity (ohms-meter)
L =Total length of the grounded conductor.

3.1 Pumping Station

A = 6483 m^2 (Grounding mesh area that cover the structure of the pump station)

ρ = 90 ohm-m (Assuming that the grounding mesh conductor shall be embedded in the concrete the maximum possible length).
ρ concrete = 30 ohm-m to 90 ohm-m (Std 80 - IEEE)

L = 2270 m

Then:

$$r = \sqrt{\frac{6483}{\pi}} = 45.43 \text{ m}$$

and $$R = \frac{90.0}{2\pi \times 45.43} + \frac{90.0}{2270}$$

$$R = 0.35 \text{ ohm} //$$

3.2 138 KV Switchgear Yard

$A = 32 \times 62 = 1984 \text{ m}^2$

$\rho = 120$ ohm - meter (JICA Report March 1994)

$L = 786$ m

Then:

$$r = \sqrt{\frac{1984}{\pi}} = 25.14 \text{ m}$$

and $$R = \frac{120.0}{2\pi \times 25.14} + \frac{120.0}{786}$$

$$R = 0.91 \text{ ohm} //$$

3.3 Main Transformers Yard

$A = 18 \times 47 = 846 \text{ m}^2$

$\rho = 120$ ohm - meter

$L = 368$ m

Then:

$$r = \sqrt{\frac{846}{\pi}} = 16.4 \text{ m}$$

and $$R = \frac{120.0}{2\pi \times 16.4} + \frac{120.0}{368}$$

$$R = 1.49 \text{ ohm} //$$

Note: The resistance of the connection to ground of the mesh of both yards will improve because of the interconnections of their grounding mesh with the pump house mesh. Besides the 120 ohm-m value, looks too high and also could be lower.

SEVERINO PUMPING STATION

VENTILATION AND AIR CONDITIONING

1. GENERAL DATA

1.1 Localization:	
Latitude:	0° 58' S
Local Meridian:	80 ° 02 w
Orientation:	SE 0.44 rad (main front of building)
Altitude	70 m over sea level

2. VENTILATION PROJECT

2.1 Space to be ventilated description

Subterranean machine house, 55 m x 16,5 m extreme sizes and 25,5 m height. It has five plants, two lower plants are occupied with the valves, pumps and motors. The other plants are side wall galleries where auxiliary systems, switchgear control panels and high tension cables are located.

The heat load of the mechanical and electrical equipment prepared by JICA, are indicated in the next table.

ELEVATION LEVEL	FLOOR	EXTERNAL SIZES m	HEAT LOAD KW
65	Cable gallery	55 x 16,5 x 5	11.2
60	Low tension switchgear	55 x 16,5 x 5	40.2
55	Higth tension switchgear	55 x 16,5 x 5	49.4
50	Motor	47 x 16,5 x 5	34.5
45	Valve	47 x 16,5 x 5	6.7

2.2 Design

2.2.1 General Criterion

This study has the purpose and is based on the heat load withdrawing because it is the most critical topic. However, other ventilation requirements as air required to provide necessary oxygen content, air required to prevent CO_2 concentrations from rising above 0.5 per cent, air required to remove objectionable body odors, are controlled too.

2.2.2 Flow rates

The next formulas are used to prepare the flow table.

$$\text{Heat load} = (\text{kw}) \times 864 \quad \text{kcal/hour}$$

$$\text{Flow Q} = 3.44 \ \frac{(\text{Kcal / ho})}{\text{AT°C}} \quad \text{CMH}$$

ELEVATION LEVEL	FLOOR	HEAT LOAD	FLOW
65	cable gallery	9677	5992
60	low tension switchgear	34733	21507
55	High tension switchgear	42682	26429
50	Motors	29808	18457
45	Valves	5789	3585

This flow shall be suplied by two independent systems each one with a 38.000 CMH VENTILATION fan.

2.2.3 Air intake sizing

for 2.5 m/s frontal velocity V

$$\text{Área} = \frac{Q}{V}$$

$$A = \frac{10.5 \text{ m}^3/\text{s}}{2.5 \text{ m/s}} = 4.22 \text{ m}^2$$

Intake louvers size: 1800 x 2400 (mm x mm).

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2.2.4 Duct Sizing

The Static Regain Method is used in the system duct sizing, exepting the duct sections limited for the trajectory free space. Next tables give the calculations and supporting summary. See the ventilation draws for section numbers assigned to the duct system.

2.2.4 V1 Ventilation System 1

SECTION	AIR FLOW	LENGTH	EQUIV-LENGTH	I/Q RATIO (LOSSES)	VELOCITY M/S	AREA M^2	SIZES mm x mm	LOSSES mm wc
V - A	37980	5,0	54.0	(0.12)	10.00	1.055	1100 x 1000	6.40
A - B	34980	5,0	27,0	(0.12)	9.72	1.000	1.100 x 950	3.24
B - C	24240	5,0	8,0	0.08	9.00	0.748	1100 x 720	
C- D	11040	5,0	5,0	0.08	8.30	0.369	875 x 450	
D - 25	1800	8,0	11,5	0.50	6.05	0.083	450 x 200	
25 - 26	1500	3,0	3,0	0.16	5.30	0.079	425 x 200	
26 - 27	1200	5,0	5,0	0,30	4.40	0.076	400 x 200	
27 - 28	900	3,0	3,0	0.21	3.90	0.064	335 x 200	
28 - 29	600	5,0	5,0	0.45	3.20	0.052	275 x 200	
29 - 30	300	3,0	3,0	0.40	2.60	0.032	250x 200	
D - 19	9240	3,0	10,0	0.18	7.20	0.356	840 x 450	
19 - 20	7700	3,0	3,0	0.06	6.80	0.315	740 x 450	
20 - 21	6160	4,0	4,0	0.09	6.30	0.272	720 x 400	
21 - 22	4620	4,0	4,0	0.11	5.75	0.223	600 x 400	
22 - 23	3080	4,0	4,0	0.14	5.20	0.165	580 x 300	
23 - 24	1540	4,0	4,0	0.20	4.50	0.095	325 x 300	
C - 13	13200	3,0	10,0	0.15	7.85	0.467	1000 x 500	
13 - 14	11000	4,0	4,0	0.06	7.40	0.413	875 x 500	
14 - 15	8800	4,0	4,0	0.07	6.90	0.354	740 x 500	
15 - 16	6600	4,0	4,0	0.085	6.40	0.286	740 x 400	
16 - 17	4400	4,0	4,0	0.11	5.80	0.210	550 x 400	
17 - 18	2200	4,0	4,0	0.17	5.15	0.119	350 x 350	
B - 7	10740	2,0	5,0	0.08	8.95	0.333	900 x 400	
7 - 8	8950	3,0	3,0	0.055	8.45	0.294	780 x 400	
8 - 9	7160	4,0	4,0	0.08	7.80	0.255	675 x 400	
9 - 10	5370	4,0	4,0	0.10	7.20	0.207	550 x 400	
10 - 11	3580	4,0	4,0	0.12	6.50	0.153	550 x 300	
11 - 12	1790	4,0	4,0	0.19	5.65	0.088	300 x 300	
A - 1	3000	2,0	3,7	0.12	8.95	0.093	400 x 250	
1 - 2	2500	3,0	3,0	0.11	8.10	0.086	360 x 250	
2 - 3	2000	4,0	4,0	0.19	6.95	0.080	340 x 250	
3 - 4	1500	4,0	4,0	0.20	6.00	0.069	290 x 250	
4 - 5	1000	4,0	4,0	0.26	5.00	0.056	290 x 200	
5 - 6	500	4,0	4,0	0.40	3.95	0.035	250 x 200	

2.2.4 V2 Ventilation System 2

Section	AIR FLOW	LENGTH	EQUIV. LENGTH	L/Q RATIO (LOSSES)	VELOCITY M/S	AREA M^2	SIZES mm x mm	LOSSES mm wc
V - E	37950	5,0	60.0	(0.12)	10.00	1.055	1100 x 1000	7.2
E - F	34940	5,0	5,0	0.04	9.60	1.013	1,100 x 960	
F - G	24230	10,0	40,0	(0.14)	9.98	0.675	1200 x 600	5.6
G - H	22340	6,0	6,0	0.061	9.40	0.660	1200 x 600	
H - I	20450	4,0	4,0	0.041	9.00	0.630	1200 x 550	
I - J	18560	3,0	3,0	0.034	8.70	0.593	1200 x 530	
J - K	11000	8,0	17,0	0.240	8.50	0.360	850 x 450	
K - L	1800	8,0	8,0	0.370	6.50	0.077	420 x 200	
L - 24	1200	1,0	3,0	0.170	5.65	0.059	250 x 250	
24 - 25	900	4,0	4,0	0.280	4.70	0.053	250 x 220	
25 - 26	600	5,0	8,0	0.700	3.40	0.049	250 x 200	
26 - 27	300	3,0	3,0	0.400	2.70	0.037	250 x 150	
L - 28	600	5,0	7,0	0.600	4.60	0.036	250 x 150	
28 - 29	300	3,0	3,0	0.400	3.70	0.023	250 x 150	
K - K1	9200	3,0	7,0	0.120	7.60	0.336	790 x 450	
K1 - 19	7360	4,0	4,0	0.080	7.10	0.288	750 400	
19 - 20	5520	4,0	4,0	0.096	6.50	0.236	700 x 360	
20 - 21	3680	4,0	4,0	0.130	5.80	0.176	650 x 290	
21 - 22	1840	4,0	4,0	0.190	5.10	0.100	425 x 250	
K1 - 23	1840	4,0	7,0	0.220	6.40	0.080	425 x 200	
J - 15	7560	2,0	2,0	0.040	8.40	0.250	670 x 400	
15 - 16	5670	3,0	3,0	0.070	7.80	0.202	600 x 350	
16 - 17	3780	4,0	4,0	0.120	7.10	0.147	450 x 350	
17 - 18	1890	4,0	4,0	0.180	6.20	0.085	350 x 250	
F - 8	10710	4,0	10,0	0.160	8.30	0.358	960 x 400	
8 - 9	9180	6,0	6,0	0.110	7.60	0.336	900 x 400	
9 - 10	7650	4,0	4,0	0.080	7.10	0.299	900 x 360	
10 - 11	6120	4,0	4,0	0.090	6.55	0.260	800 x 350	
11 - 12	4590	4,0	4,0	0.110	6.00	0.213	650 x 350	
12 - 13	3060	4,0	4,0	0.140	5.40	0.157	550 x 300	
13 - 14	1530	4,0	4,0	0.200	470	0.090	300 x 300	
E - 1	3010	4,0	7,0	0.240	8.20	0.102	350 x 300	
1 - 2	2580	6,0	6,0	0.220	6.80	0.105	350 x 300	
2 - 3	2150	4,0	4,0	0.170	6.00	0.099	350 x 290	
3 - 4	1720	4,0	4,0	0.190	5.20	0.092	350 x 270	
4 - 5	1290	4,0	4,0	0.240	4.40	0.081	350 x 240	
5 - 6	860	4,0	4,0	0.300	3.70	0.064	300 x 220	
6 - 7	430	4,0	4,0	0.420	3.00	0.040	250 x 200	

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2.2.5 Register Selection

Registers are sized for 2.5 m/s outlet velocity. Results are presented in the table.

PATH	AIR FLOW CMH	TRHOW M / S	SIZE mm x mm	QUANTITY
A	500	2.5	500 x 200	6
B	1790	2.5	850 x 300	6
C	2200	2.87	900 x 300	6
D - 19	1540	2.5	900 x 250	6
D - 25	300	2.5	300 x 200	6
E	430	2.5	400 x 200	7
F	1530	2.5	730 x 300	7
G	1890	2.5	900 x 300	7
K	1840	2.5	900 x 300	5
L	300	2.5	300 x 200	6

2.2.6 Fan Selection

2.2.6.1 Maxim Total Pressure Required

H = he + hf + hv + hd + hr + hda

H = Total pressure, milimeters of water column mm

he = Entry losses

hf = Filters losses

hv = Velocity pressure

hd = Duct losses

hr = Outlet operating pressure

hda = Fire and volume dampers losses mm

V1

H = (2.5 + 6 + 6.1 + 9.72 + 3 + 19) mm

H = 46.32 mm

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V2

$H = (2.5 + 6 + 6.1 + 12.8 + 3 + 19)$ mm

$H = 49.4$ mm

2.2.6.2 Power Input

$$\text{Power} = 2.757 \times 10^{-6} \times \text{CMH} \times H \times \frac{1}{n}$$

CMH →Flow rate in cubic meters per hour

H →Total pressure in milimeters of water column

n →Total efficiency

Considering two similar fans of= 38.000 CMH and 50 mm wc total pressure:

$$\text{Power} = 2.757 \times 10^{-6} \times 38.000 \times 50 \times \frac{1}{0.50} \text{ kw}$$

Power = 10,476 kw

2.2.6.3 Summary of fan selection:

Q = 38.000 CMH

H = 50 mm

Power = 10.5 kw

3. AIR CONDITIONING PROJECT

3.1 Served Space

The study is for the administration and control areas of Severino Pumping Station. These are in the 70:20 elevation level as the plans indicate. Sizes, heights, orientation, building materials and finishes are in the plans too. Form 1 gives an extract of sizes required for the load calculation.

3.2 Project Conditions

3.2.1 Outdoor Conditions

To stablish the external conditions nearest to project localization, metereological stations information was review. Based on Portoviejo, Poza Honda, Alajuela and Chamotete Stations the following data are stablished.

Dry bulb temperature	33 °C
Average relative humidity	70%
Outdoor daily range	10 °C
Wind velocities	1.6 m/s, SO
Barometer pressure	1006,5 m bar
Annual sunshine	1430 hours
Maxim daily sunshine	10 hours
Altitude	70 over sea level

3.2.2 Indoor Conditions

Design is based on 24 °C indoor temperature and on 50 % indoor relative humidity. Continuous operating as considered for the control room area.

3.3 Air Conditioning Cooling Load

March, 23, 15hoo is considered the project day for the air conditioning load estimation.

Out Door Loads

Solar heat gain throught glass areas, solar heat gain throught walls and roofs, load from partitions, ceilings and floor because the temperature difference, are considered in the exterior loads. Since the low average wind velocity, infiltration air load is not considered.

To determine the load from outdoor air ventilation, a number of occupants within each space is assumed.

Indoor Loads

Included de indoor loads the next sources are considered: heat and moisture given of by people, heat gain from electric lighting, heat gain from equipment and apliances, and the heat delivery for control and protection panels specially in control room and telephone room.

The form 2 is used to estimate the conditioning load. This form is aplied in each local and summarized for each system. In the forms are indicated the parameters used in the load calculation.

The different rates and calculation procedures presented are in accordance to ASHRAE guide, and Carrier Company Air Conditioning. hand-book

3.4.1 Suply Air Conditioning System Duct Sizing

SECTION	AIRFLOW	TOTAL LENGTH	RATIO L/Q	VELOCITY	AREA	SIZE	LOSS
V - A	9460	11	(0.12)	7.66	0.343	1100 x 350	1,37
A - B	7900	3	0.06	7.25	0.303	950 x 350	
B -C	6340	3	0.066	6.80	0.259	800 x 350	
C - D	4780	3	0.079	6.40	0.207	750 x 300	
D - E	3220	.3	0.095	5.85	0.153	670 x 250	
E -F	2200	4	0.170	5.20	0.118	500 x 250	
A - 1	780	2.5	0.200	6.55	0.033	250 x 200	
A -2	780	4.5	0.340	5.95	0.036	250 x 200	
B - 1	780	2.5	0.200	6.25	0.035	250 x 200	
B - 2	780	4.5	0.340	5.70	0.038	250 x 200	
C - 1	780	2.5	0.200	5.90	0.036	250 x 200	
C - 2	780	4.5	0.340	5.45	0.040	250 x 200	
D - 1	780	2.5	0.200	5.50	0.039	250 x 200	
D - 2	180	4.5	0.340	5.10	0.042	250 x 200	
E - 1	1020	2.0	0.135	5.30	0.053	250 x 220	
F - 1	1100	3.0	0.190	4.50	0.068	350 x 250	
F - 2	1100	3.0	0.190	4.50	0.068	350 x 250	
V - 6	3580	13.0	(0,06)	5.92	0.168	500 x 350	0.78
G - H	2320	7,0	0.290	4.85	0.133	460 x 300	
H - I	1160	4,0	0.240	4.20	0.078	420 x 200	
G - 1	630	2,0	0.180	5.15	0.034	250 x 200	
G - 2	630	2.5	0.300	4.45	0.040	250 x 200	
H - 1	580	3.0	0.280	4.10	0.039	250 x 200	
H - 2	580	3,0	0.280	4.10	0.039	250 x 200	
I - 1	580	3.0	0.280	3.60	0.044	250 x 200	
I - 2	580	3.0	0.280	3.60	0.044	250 x 200	

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3.4 Duct Sizing

3.4.1 Suply

The static regain method is used, to duct sizing. 250 x 200 mm x mm are the minimum sizes. Next table gives the results- The abreviations and symbols are refered to the air conditioning draws.

3.4.2 Return

Each air conditioning system use a duct return line. The constant loss method is used to the duct sizing. Next tables gives the results.

3.4.2 Return Air Conditioning System Duct Sizing

SECTION	QI	Q2 CMH	VEL	AREA	DUCT SIZES	REGISTERS SIZES	% Q	% A
R1	2020	8829	7	0.343	1100 x 350	950 x 400	100	100
R2	2020	6809		0.281	900 x 350	950 x 400	77	82
R3	2020	4789		0.213	800 x 300	950 x 400	54	62
R4	944	2769		0.134	500 x 300	750 x 300	31	39
R5	1825	1825		0.093	400 x 250	900 x 400	20	27
R8	1160	3280	6	0.152	450 x 350	800 x 300	100	100
R7	1060	2120		0.109	450 x 250	750 x 300	65	71.5
R6	1060	1060		0061	350 x 200	750 x 300	32	40

3.5 Register and Diffuser Selection

For the suply air conditioning system, 250 mm diameter round ceiling diffusers are selected.

For the returns, rectangular registers are selected. Sizes are in accordance to velocity and capacity and are presented in table 3.4.2

3.6 Air Conditioning Control System

A combination of on-off control, refrigeration capacity control and reheating control shall be used to maintain the temperature within a deviation range of ± 1 °C from the set point. For reheating control an electrical heater is considered in the air conditioning unit. Its capacity was stablished considering the 50% of the 70% partial refrigeration load after the 30% of refrigeration capacity control. This heating capacity shall be used to restore the heating load which develops when the minimun night temperatures occur, too.

The control system described heretofore is considered for the total refrigeration load divided in two compresors of equal capacity and similar characteristics, to obtain the better steady perfomance and economical operation.

1-3-92

Form No. 1

Local: Manager Room

SURFACE No.	WINDOWS		WALLS AREA	DOORS		TOTAL AREA
	PERIMETER	AREA		PERIMETER	AREA	
1 SE	6.60	2.70	17.3			20.00
2 NE			27.5			27.50
3 NO			17.2	6.8	2.8	20.00
4 SO			27.5			27.50
5 . H			22.0			22.0
6						
7						
8						

Form No. 1

Local: Office

SURFACE No.	WINDOWS		WALLS AREA	DOORS		TOTAL AREA
	PERIMETER	AREA		PERIMETER	AREA	
1	13.2	5.4	32.1			37.5
2			32.5			32.5
3			36.5	5.6	1.6	37.5
4			29.5	7	3,0	32.5
5			48.75			48.75
6						
7						
8						

1-3-99

Form No. 1

Local: Conference Room

SURFACE No.	WINDOWS		WALLS AREA	DOORS		TOTAL AREA
	PERIMETER	AREA		PERIMETER	AREA	
1	6.6	2.7	24.8			27.5
2			32.5			32.5
3			24.5	7	3	27.5
4			32.5			32.5
5			35.75			35.75
6						
7						
8						

1-3-95

Form No. 1

Local: Control Room

SURFACE No.	WINDOWS		WALLS AREA	DOORS		TOTAL AREA
	PERIMETER	AREA		PERIMETER	AREA	
1	13.2	5.4	46.6	7,00	3,00	55
2			39.5	7,00	3,00	42.5
3	19.8	8.1	46.9			55
4			40.9	5.6	1.6	42.5
5			93.5			93.5
6						
7						
8						

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Form No. 1

Local: Telephone Room

SURFACE No.	WINDOWS		WALLS AREA	DOORS		TOTAL AREA
	PERIMETER	AREA		PERIMETER	AREA	
1	6.6	2.7	12.3			15
2			27.5			27.5
3			13.4	5.60	1.6	1.5
4			27.5			27.5
5			16.5			16.5
6						
7						
8						

1-3-97

REFERENCES:

ACGIH Industrial Ventilation. A manual of recommended practices. 15 th ed. American Conference of Governmental Industrial Hygienists.

ASHRAE 1989 Fundamentals Handbook

ASHRAE 1961 Guide and Data book, Fundamentals and Equipment.

CARRIER COMPANY. 1972 Hand book of Air Conditioning System Design

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SHEET: 1 / 7
PREPARED BY: H. PEREZ OFICCE ________
CUSTOMER ________
LOCATION SEVERINO POMPING STATION

DATE: 10 / 1994
PROJECT ________ INSTALATION Nº 1
APROVED BY ________

SPACE USED BY ADMINISTRATION AREA (SUMMARY)
LOCAL DIMENSIONS m x m = 70.75 m² x 3 m = 212 m³

CONCEPT	AREA	SOLAR GAIN OR TEMP. DIFFERENCE	FACTOR	Kcal/h
SOLAR - GAIN - GLASS				
Glass	m² x		x	
Glass	m² x		x	
Glass	m² x		x	
Glass	m² x		x	
Skylight	m² x		x	
SOLAR - GAIN - & TRANS. WALLS & ROOF				
WALL	m² x		x	
WALL	m² x		x	
WALL	m² x		x	
WALL	m² x			
ROOF-SUN	m² x		x	
ROOF-SHADE	m² x		x	
GAIN. TRANS.- EXCEPT WALL AND ROOF				
Total Glass	m² x		x	
Divisory wall - Door	m² x		x	
Roof	m² x		x	
Floor	m² x		x	
Filtering	m³/h			
INTERNAL HEAT				
People		people	x	
Power		KW	x	
Light		Watts x 0.86—	x	
Applications			x	
Additional Gains			x	
			SUBTOTAL	
Storage	m² x		x (-)	
			SUBTOTAL	
Safety Factor		%		
ROOM SENSIBLE HEAT				10407
Sup. Duct heat gain % +		Loss due to leaks % +	KW Fan %	
Outside air	m³/seg x	°C x	BF x 0.3	
EFFECTIVE ROOM SENSIBLE HEAT				11609
LATENT HEAT				
INFILTRATION		m³/seg x		
People		people	x	
Vapor	KG/h x			
Applications				
Additional Gains				
Vapor Difussion	m² x	GR/KG		
			SUBTOTAL	
Safety Factor		%		
			ROOM LATENT HEAT	
DISTRIBUTION DUCT FILTRATION LOSS				
outside air	m³/h x	GR/KG x	BF x0.72	
			EFFECTIVE ROOM LATENT HEAT	2016
			EFFECTIVE ROOM TOTAL HEAT	13625
OUTSIDE AIR HEAT				
Sensible	m³/h x	°C (1- BF) x	0.3	648
Latent	m³/seg x	GR/KG x (1- BF) x	x 0.72	4320
			Subtotal	
Return Duct Heat Gian % +	Return Duct Leakage Gain % +	C.V. Pump % +	Dehumid. & Pipe Loss %	682
GREAT TOTAL OF HEAT				19275

CALCULATED FOR	LOCAL HOUR SOLAR HOUR	MAX. LOAD	LOCAL HOUR SOLAR HOUR		
Working Hours					
Conditions	DB	WB	% HR	T.R.	GR/KG
Exteriors	33		70		
Interior	24		50		
Difference	9				

OUTSIDE AIR

VENTILATION
____ people x ________ m³/h = ________
____ m x ________ m³/h = ________
m³/h ventilation 300

INFILTRATION
revolving doors ___ x ___ people m³/h people= ___
open doors ___ x ___ doors m³/h m²= ___
Extractor ________
Cracks ___ m x m³/h ______ m³/h = ______
______ m³/h Infiltration ■
- m³/h OUTSIDE AIR ■ ________ m³/h

ADP

SHFE
SHF EFFECTIVE = 11609 EFFECTIVE ROOM SENS / 13625 EFFECTIVE ROOM TOTAL HEAT = 0.85

ADP
INDICATED ADP = 11 °C SELECTED ADP = 11 °C

Δt
QUANTITY OF DEHUMIDIFIED AIR
(1-0.2 BF) x (°C Loc 24 - 11 ADP) = 10.4 °C

m3/h
11609 EFFEC. ROOM SENS / 0.3 x 10.4 °C Δt = 3720 m³/h

Δt outlet
10407 ROOM SENS. HEAT / 0.3 x 3720 m³/h Dehumidified = 9.3 °C (Room - air outlet) *

AIR SUPPLIED FLOW

m³/h Supplied
Room Sen. Heat / 0.3 x °C Δt = ________ m³/h

m³/h By-passed
____ m³/h AS - ________ m³/h AD = ________ m³/h

INLET AND OULET CONDITIONS OF THE DEVICE

DB Inlet
Tr 24 °C + 300 m³/h EA / 3720 m³/h ‡ (Tae 33 - Tr 24) = Tdie 24.7 °C

DB Outlet
Tadp 11 °C + 0.2 BF (Tdie 24.7 - Tadp 11) = Tdie 13.8 °C
From Psychrometric chart Tube 18.4 °C Tubs 12.7 °C

NOTES

* If this Δt is too high, determine the m³/h supplied by the difference desired, by the way of te amount of impulsed air

‡ When using a by-pass of mixed air of exterior air and returned air, use m³/h supplied.

When by-passing only return air, use m³/h dehumidified.

FORM 2

1-3-49

SHEET: 2/7
PREPARED BY: H. PEREZ OFICCE ______
CUSTOMER ______
LOCATION SEVERINO PUMPING STATION

SPACE USED BY MANAGER ROOM
LOCAL DIMENSIONS m x m = 22 m² x 3 m = 66 m³

DATE: 10/1994
PROJECT ______ INSTALATION N° 1
APROVED BY ______

CONCEPT	AREA	SOLAR GAIN OR TEMP. DIFFERENCE	FACTOR	Kcal/h
		SOLAR - GAIN - GLASS		
Glass SE	2.7 m²x	320	x 0.45	389
Glass	m²x		x	
Glass	m²x		x	
Glass	m²x		x	
Skylight	m²x		x	
		SOLAR - GAIN - & TRANS. WALLS & ROOF		263
WALL SE	13.3 m²x	8	x 1.90	418
WALL NE	23.5 m²x	8	x 1.90	262
WALL NO	13.2 m²x	8	x 1.90	
WALL	m²x			546
ROOF-SUN	22 m²x	18	x 1.33	
ROOF-SHADE	m²x		x	
		GAIN. TRANS.- EXCEPT WALL AND ROOF		134
Total Glass	2.7 m²x	9	x 5.50	
Divisory wall - Door	2.8 m²x	9	x 2.50	63
Roof	m²x		x	180
Floor	22.0 m²x	8	x 1.02	
Filtering	m³/h			
		INTERNAL HEAT		244
People	4	people	x 61.0	516
Power	0.6	KW	x 860.0	172
Light	160	Watts x 0.86 —	x 1.25	
Applications			x	
Additional Gains			x	
			SUBTOTAL	
Storage	m²x		x (-)	
			SUBTOTAL	3187
Safety Factor		10 %		319
		ROOM SENSIBLE HEAT		3506
Imp. Duct heat gain 4.5 %	+ Loss due to leaks 2 %	+ KW Fan 3.5 %		350 54
Outside air	100 m³/seg x 9 °C	x	0.2 BF x 0.3	3910
		EFFECTIVE ROOM SENSIBLE HEAT		
		LATENT HEAT		
INFILTRATION		m³/seg x		
People	4	people	x 51.0	208
Vapor	KG/h x			
Applications				
Additional Gains				
Vapor Difusion	m³x	GR/KG		
			SUBTOTAL	
Safety Factor		%		
			ROOM LATENT HEAT	70
IMPULTION DUCT FILTRATION LOSS			2 %	360
outside air	100 m³/h x 25 GR/KG	x 0.2	BF x 0.72	
			EFFECTIVE ROOM LATENT HEAT	638
			EFFECTIVE ROOM TOTAL HEAT	4548
		OUTSIDE AIR HEAT		216
Sensible	100 m³/h	x 9 °C (1- 0.2 BF) x	0.3	1440
Latent	100 m³/seg x 25 GR/KG x (1-0.2 BF) x		x 0.72	
			Subtotal	
Return Duct heat Gian 3 % +	Return Duct Leakage Gain 2 % +	C.V. Pump % +	Dehumid. & Pipe Loss %	228
		GREAT TOTAL OF HEAT		6432

CALCULATED FOR	LOCAL HOUR SOLAR HOUR	MAX. LOAD	LOCAL HOUR SOLAR HOUR		
Working Hours					
Conditions	DB	WB	% HR	T.R.	GR/KG
Exteriors	33		70		
Interior	24		50		
Difference	9				

OUTSIDE AIR

VENTILATION
4 people x 25 m³/h = 100
______ m x ______ m³/h = ______
m³/h ventilation

INFILTRATION
revolving doors ___ x ___ people m³/h people = ___
open doors ___ x ___ doors m³/h m² = ___
Extractor ______
Cracks ___ m x m³/h ___ m³/h = ___
______ m³/h Infiltration ■

m³/h OUTSIDE AIR ■ ______ m³/h

ADP

SHFE: SHF EFFECTIVE = ______ EFFECTIVE ROOM SENS / EFFECTIVE ROOM TOTAL HEAT = ______

ADP: INDICATED ADP = ______ °C SELECTED ADP = 11 °C

QUANTITY OF DEHUMIDIFIED AIR

Δt: (1-0.2BF) x (°C Loc 24 - 11 ADP) = 10.4 °C

m3/h: 3910 EFFEC. ROOM SENS. / 0.3 × 10.4 °C Δt = 1253 m³/h

Δt outlet: 3506 ROOM SENS. HEAT / 0.3 × 1253 m³/h Dehumidified = 9.3 °C (Room - air outlet)

AIR SUPPLIED FLOW

m³/h Supplied: Room Sen. Heat / 0.3 x °C Δt = ______ m³/h

m³/h By-passed: ______ m³/h AS - ______ m³/h AD = ______ m³/h

INLET AND OULET CONDITTIONS OF THE DEVICE

DB Inlet: Tr ______ °C + m³/h EA / m³/h ǂ (Toe ___ - Tr ___) = Tdbe ___ °C

DB Outlet: Tadp ___ °C + ___ BF (Tdbe ___ - Tadp ___) = Tdbs ___ °C
From Psychrometric chart Twbe ___ °C Twbs ___ °C

NOTES

- If this Δt is too high, determine the m³/h supplied by the difference desired, by the way of te amount of impulsed air

ǂ When using a by-pass of mixed air of exterior air and returned air, use m³/h supplied.

When by-passing only return air, use m³/h dehumidified.

FORM 2

1-3-50

SHEET: 3/7
PREPARED BY: M. PEREZ OFICCE ________
CUSTOMER ________
LOCATION SEVERINO PUMPING STATION

DATE: 10/1994
PROJECT ________ INSTALATION N° 1
____
APROVED BY ________

SPACE USED BY OFFICE
LOCAL DIMENSIONS m x m = 48.75m² x 3.0m = 146 m³

CONCEPT	AREA	SOLAR GAIN OR TEMP. DIFFERENCE	FACTOR	Kcal/h
SOLAR - GAIN - GLASS				
Glass SE	5.4 m²x	320	x 0.45	778
Glass	m²x		x	
Glass	m²x		x	
Glass	m²x		x	
Skylight	m²x		x	
SOLAR - GAIN - & TRANS. WALLS & ROOF				
WALL SE	32.1 m²x	8	x 1.90	490
WALL	m²x		x	
WALL NO	36.5 m²x	8	x 1.90	555
WALL SO	29.5 m²x	8	1.90	494
ROOF-SUN	48.75 m²x	18	x 1.37	1202
ROOF-SHADE	m²x		x	
GAIN TRANS.- EXCEPT WALL AND ROOF				
Total Glass	5.4 m²x	9	x 5.5	267
Divisory wall - Door	4.6 m²x	9	x 2.5	104
Roof	m²x		x	
Floor	48.75 m²x	8	x 1.02	398
Filtering	m³/h			
INTERNAL HEAT				
People	10	people	x 61.0	610
Power	1	KW	x 860.0	860
Light	480	Watts x 0.86—	x 1.25	516
Applications			x	
Additional Gains			x	
			SUBTOTAL	
Storage	m²x		x (-)	
			SUBTOTAL	6274
Safety Factor		10 %		627
ROOM SENSIBLE HEAT				6901
Imp. Duct heat gain 4.5 % +		Lost due to leaks 2 % +	KW Fan 3.5%	690
Outside air	200 m³/seg x 9 °C	x	0.2 BF x 0.3	108
EFFECTIVE ROOM SENSIBLE HEAT				7699
LATENT HEAT				
INFILTRATION		m³/seg x		
People	10	people	x 52.0	520
Vapor	KGS x			
Applications				
Additional Gains				
Vapor Difusion	m²x	OR KO		
			SUBTOTAL	
Safety Factor		%		
			ROOM LATENT HEAT	
IMPULTION DUCT FILTRATION LOSS			2 %	138
outside air	200 m³/h x 2.5 GR KO	x	0.2 BF x 0.72	720
			EFFECTIVE ROOM LATENT HEAT	1378
			EFFECTIVE ROOM TOTAL HEAT	9077
OUTSIDE AIR HEAT				
Sensible	200 m³/h	x 9 °C (1- 0.2 BF) x	0.3	432
Latent	200 m³/seg x 25 GR/KO x (1-0.2BF) x		x 0.72	2880
			Subtotal	
Return Duct heat Gain 3 % +	Return Duct Leakage Gain 2 % +	C.V. Pump % +	Dehumid. & Pipe Loss %	454
GREAT TOTAL OF HEAT				12843

CALCULATED FOR	LOCAL HOUR / SOLAR HOUR	MAX. LOAD		LOCAL HOUR / SOLAR HOUR	
Working Hours					
Conditions	DB	WB	% HR	T R.	GR KG
Exteriors	33		70		
Interior	24		50		
Difference	9				

OUTSIDE AIR

VENTILATION
10 people x 20 m³/h = 200
____ m x ____ m³/h = ____
m³/h ventilation

INFILTRATION
revolving doors ___ x ___ people m³/h people= ___
open doors ___ x ___ doors m³/h m²= ___
Extractor ________
Cracks ___ m x m³/h ___ m³/h = ___
___ m³/h Infiltration ■
m³/h OUTSIDE AIR ■ ___ m³/h

ADP

SHFE
SHF EFFECTIVE = ________ EFFECTIVE ROOM SENS. / EFFECTIVE ROOM TOTAL HEAT = ___ *

ADP
INDICATED ADP = ________ °C SELECTED ADP = 11 °C

QUANTITY OF DEHUMIDIFIED AIR

Δᵀ
(1-0.2 BF) x (°C Loc 24 - 11 ADP) = 10.4 °C

m3/h
7699 EFFEC. ROOM SENS. / 0.3 · 10.4 °C Δᵀ = 2467 m³/h

Δᵀ outlet
6901 ROOM SENS. HEAT / 0.3 · 2467 m³/h Dehumidified = 9.3 °C (Room - air outlet) *

AIR SUPPLIED FLOW

m³/h Supplied
Room Sen. Heat / 0.3 x °C Δᵀ = ________ m³/h

m³/h By-passed
____ m³/h AS - ________ m³/h AD = ________ m³/h

INLET AND OULET CONDITIONS OF THE DEVICE

DB Inlet
Tr ______ °C + m³/h EA / m³/h † (Tae ___ - Tr ___) = Tdie ___ °C

DB Outlet
Tadp ______ °C + ____ BF (Tdbe ______ - Tadp ______) = Tdbs ___ °C
From Psychrometric chart Twbe ______ °C Twbs ______ °C

NOTES

- * If this Δᵀ is too high, determine the m³/h supplied by the difference desired, by the way of te amount of impulsed air

- † When using a by-pass of mixed air of exterior air and returned air, use m³/h supplied.

When by-passing only return air, use m³/h dehumidified.

FORM 2

1-3-51

SHEET: 4/7
PREPARED BY: H. PEREZ OFICCE ________
CUSTOMER ________
LOCATION SEVERINO PUMPING STATION

SPACE USED BY CONTROL ROOM AND OTHERS (SUMMARY)
LOCAL DIMENSIONS m x m = m^2 x m = 475 m^3

DATE: 10/1994
PROJECT ________ INSTALATION N° 2
APROVED BY ________

CONCEPT	AREA	SOLAR GAIN OR TEMP. DIFFERENCE	FACTOR	Kcal/h
SOLAR - GAIN - GLASS				
Glass	m^2 x		x	
Glass	m^2 x		x	
Glass	m^2 x		x	
Glass	m^2 x		x	
Skylight	m^2 x		x	
SOLAR - GAIN - & TRANS. WALLS & ROOF				
WALL	m^2 x		x	
WALL	m^2 x		x	
WALL	m^2 x		x	
WALL	m^2 x			
ROOF-SUN	m^2 x		x	
ROOF-SHADE	m^2 x		x	
GAIN. TRANS. - EXCEPT WALL AND ROOF				
Total Glass	m^2 x		x	
Divisory wall - Door	m^2 x		x	
Roof	m^2 x		x	
Floor	m^2 x		x	
Filtering	m^3/h			
INTERNAL HEAT				
People		people	x	
Power		KW	x	
Light		Watts x 0.86 —	x	
Applications			x	
Additional Gains			x	
			SUBTOTAL	
Storage	m^2 x		x (-)	
			SUBTOTAL	
Safety Factor		%		
ROOM SENSIBLE HEAT				26798
Imp. Duct heat gain	% +	Loss due to leaks % +	KW Fan %	
Outside air	m^3/seg x	°C x	BF x 0.3	
EFFECTIVE ROOM SENSIBLE HEAT				29830
LATENT HEAT				
INFILTRATION		m^3/seg x		
People		people	x	
Vapor	KG/h x			
Applications				
Additional Gains				
Vapor Difusion	m^2 x	GR/KG		
			SUBTOTAL	
Safety Factor		%		
			ROOM LATENT HEAT	
IMPULTION DUCT FILTRATION LOSS				
outside air	m^3/h x	GR KG x	BF x 0.72	
			EFFECTIVE ROOM LATENT HEAT	4179
			EFFECTIVE ROOM TOTAL HEAT	34009
OUTSIDE AIR HEAT				
Sensible	m^3/h x	°C (1- BF) x	0.3	1406
Latent	m^3/seg x	GR KG x (1- BF) x	x 0.72	9374
			Subtotal	
Return Duct heat Gain 2 % +	Return Duct Leakage Gain 1 % +	C.V. Pump % +	Dehumid. & Pipe Loss %	1019
GREAT TOTAL OF HEAT				45809

CALCULATED FOR	LOCAL HOUR SOLAR HOUR	MAX. LOAD		LOCAL HOUR SOLAR HOUR	
Working Hours					
Conditions	DB	WB	% HR	T.R.	GR/KG
Exteriors	33		70		
Interior	24		50		
Difference	9				

OUTSIDE AIR

VENTILATION
_____ people x _____ m^3/h = _____
_____ m x _____ m^3/h = _____
m^3/h ventilation 651

INFILTRATION
revolving doors ___ x ___ people m^3/h people = ___
open doors _____ x ___ doors m^3/h m^2 = _____
Extractor _____
Cracks _____ m x m^3/h _____ m^3/h = _____
_____ m^3/h Infiltration ■
m^3/h OUTSIDE AIR ■ _____ m^3/h

ADP

SHFE
SHF EFFECTIVE = 29830 EFFECTIVE ROOM SENS / 34009 EFFECTIVE ROOM TOTAL HEAT = 0.87

ADP
INDICATED ADP = 11.5 °C SELECTED ADP = 11 °C

QUANTITY OF DEHUMIDIFIED AIR

Δt
(1-0.2BF) x (°C Loc 24 - 11 ADP) = 10.4 °C

m3/h
29830 EFFEC. ROOM SENS / 0.3 x 10.4 °C Δt = 9510 m^3/h

Δt outlet
ROOM SENS. HEAT / 0.3 x m^3/h Dehumidified = °C (Room - air outlet) *

AIR SUPPLIED FLOW

m^3/h Supplied
Room Sen. Heat / 0.3 x °C Δt = _____ m^3/h

m^3/h By-passed
_____ m^3/h AS - _____ m^3/h AD = _____ m^3/h

INLET AND OULET CONDITIONS OF THE DEVICE

DB Inlet
Tr 24 °C + m^3/h EA / m^3/h † (Tec 33 - Tr 24) = Tdbe 24.6 °C

DB Outlet
Tadp 11 °C + 0.2 BF (Tdbe 24.6 - Tadp 11) = Tdbs 13.7 °C
From Psychrometric chart Twbe 18.3 °C Twbs 12.6 °C

NOTES

- * If this Δt is too high, determine the m^3/h supplied by the difference desired, by the way of te amount of impulsed air
- † When using a by-pass of mixed air of exterior air and returned air, use m^3/h supplied.

When by-passing only return air, use m^3/h dehumidified.

FORM 2

1-3-52

SHEET: 5/7
PREPARED BY: M. PEPE OFICCE
CUSTOMER
LOCATION SEVERINO PUMPING STATION

DATE: 10/1994
PROJECT INSTALATION N° 2

APROVED BY

SPACE USED BY
LOCAL DIMENSIONS m x m = 93.5 m² x 3.4 m = 318 m³

CONCEPT	AREA	SOLAR GAIN OR TEMP. DIFFERENCE	FACTOR	Kcal/h
SOLAR - GAIN - GLASS				
Glass SE.	5.4 m² x	320	x 0.45	778
Glass	m² x		x	
Glass NO	8.1 m² x	320	x 0.30	778
Glass	m² x		x	
Skylight	m² x		x	
SOLAR - GAIN - & TRANS. WALLS & ROOF				
WALL SE	46.6 m² x	8	x 1.90	708
WALL	m² x		x	
WALL NO	46.9 m² x	8	x 1.90	713
WALL SO	40.9 m² x	8	1.90	622
ROOF-SUN	93.5 m² x	18	x 1.33	2306
ROOF-SHADE	m² x		x	
GAIN. TRANS. - EXCEPT WALL AND ROOF				
Total Glass	5.4 m² x	9	x 5.5	267
Divisory wall - Door	7.6 m² x	9	x 2.5	171
Roof	m² x		x	
Floor	93.5 m² x	8	x 1.02	763
Filtering	m³/h			
INTERNAL HEAT				
People	8	people	x 61.0	468
Power	8	KW	x 860.0	6880
Light	1440	Watts x 0.86—	x 1.25	1800
Applications			x	
Additional Gains			x	
			SUBTOTAL	
Storage	m² x		x ( )	
			SUBTOTAL	16254
Safety Factor		10 %		1625
ROOM SENSIBLE HEAT				17879
Imp. Duct heat gain	4.5 % +	Loss due to leaks 2 % +	KW Fan 3.5%	1788
Outside air	200 m³/seg x 9°C	x	0.2 BF x 0.3	108
EFFECTIVE ROOM SENSIBLE HEAT				19775
LATENT HEAT				
INFILTRATION		m³/seg x		
People	8	people	x 52.0	416
Vapor	KG/h	x		
Applications				
Additional Gains				
Vapor Difusion	m² x		GR/KG	
			SUBTOTAL	
Safety Factor		%		
			ROOM LATENT HEAT	
IMPULTION DUCT FILTRATION LOSS			2%	357
outside air	200 m³/h x 25 GR/KG	x 0.2	BF x 0.72	720
			EFFECTIVE ROOM LATENT HEAT	1493
			EFFECTIVE ROOM TOTAL HEAT	21268
OUTSIDE AIR HEAT				
Sensible	200 m³/h	x 9 °C (1- 0.2 BF) x	0.3	432
Latent	200 m³/seg x 25 GR/KG x (1-0.2 BF) x		x 0.72	2880
			Subtotal	
Return Duct heat Gian 2 % +	Return Duct Leakage Gain 1 % +	C.V. Pump % +	Dehumid. & Pipe Loss %	638
GREAT TOTAL OF HEAT				25218

CALCULATED FOR	LOCAL HOUR / SOLAR HOUR	MAX. LOAD	LOCAL HOUR / SOLAR HOUR		
Working Hours					
Conditions	DB	WB	% HR	T.R.	GR/KG
Exteriors	33		70		
Interior	24		50		
Difference	9				

OUTSIDE AIR

VENTILATION
8 people x 25 m³/h = 200
m x m³/h =
m³/h ventilation

INFILTRATION
revolving doors x people m³/h people =
open doors x doors m³/h m² =
Extractor
Cracks m x m³/h m³/h =
m³/h Infiltration =
- m³/h OUTSIDE AIR = m³/h

ADP

SHFE
SHF EFFECTIVE = EFFECTIVE ROOM SENS. / EFFECTIVE ROOM TOTAL HEAT =

ADP
INDICATED ADP = °C SELECTED ADP = 11 °C

Δt
QUANTITY OF DEHUMIDIFIED AIR
(1-0.2BF) x (°C Loc 24 - 11 ADP) = 10.4 °C

m3/h
19775 EFFEC. ROOM SENS. / 0.3 x 10.4°C Δt = 6338 m³/h

Δt outlet
ROOM SENS. HEAT / 0.3 x m³/h Dehumidified = °C (Room - Air outlet)*

AIR SUPPLIED FLOW

m³/h Supplied
Room Sen. Heat / 0.3 x °C Δt = m³/h

m³/h By-passed
m³/h AS - m³/h AD = m³/h

INLET AND OULET CONDITIONS OF THE DEVICE

DB Inlet
Tr °C + m³/h EA / m³/h ǂ (Tae - Tr) = Tdbe °C

DB Outlet
Tadp °C + BF (Tdbe - Tadp) = Tdbs °C
From Psychrometric chart Twbe °C Twbs °C

NOTES

- * If this Δt is too high, determine the m³/h supplied by the difference desired, by the way of te amount of impulsed air
- ǂ When using a by-pass of mixed air of exterior air and returned air, use m³/h supplied.

When by-passing only return air, use m³/h dehumidified.

FORM 2

1-3-53

SHEET: 6/7
PREPARED BY: M. PEREZ OFICCE: ______
CUSTOMER ______
LOCATION SEVERINO PUMPING STATION

DATE: 10/1994
PROJECT ______ INSTALATION N° 2
APROVED BY ______

SPACE USED BY CONFERENCE ROOM
LOCAL DIMENSIONS m x m = 35.75 m² x 3 m = 107 m³

CONCEPT	AREA	SOLAR GAIN OR TEMP. DIFFERENCE	FACTOR	Kcal/h
SOLAR - GAIN - GLASS				
Glass SE	2,7 m²x	320	x 0.45	389
Glass	m²x		x	
Glass	m²x		x	
Glass	m²x		x	
Skylight	m²x		x	
SOLAR - GAIN - & TRANS. WALLS & ROOF				
WALL SE	24.8 m²x	8	x 1.90	377
WALL NE	32.5 m²x	8	x 1.90	494
WALL NO	24.5 m²x	8	x 1.90	372
WALL	m²x			
ROOF-SUN	35.75 m²x	18	x 1.37	882
ROOF-SHADE	m²x		x	
GAIN. TRANS.- EXCEPT WALL AND ROOF				
Total Glass	2.7 m²x	9	x 5.5	134
Divisory wall - Door	3.0 m²x	9	x 2.5	68
Roof	m²x		x	
Floor	35.75 m²x	8	x 1.02	292
Filtering	m³/h			
INTERNAL HEAT				
People	15	people	x 61	915
Power	1.2	KW	x 860	1032
Light	440	Watts x 0.86→	x 1.25	550
Applications			x	
Additional Gains			x	
			SUBTOTAL	
Storage	m²x		x (-)	
			SUBTOTAL	5505
Safety Factor		10 %		551
ROOM SENSIBLE HEAT				6056
Imp. Duct heat gain	4.5 % +	Loss due to leaks 2 % +	KW Fan 3.5%	606
Outside air	375 m³/seg x 9°C	x	0.10 BF x 0.3	203
EFFECTIVE ROOM SENSIBLE HEAT				6865
LATENT HEAT				
INFILTRATION		m³/seg x		
People		15 people	x 52.0	780
Vapor		KG/h x		
Applications				
Additional Gains				
Vapor Difussion	m²x	GR KG		
			SUBTOTAL	
Safety Factor		%		
			ROOM LATENT HEAT	
IMPULTION DUCT FILTRATION LOSS			2 %	121
outside air	375 m³/h x 25 GR KG	x 0.2	BF x 0.72	1350
			EFFECTIVE ROOM LATENT HEAT	2251
			EFFECTIVE ROOM TOTAL HEAT	9116
OUTSIDE AIR HEAT				
Sensible	375 m³/h	x 9°C(1-0.2 BF) x	0.3	810
Latent	375 m³/seg x 25 GR KG x (1-0.BF) x		x 0.72	5400
			Subtotal	
Return Duct heat Gian 2% +	Return Duct Leakage Gain 1% +	C.V. Pump %+	Dehumid. & Pipe Loss %	273
GREAT TOTAL OF HEAT				15593

CALCULATED FOR	LOCAL HOUR / SOLAR HOUR	MAX LOAD	LOCAL HOUR / SOLAR HOUR

Working Hours					
Conditions	DB	WB	% HR	T.R.	GR KG
Exterior	33		70		
Interior	24		50		
Difference	9				

OUTSIDE AIR

VENTILATION
15 people x 25 m³/h = 375
______ m x ______ m³/h = ______
m³/h ventilation

INFILTRATION
revolving doors ___ x ___ people m³/h people = ___
open doors ___ x ___ doors m³/h m³ = ___
Extractor ______
Cracks ___ m x m³/h ______ m³/h = ______
m³/h Infiltration ■
m³/h OUTSIDE AIR ■ ______ m³/h

ADP

SHFE SHF EFFECTIVE = ______ EFFECTIVE ROOM SENS / EFFECTIVE ROOM TOTAL HEAT = ___

ADP INDICATED ADP = ______ °C SELECTED ADP = 11 °C

QUANTITY OF DEHUMIDIFIED AIR

Δt (1-0.2BF) x (°C LCC 24 - 11 ADP) = 10.4 °C

m³/h 6865 EFFEC. ROOM SENS / 0.3 · 10.4 °C Δt = 2200 m³/h

Δt outlet ROOM SENS. HEAT / 0.3 · m³/h Dehumidified = °C (Room - air outlet) *

AIR SUPPLIED FLOW

m³/h Supplied Room Sen. Heat / 0.3 x °C Δt = ______ m³/h

m³/h By-passed ___ m³/h AS - ______ m³/h AD = ______ m³/h

INLET AND OULET CONDITIONS OF THE DEVICE

DB Inlet Tr ______ °C + m³/h EA / m³/h ǂ (Tae ___ - Tr ___) = Tdie ___ °C

DB Outlet Tadp ___ °C + ___ BF (Tdie ___ - Tadp ___) = Tdie ___ °C
From Psychometric chart Twbe ______ °C Twbs ______ °C

NOTES

* If this Δt is too high, determine the m³/h supplied by the difference desired, by the way of te amount of impulsed air

ǂ When using a by-pass of mixed air of exterior air and returned air, use m³/h supplied.

When by-passing only return air, use m³/h dehumidified.

FORM 2

SHEET: 7/7
PREPARED BY: H. PEREZ OFFICE
CUSTOMER
LOCATION SEVERINO PUMPING STATION

DATE 10/1994
PROJECT ________ INSTALATION N° 2

APROVED BY ________

SPACE USED BY TELEPHONE ROOM
LOCAL DIMENSIONS m x m = 16.5 m² x 3 m = 50 m³

CONCEPT	AREA	SOLAR GAIN OR TEMP. DIFFERENCE	FACTOR	Kcal/h
SOLAR - GAIN - GLASS				
Glass SE	2.7 m²x	320	x 0.45	389
Glass	m²x		x	
Glass	m²x		x	
Glass	m²x		x	
Skylight	m²x		x	
SOLAR - GAIN - & TRANS. WALLS & ROOF				
WALL SE	12.3 m²x	8	x 1.90	187
WALL	m²x		x	
WALL NO	13.4 m²x	8	x 1.90	204
WALL	m²x			
ROOF-SUN	16.5 m²x	18	x 1.37	407
ROOF-SHADE	m²x		x	
GAIN. TRANS.- EXCEPT WALL AND ROOF				
Total Glass	2.7 m²x	9	x 5.5	134
Divisory wall - Door	1.6 m²x	9	x 2.5	36
Roof	m²x		x	
Floor	16.5 m²x	8	x 1.02	135
Filtering	m³/h			
INTERNAL HEAT				
People	2	people	x 61.0	122
Power	1	KW	x 860.0	860
Light	120	Watts x 0.86	x 1.25	129
Applications			x	
Additional Gains			x	
			SUBTOTAL	
Storage	m²x		x (-)	
			SUBTOTAL	2603
Safety Factor		10 %		260
ROOM SENSIBLE HEAT				2863
Imp. Duct heat gain 4.5 % +	Loss due to leaks 2 % +		KW Fan 3.5%	286
Outside air	76 m³/seg x 9 °C	x	0.2 UF x 0.3	41
EFFECTIVE ROOM SENSIBLE HEAT				3190
LATENT HEAT				
INFILTRATION		m³/seg x		
People	2	people	x 52.0	104
Vapor	KG/h	x		
Applications				
Additional Gains				
Vapor Difussion	m²x	GR.KG		
			SUBTOTAL	
Safety Factor		%		
			ROOM LATENT HEAT	
IMPULTION DUCT FILTRATION LOSS			2%	57
outside air	76 m³/h x 25 GR.KG x		0.2 UF x 0.72	274
			EFFECTIVE ROOM LATENT HEAT	435
			EFFECTIVE ROOM TOTAL HEAT	3625
OUTSIDE AIR HEAT				
Sensible	76 m³/h	x 9 °C (1- 0.2 BF) x	0.3	164
Latent	76 m³/seg x 25 GR.KG x (1- BF) x		x 0.72	1094
			Subtotal	
Return Duct heat Gain 2 % +	Return Duct Leakage Gain 1 % +	C.V. Pump % +	Dehumid & Pipe Loss %	108
GREAT TOTAL OF HEAT				4991

CALCULATED FOR	LOCAL HOUR SOLAR HOUR	MAX. LOAD	LOCAL HOUR SOLAR HOUR

Working Hours

Conditions	DB	WB	% HR	T.R.	GR.KG
Exterior	33		70		
Interior	24		50		
Difference	9				

OUTSIDE AIR

VENTILATION
______ people x ______ m³/h = ______
______ m x ______ m³/h = ______
m³/h ventilation

INFILTRATION
revolving doors ___ x ___ people m³/h people = ___
open doors ___ x ___ doors m³/h m² = ___
Extractor ______
Cracks ___ m x m³/h ______ m³/h = ______
m³/h Infiltration =
m³/h OUTSIDE AIR = ______ m³/h

ADP

SHFE
SHF EFFECTIVE = ______ EFFECTIVE ROOM SENS / EFFECTIVE ROOM TOTAL HEAT =

ADP
INDICATED ADP = ______ °C SELECTED ADP = 11 °C

Δ T
QUANTITY OF DEHUMIDIFIED AIR
(1-0.2BF) x (°C Loc 24 - 11 ADP) = 10.4 °C

m3/h
3190 EFFEC. ROOM SENS / 0.3 x 10.4 °C Δ T = 10.22 m³/h

Δ T outlet
ROOM SENS. HEAT / 0.3 x m³/h Dehumidified = °C (Room - air outlet)

AIR SUPPLIED FLOW

m³/h Supplied
Room Sen. Heat / 0.3 x °C Δ T = ______ m³/h

m³/h By-passed
______ m³/h AS - ______ m³/h AD = ______ m³/h

INLET AND OULET CONDITIONS OF THE DEVICE

DB Inlet
Tr ______ °C + m³/h EA / m³/h ‡ (Tae ___ - Tr ___) = Tdbe ___ °C

DB Outlet
Tadp ______ °C + ______ UF (Tdbe ______ - Tadp ______) = Tdbs ___ °C
From Psychrometric chart Twbe ______ °C Twbs ______ °C

NOTES

- If this Δ T is too high, determine the m³/h supplied by the difference desired, by the way of te amount of impulsed air

‡ When using a by-pass of mixed air of exterior air and returned air, use m³/h supplied.

When by-passing only return air, use m³/h dehumidified.

FORM 2

1-3-55

GRAFICO 10. RELACIÓN L/Q

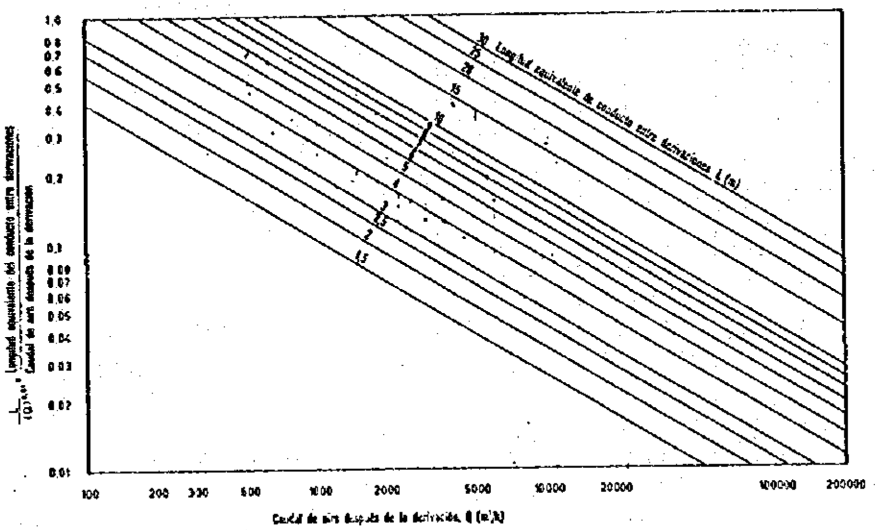
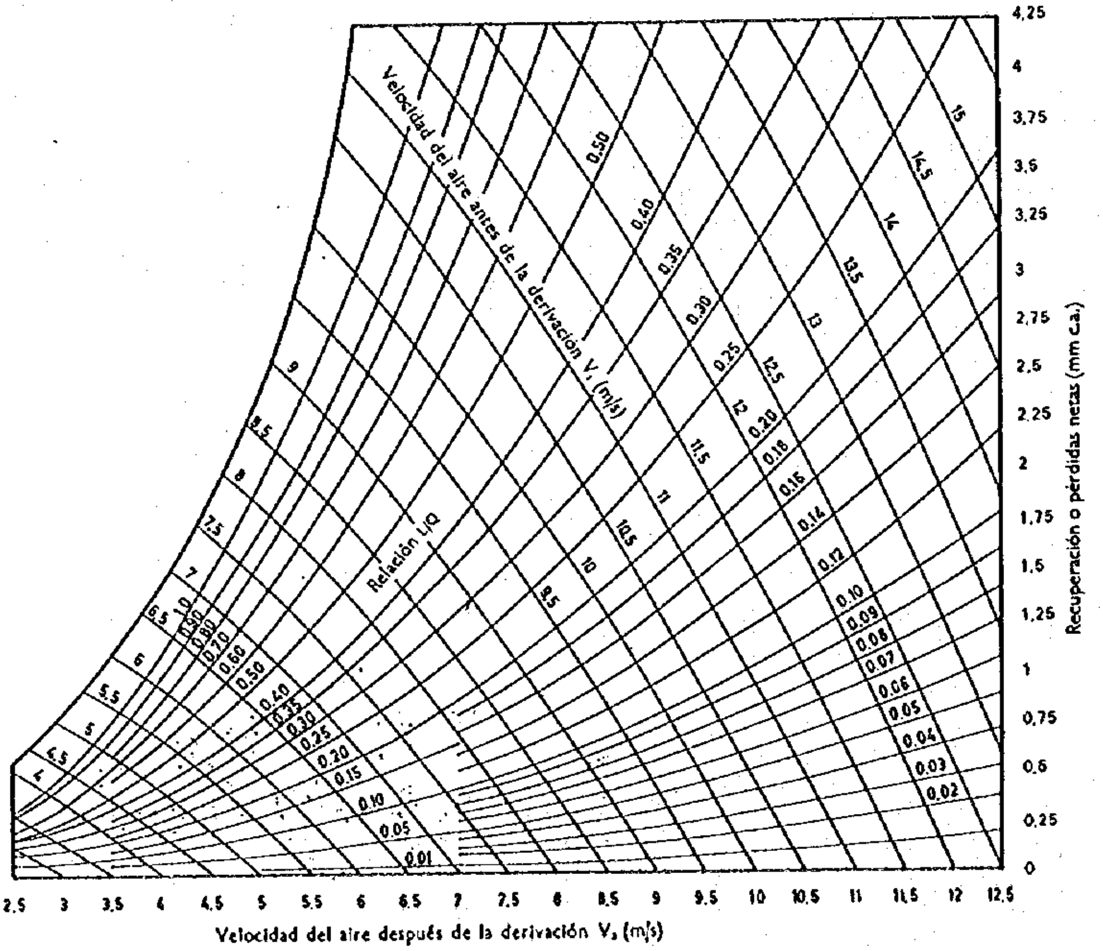


GRAFICO 11. RECUPERACIÓN ESTATICA EN BAJA VELOCIDAD



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1.3 (5) Sanitary Installations

(A) Sanitary Installations

1 GENERALIDADES

La presente memoria técnica describe el cálculo, diseño y dimensionamiento de las instalaciones sanitarias, tanto interiores como exteriores de la Estación de Bombeo Severino.

2. ALCANCE DEL PROYECTO

El sistema de abastecimiento de agua para la Estación de Bombeo comprende el suministro de agua potable, agua para uso sanitario y el sistema para protección de incendios.

El agua cruda es obtenida desde la tubería de enfriamiento de la bomba en el nivel 45.000. El equipo de tratamiento consiste de un tanque de filtración, tanque de almacenamiento de agua tratada, bombas de alimentación, tanque hidroneumático y unidades de esterilización instaladas en el nivel 50.000.

El agua para uso doméstico y sanitario, es filtrada a través de filtros de arena, clorinada automáticamente, almacenada en el tanque de agua tratrada y distribuida a todos los servicios por medio del conjunto bomba - tanque hidroneumàticio.

El sistema de protección contra incendios es independiente y funciona a través de su propio sistema de bombeo. El agua para el sistema no es tratada y es suministrada desde el tanque de almacenimiento de agua cruda, ubicado en el nivel 45.000.

El sistema de drenaje y desagüe esta constituido por las aguas de desecho y aguas negras (residuales).

Las aguas negras y de desecho son colectadas en el tanque séptico, y bombeadas al sistema de drenaje de aguas negras después de ser tratadas, descargando a las zanjas de infiltración.

3. SISTEMA DE AGUA POTABLE

3.1 Alimentación del Sistema

La alimentación de agua cruda proveniente del embalse, se realiza a través de una derivación del sistema de suministro de agua de enfriamiento, almacenándose en el tanque

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de agua cruda; de este tanque, se bombea hacia la unidad de tratamiento y se almacena en el tanque para agua tratada.

3.2 Tanques de Almacenamiento y Equipos

El volúmen del tanque de incendios se determinó en 12.0 m^3 y el volúmen del tanque de agua tratada en 4.0 m^3 . Volúmenes que se obtuvieron, en incendios al considerar dos hidrantes funcionando durante 40 minutos con un caudal total de 5.0 l/s y en agua potable dotaciones de 70 l/hb x día para un total máximo de 30 personas.

Los tanques serán metálicos y herméticos con tapas sanitarias y bocas de ventilación para su mejor operación y mantenimiento.

Para el sistema contra incendios será necesaria una bomba centrífuga de eje horizontal que maneje un caudal de 5.0 lit./s a una altura dinámica total de 60 m, acoplada a un motor de 5.5 Vw, de 3500 rpm, corriente trifásica 220/440 v y 60 ciclos.

En el sistema de agua potable se utilizará el siguiente equipo; dos bombas una de reversa y otra de operación, centrífugas de eje horizontal para un caudal de 1.5 l/s, con una altura dinámica total de 15.0 m, acopladas a un motor de 0.75 kw, de 3500 rpm, 220 v y 60 ciclos, la succión y descarga de la bomba serán de 40 mm de diámetro. Estas bombas alimetarán desde el nivel 45.000 a la unidad de filtración ubicada en el nivel 50.000.

Una unidad de filtración, con arena como medio filtrante, con capacidad de 50 l/min con una bomba para retrolavado.

Una unidad de clorinación compuesta básicamente por una bomba dosificadora de diafragma y un tanque de almacenamiento para la solución de hipoclorito.

Dos bombas centrífugas (operación y reserva) para un caudal de 1.1 l/s, con una altura dinàmica total de 43 m, acopladas a un motor de 3.0 kw, de 3500 rpm, 220 v y 60 ciclos, con succión y descarga de 32 mm de diámetro. La descarga de la bomba irá acoplada a un tanque hidroneumàtico de 500 l/s de capacidad y 10 bar. de presión de trabajo, con presiones mínimas y máximas de 43 m y 60 m respectivamente.

Finalmente se dispondrá de un compresor de aire, con presión mínima de 6.0 atm, caudal de aspiración de 3900 lit/hora y una potencia de 1.5 kw.

3.3 Red de Agua Potable

La red de distribución se inicia en la salida del tanque hidroneumático, en el nivel 50.000; a partir de este nivel existe una columna principal de 32 mm de diámetro que llega hasta el nivel 70.000, donde se deriva en ramales que dan servicio a todos los aparatos sanitarios de la estación de bombeo.

Para la determinación de caudales de diseño y diámetros en cada una de las tuberías se ha considerado: caudales tipo entre 0.10 l/s y 0.15 l/s para los distintos aparatos, el porcentaje de simultaniedad correspondiente (100%) y que la velocidad en la tuberías se encuentre en el rango de 1.5 a 2.0 m/s.

De acuerdo a las variables anteriormente descritas y considerando las pérdidas de carga tanto localizadas como de fricción, se ha determinado para el uso sanitario más elevado y alejado del punto de alimentación, que la presión mínima necesaria que se debe suministrar es de 43.0 m.

Las tuberías y accesorios serán de hierro galvanizado de acuerdo a las especificaciones.

Para direccionar el flujo en cierto sentido o interrumpir, se ha colocado válvulas check o de paso en diferentes tramos de la red, las mismas que deberán cumplir con las especificaciones respectivas y serán instaladas en la cantidad y sitios indicados en los planos.

3.4 Red de Distribución de Agua Caliente

La temperatura promedio de la zona de 25 °C y un clima cálido - húmedo a determinado que este servicio se preste a las unidades del fregadero de cosina y cuarto de duchas.

El equipo de generación de agua caliente está constituido por dos calentadores eléctricos instantáneos de 7.0 litros y 1.5 kw.

4. SISTEMA CONTRA INCENDIOS

El agua para la red de incendios no será tratada, será agua cruda proveniente del embalse la Esperanza. El tanque de almacenamiento-reserva de agua cruda será de 12.0 m^3 y el control del afluente se realizará a través de una llave de flotador.

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El sistema tiene una bomba de alimentación independiente, con un ramal de derivación para recirculación; la red de distribución alimenta a todos los niveles de la estación de bombeo, cada nivel está cubierto por dos cojinetes contra incendio. El diámetro de la columna principal es de 65 mm y el de las derivaciones y tomas de 40 mm.

En la determinación de la altura dinámica total, se considera una presión mínima en cajetín de 24.0 m y las pérdidas de carga para el cajetín mas elevado y alejado del punto de alimentación.

Adicionalmente en el sistema contra incendios se considera extinguidores portátiles de incendio que se ubicarán en los ambientes cerrados, como se indica en los planos.

5. SISTEMA DE AGUAS RESIDUALES Y VENTILACIÓN

Este sistema comprende la tubería, accesorios, ramales, colectores, conexiones, bajantes, tuberías exteriores, cajas de revisión y tuberías de ventilalción.

5.1 Red de Aguas Residuales

En el diseño de la red de aguas negras se considera como unidad de desague 0.47 l/s; las unidades de descarga consideradas para los distintos aparatos fluctúan entres 2 y 5, tomadas para uso de oficinas.

Las derivaciones de retretes (wc) tienen un diámetro de 110 mm y los demás desagues provenientes de otros aparatos sanitarios tendrán un diámetro mínimo de 50 mm. La pendiente mínima de los ramales colectores será del 1%. Los ramales colectores descargan a cajas de revisión independientes como se indica en los planos.

Las aguas negras y de desecho son recolectadas en el tanque séptico, una vez tratadas, son bombeadas a la red de drenaje de aguas negras y descargadas a la zanja de infiltración de 42.0 m de longitud.

La red de aguas negras y de desecho estará compuesta en su totalidad de tubería de pvc. y obedecerá a las especificaciones técnicas.

El tanque séptico será de hormigón armado y sus dimensiones exteriores en planta son 2.33 m x 4.51 m y su emplazamiento como se indica en los planos. Esta coformado por una

1-3-60

doble cámara y filtro de material granular, un tanque biodigestor, un depósito de contacto para desinfección y un equipo de bombeo de las aguas tratadas.

5.2 Red de Ventilación

Para evitar pérdidas del sello hidráulico en los desagües de los aparatos sanitarios en la batería de servicios, se ha diseñado un sistema de ventilalción sanitaria.

La red de ventilación esta conformada en su totalidad con tuberías de pvc 50 mm de diámetro, y está constituida de ramales de ventilación con pendiente al aparato sanitario de 0.5%, que se conectan a la columna de ventilación; en la parte superior de la columna se ubicará un sombrerete.

(B) Formulas

FÓRMULAS

1) $V = 1.273 * Q/D^2$

V : Velocidad del flujo (m/s)
Q : Caudal (m^3/s)
D : Diámetro de la tubería (m)

2) $$hf = \left(\frac{Q}{0.28 * C * D^{2.63}}\right)^{1.85} * L$$

$$hl = K \frac{V^2}{2g}$$

hf : Pérdidas de carga por fricción (m)
hl : Pérdidas de carga localizadas (m)
Q : Caudal (m^3/s)
D : Diámetro (m)
L : Longitud (m)
C : Coeficiente (120 acero)
v : Velocidad (m/s)
g : Gravedad (m/s^2)
K : Coeficiente en función del accesorio

Accesorio	K
Codo 90°	1.0
Reductor	0.5
Tee	1.0
Val. compuerta	1.0
Válvula check	1.0

3) $$P = \frac{\gamma * Q * HDT}{76.2 * \eta}$$

P : Potencia (Hp)
Q : Caudal (m^3/s)
γ : Peso específico (1000 kg/m^3)

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HDT : Altura dinámica total (m)
η : Eficiencia (0.6 adoptada)

4) $$V = Q * \frac{25}{sc} * \left(\frac{pl + 1}{p1 - p2}\right)$$

V : Volumen tanque hidroneumático (lit)
Q : Caudal máximo absoluto (lit/min)
Sc : Número de disparos máximos por hora (15)
p1 : Presión máxima de trabajo (atm)
p2 : Presión mínima de trabajo (atm)

5) $$V = 1.3 N (C * T + 100 * Lf)$$

V : Volumen útil total del tanque séptico (lit)
N : Número de usuarios (hb)
C : Producción Aguas Negras (50 l/dia - hb)
T : Período de detención (1 dia)
Lf : Producción de lodo fresco (0.20 l/dia - hb)

6) $$L = \frac{N * Q}{2 * D * I}$$

L : Longitud de la zanja de infiltración (m)
N : Número de usuarios (hb)
Q : Contribución (caudal) (lit/hb-dia)
D : Profundidad efectiva de la zanja (m)
I : Velocidad de infiltración (18 l/dia-m^2)

7) Equivalencias

1 hp = 0.746
1 Gal = 3.784
1 atm = 10 m H_2O
1 atm = 14.7 psi

1-3-13

(C) Cold and hot Domestic Water

1. GENERAL ASSUMPTIONS

- For the calculation, the following flows in each faucet are adopted

SANITARY DEVICE	FLOW	SIMBOLOGY
Lavatory sink	0.10	(L)
Shower	0.10	(SH)
Water closet	0.10	(WC)
Slop sink	0.15	SK, S
Faucet	0.10	(F)

- The speed of water flow in pipeline are between 1.0 and 2.0 m/s.

- The head losses in the pipeline is determined for the far away device and it is considered as 12 m of water head

- The hot water system including automatic heaters for the shower room and sink service.

2. CALCULATION AND ESTIMATION OF PERSONS IN THE STATION

ENVIRONMENT	AREA (m^2)	No. OF PERSONS persons/m^2	TOTAL PERSONS
Control room	99.0	1/22 m^2	3.0
Telecommunication room	15.0	1/15 m^2	1.0
	40.0	1/2 m^2	20.0
	47.0	1/10 m^2	5.0
	19.0	1/10 m^2	2.0
		Total	..........31.0

Normally we estimate that in the pumping station will stay 11 persons; in some special case (maximum) is considered that the conference room will stay at least 20 persons thus the total is 31 persons.

* 30 persons are considered for design.

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3. CONSUMPTION RATES AND RESERVE RATES OF DOMESTIC WATER

Considering that the area is used for offices, the consumption and reserve rates are the following:

No. OF PERSONS (p)	CONSUMPTION RATE l/p-day	CAPACITY l/day	No.RESERVE DAYS	RESERVE VOLUME liters
11.0	70	770	3.0	2,310
19.0	70	1,330	1.0	1,330
				3,640

* 40 m^3 is taking to design.

4. DIAMETERS AND FLOW RATE CALCULATION

Right branch

SH	F	S	L	U	WC	SK	Q. FLOW c/s	DIAMETER (mm)
0.1							0.1	20
0.1	0.1	0.15					0.35	20
0.1	0.1	0.15	0.2				0.55	25
0.1	0.1	0.15	0.2	0.2			0.75	25
0.1	0.1	0.15	0.2	0.2	0.2		0.95	32
0.1	0.1	0.15	0.2	0.2	0.2	0.15	1.10	3.2

Left branch

	S	F	F	Q. FLOW	DIAMETER
	0.15			0.15	20
	0.15	0.1	0.1	0.35	20
Stand pipe			1.10 + 0.35	1.45	3.2

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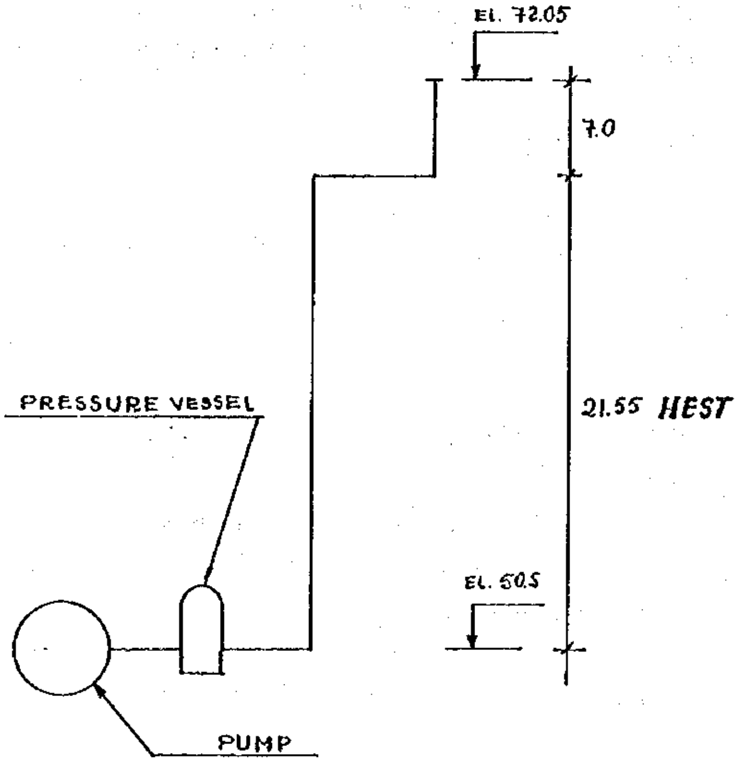
5. CALCULATION OF PUMP AND PRESSURE VESSEL

- Total dynamic head (HDT)

HDT = HEST + head service + HF

HEST : static head
HF : Head losses



HF = hl + hf
hl = fittings losses
hf = friction losses

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DIAMETER (mm)	Q Flow (l/s)	J Head losses	L Length (m)	hf (m)	V Speed (m/s)	Σk	hl (m)
20	0.10	0.0165	4.30	0.07	0.318	3.0	0.015
20	0.35	0.1470	22.95	3.37	1.11	2.5	0.16
25	0.55	0.0935	2.60	0.24	1.035	3.0	0.16
25	0.75	0.1610	2.40	0.39	1.411	1.0	0.10
25	0.95	0.2230	0.80	0.18	1.693	1.5	0.22
32	1.10	0.0765	2.50	0.19	1.144	4.0	0.27
32	1.45	0.1300	20.05	<u>2.61</u>	1.56	6.0	<u>0.74</u>
				7.05			0.67

HF = 7.05 + 1.67 = 8.72 ≅ 9.0 m

HDT = 21.55 + 12 + 9.0 + = 42.55 ≅ <u>43.0 m</u>

- Output of pump

$$P = \frac{100 * 0.0015 * 43}{762 * 0.60} = 1.41 \text{ Hp} * 1.5 = 2.12 \text{ Hp} = 2.84 \text{ Kw} \cong 3.0 \ \underline{\text{kW}}$$

- Pump features

Q = 90 l/min
HDT = 43.0 m
P = 3.0 kW, 220 v, 60 Hz, 3 Phases

- Calculation of pressure

Min. pressure = 43.0 m (at the starting)

Max. pressure $= \frac{4}{3} * 43.0 = 57.33$ (pump out of service)

Max. discharge simultaneous 1.5 l/s

Max. discharge $1.5 * \frac{2}{3} * 60 = 60 \text{ l} / \text{min}$

Pressure vessel capacity $= 60 * \frac{25}{15} * \left(\frac{5.7 + 1}{5.7 - 4.3}\right) = 478.6 \text{ l} \cong$ <u>126 gallons</u>

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6) DIMENSIONING OF EQUIPMENT

* Equipment at El. 45.0

- Raw water storage tank

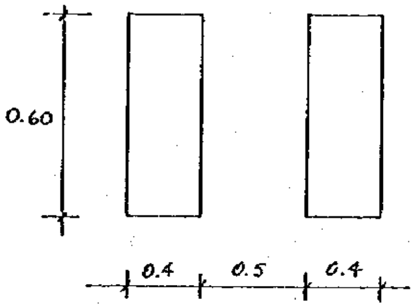
Volume = 12000 lit
Section = rectangular
Dimensions = 2.0 L * 3.0 w * 2.0 H

- Hydrant pump

Type = Centrifugal - horizontal shaft
Exterior dimensions: 0.40 * 0.60

- Feed pump for filtering

Type : centrifugal - horizontal shaft
Total exterior dimensions: 0.40 * 0.60



- Note: The final arrangement of the equipment at El. 45.0 m shall be as shown on the drawings.

* Treated water equipment

- Treated water storage tank

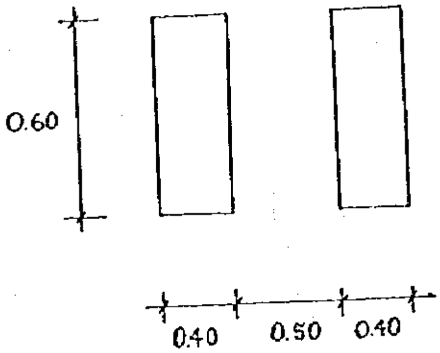
Volume : 4000 lit
Section : rectangular
Dimensions : 1.5 L * 1.5 w * 1.8 H

- Pressure vessel

Volume : 500 lit
Section : circular
Dimensions : 0.60 D * 1.80 H

- Feed pump for distribution system

Type : centrifugal - horizontal shaft
Total exterior dimensions: 0.40 * 0.60



- Water filter unit

Filter : sand
Type : circular
Dimensions : 0.50 D * 1.40 H

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Back washing pump
Type : centrifugal
Exterior dimensions: 0.40 * 0.60

- Chemical feeder pump of hypochlorite

Type : diaphragm
Dimensions : 0.40 * 0.60

- Hypochlorite solution tank

Volume : 200 lit (min 50 lit)
Dimensions : 0.5 L * 0.5 N * 0.8 H

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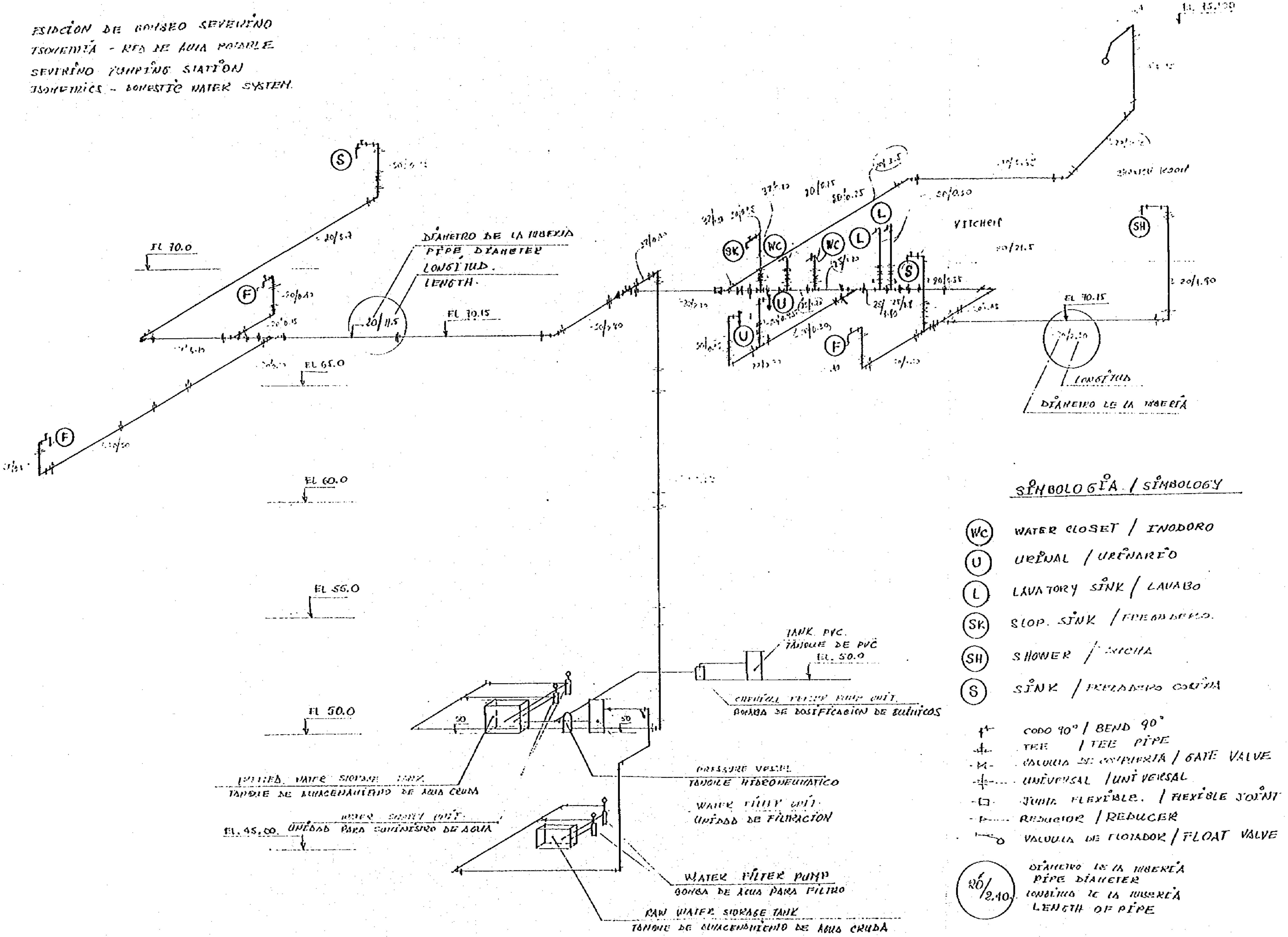
ESTACION DE BOMBEO SEVERINO
ISOMETRIA - RED DE AGUA POTABLE
SEVERINO PUMPING STATION
ISOMETRICS - DOMESTIC WATER SYSTEM



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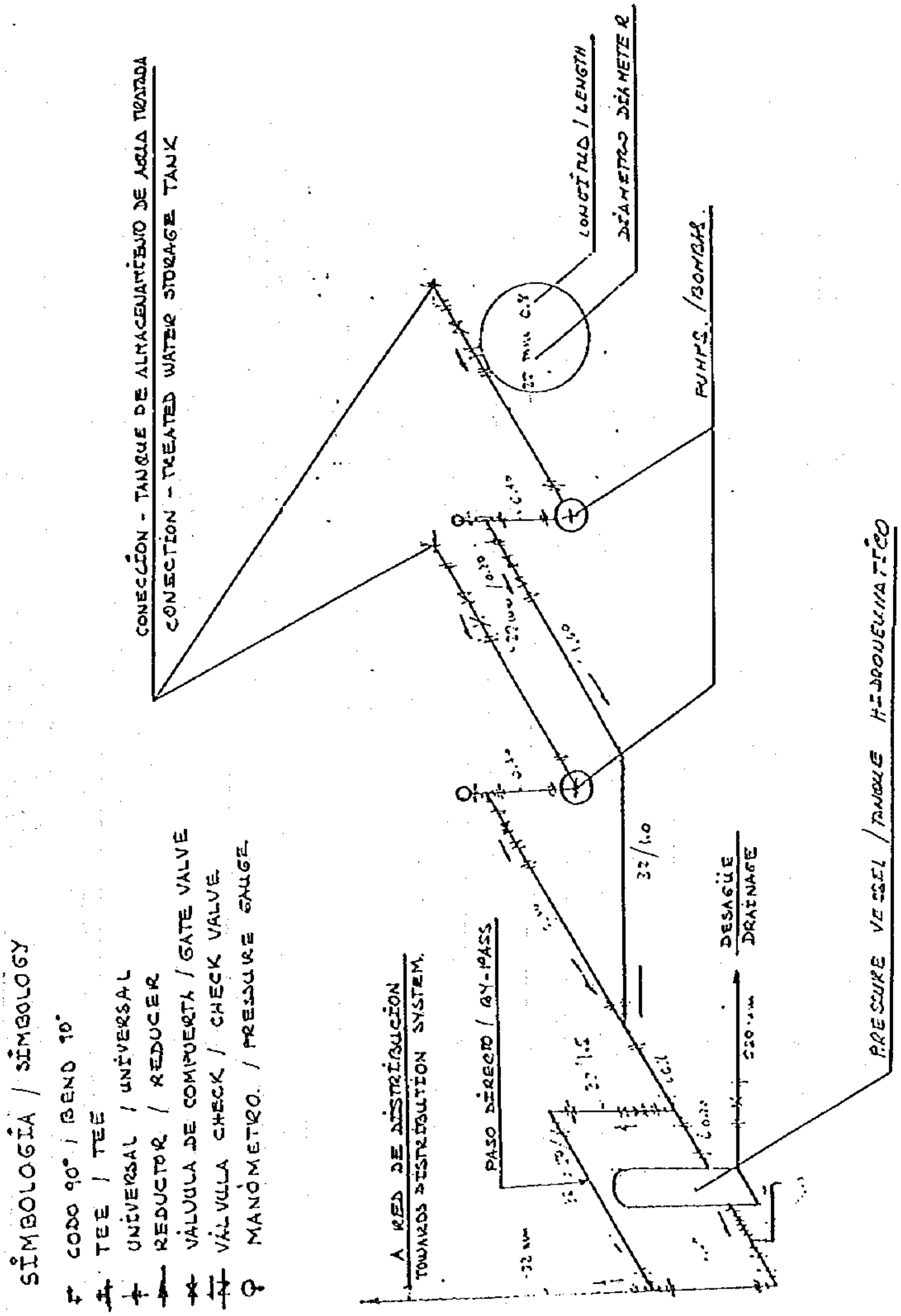
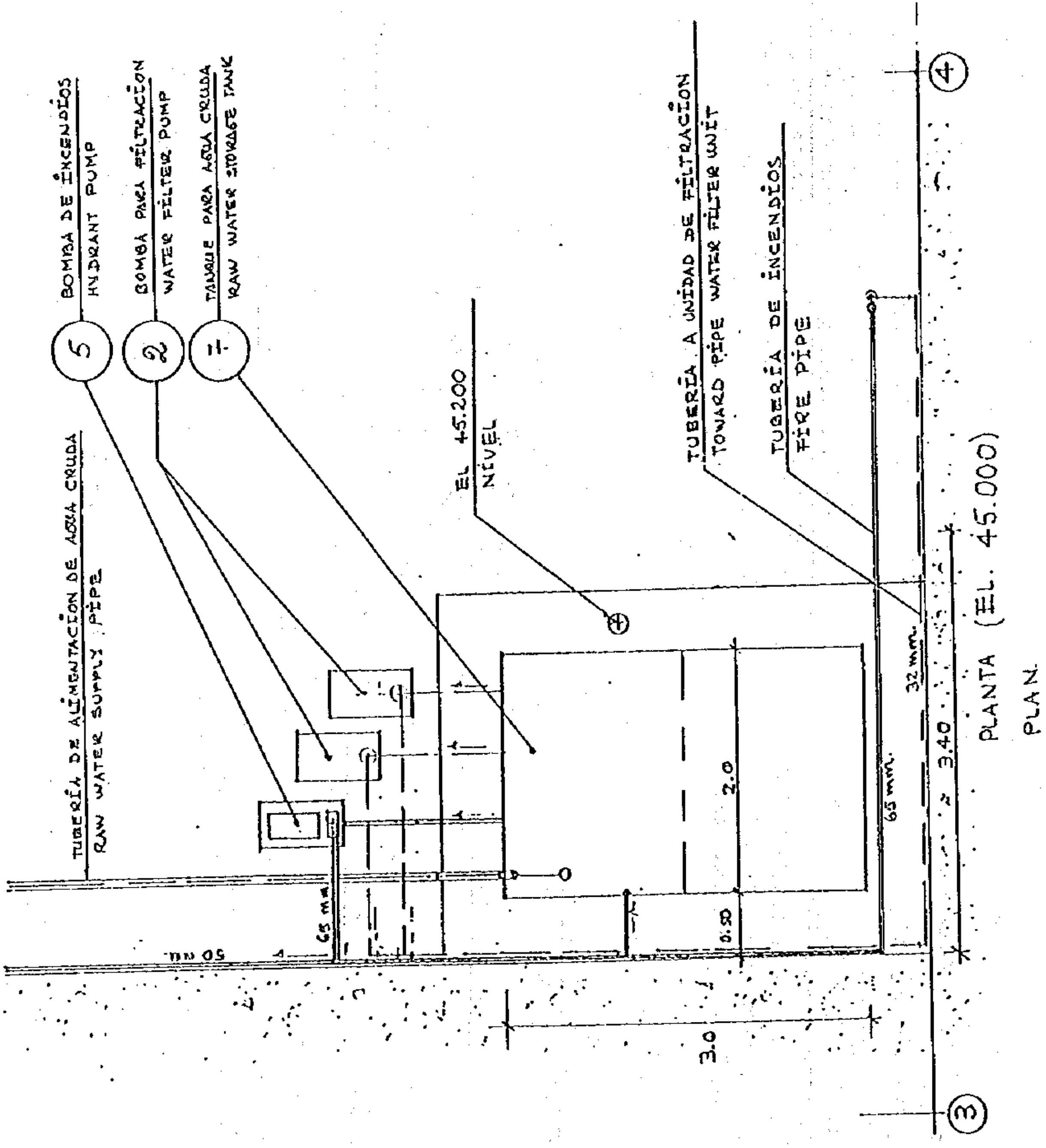
INSTALACIONES SANITARIAS / AGUA POTABLE
CONEXION BOMBA - TANQUE HIDRONEUMATICO.
SANITARY INSTALATIONS / DOMESTIC WATER
CONECTION PUMP - PRESSURE VESSEL



INSTALACIONES SANITARIAS
DISPOSICION EN PLANTA DE EQUIPOS
SANITARY INSTALATIONS
ARRANGEMENT OF EQUIPMENT PLAN.



PLANTA (EL. 45.000)
PLAN

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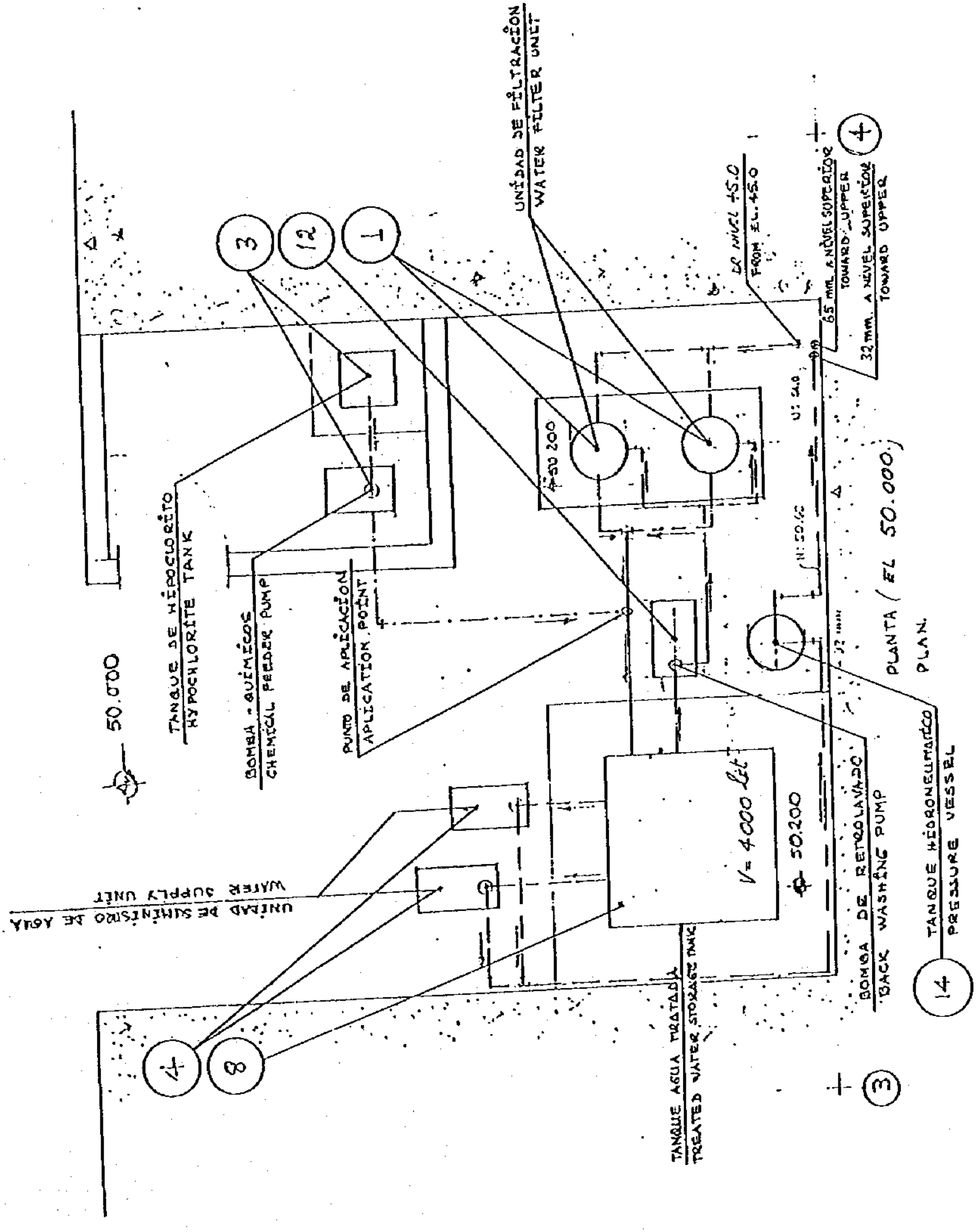
INSTALACIONES SANITARIAS

DISPOSICION EN PLANTA DE EQUIPOS

SANITARY INSTALATIONS

ARRANGEMENT OF EQUIPMENT PLAN.



(D) Fire Fighting System

1. GENERAL ASSUMPTIONS

- Itshall not be treated the fire network water, it shall be raw from La Esperanza dam.

- The minimum diameter of the column shall be 65 mm and the diameter of the diversions and inlets shall be 40 mm.

- It has been estimated the quantity of fire considering one hydrant-box for each 625 m^2 area (2 for each floor).

- The maximum distance between hydrant boxes shall not be less than 30 m neither greater than 60 m.

- The hydrant boxes dimensions shall be 900 H * 850 W * 250 D.

- The minimum pressure for each hydrant box shall be 24 m.

- The portable fire extinguishers shall be arranged at close locals, with quantity and characteristics as the drawings.

2. FIRE RESERVE

It has been considered two hydrants operating simultaneously during 10 minutes for the computation of the fire reserve, with a flow for each hydrant of 2.5 l/s.

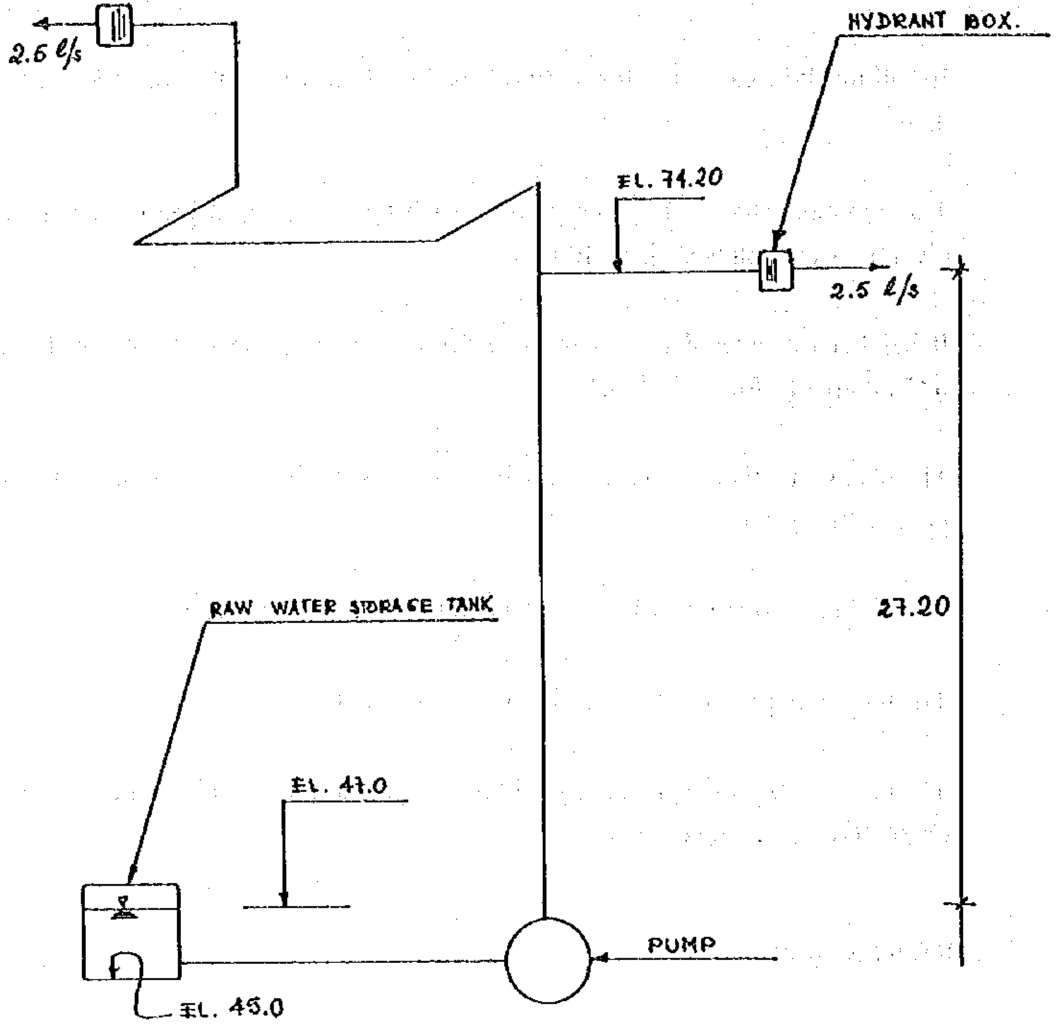
$$\text{Fire volume} = 2 * 2.5 \frac{l}{s} * 2400 \text{ s} = 12000 \text{ lit}$$

In Ecuador, the fire volume varies between 8 to 20 m^3.

3. COMPUTATION OF PUMPING SYSTEM

- It shall be considered one unit
- Flow total of design: 5 l/s; 2.5 l/s for each hydrant
- Computation squetch

1-3-76



HDT = HEST + CARG + HF

HF = hf + hl

HDT = Altura dinámica total
CARG = Presión en cajetín
HF = Pérdidas de carga
hf = Pérdidas de fricción
hl = Pérdidas localizadas

HEST = 27.2 m
CARG = 24.0 m

Computation of losses (HF)

- Losses until level 69.0

$$hf = \left(\frac{0.005}{0.28 * 120 * 0.065^{2.63}}\right)^{1.85} * 32.7 = 1.62 \text{ m}$$

FITTING	K	QUANTITY	Σk
90° Elbow	1.0	2.0	2.0
Reducer	0.5		
"T"	1.0	6.0	6.0
Gate valve	1.0	1.0	1.0
Check valve	1.0	1.0	1.0
			10.0

$$hl = 10 * \frac{\left[\frac{0.005 * 4}{\pi * (0.065)^2}\right]^2}{19.62} \quad 1.16 \text{ m} //$$

- Loss at the nearest hydrant
  Friction loss

DIAMETER mm	LENGTH m	hf m	v m/s
65	12.4	0.17	0.75
50	3.9	0.19	1.27
40	25.9	3.80	1.99

DAY	FITTING	K	QUANTITY	Σk	hl
65	90° Elbow	1.0	2.0	2.0	
	"T"	1.0	2.0	2.0	
				4.0	→ 0.11

1-3-78

DAY	FITTING	K	QUANTITY	Σk	hl
50	Reducer	0.5	2.0	1.0	
	Elbow	1.0	1.0	1.0	
	"T"	1.0	1.0	1.0	
				3.0	→ 0.25
40	90° Elbow	1.0	5.0	5.0	→ 1.0

hf total = 1.62 + 0.17 + 0.19 + 3.80 = 5.78
hl total = 1.16 + 0.11 + 0.25 + 1.0 = 2.52
HF = hf + hl 8.30 m

HDT = 27.2 + 24.0 + 8.30 = 49.5 m ≅ 60 m

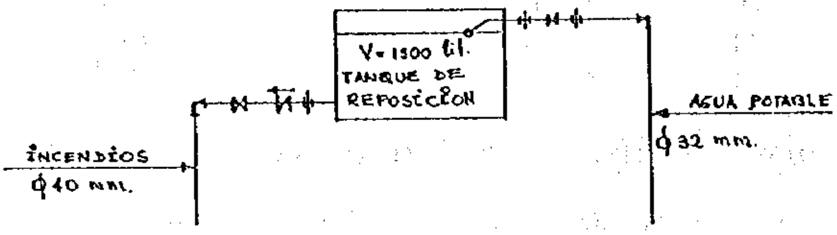
- Motor output

$$P = \frac{1000 * 0.005 * 60}{76.2 * 0.60} = 6.56\,Hp * 1.1 = 7.22\,Hp = 5.4\,kw = 5.5\,\underline{kW}$$

- Pump specifications

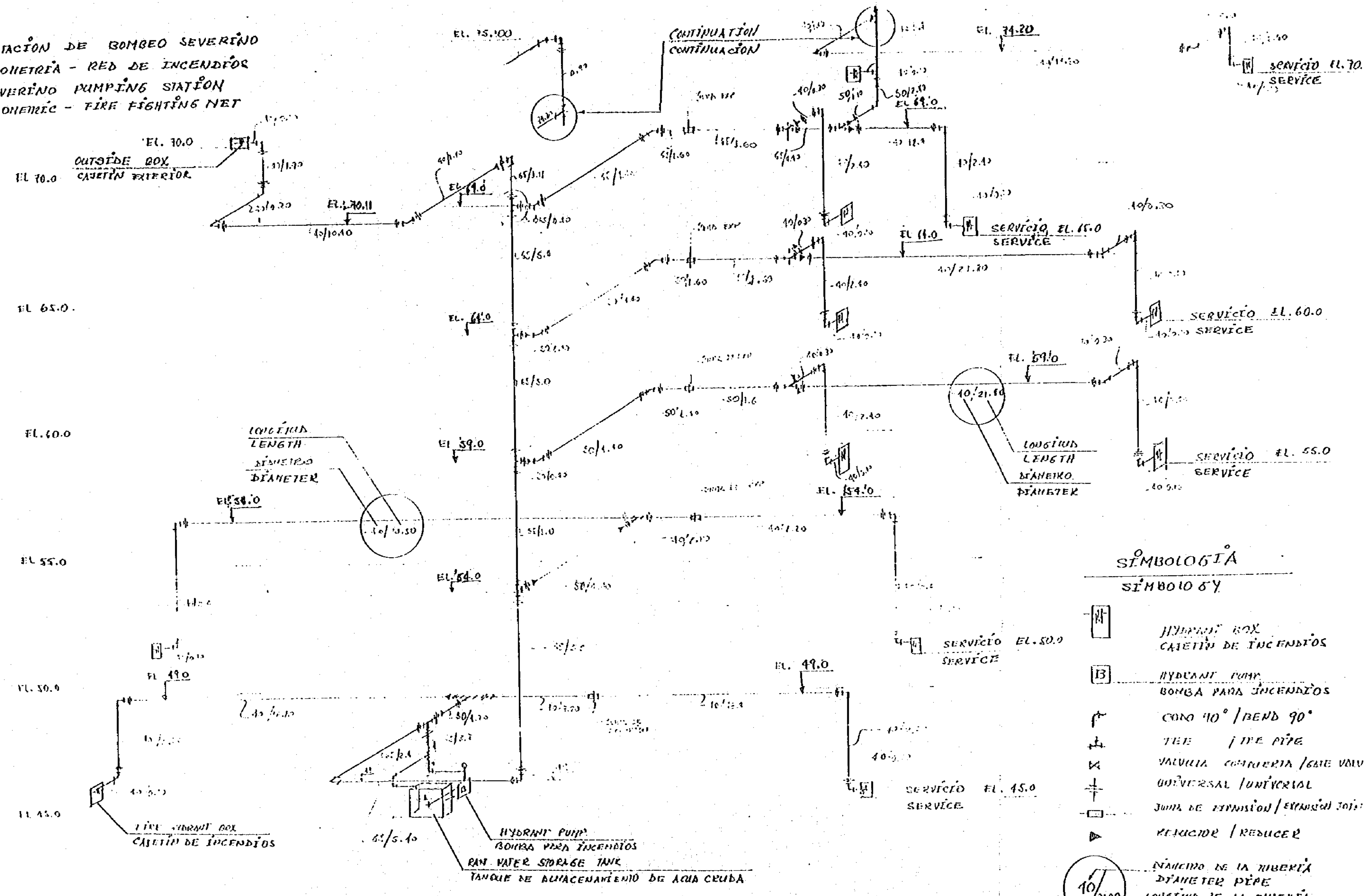
Q = 300 l/min
HDT = 60 m
P = 5.5 kW, 220 v, 60 Hz, 3 Phases.

- Squetch of the connection, level 75.100



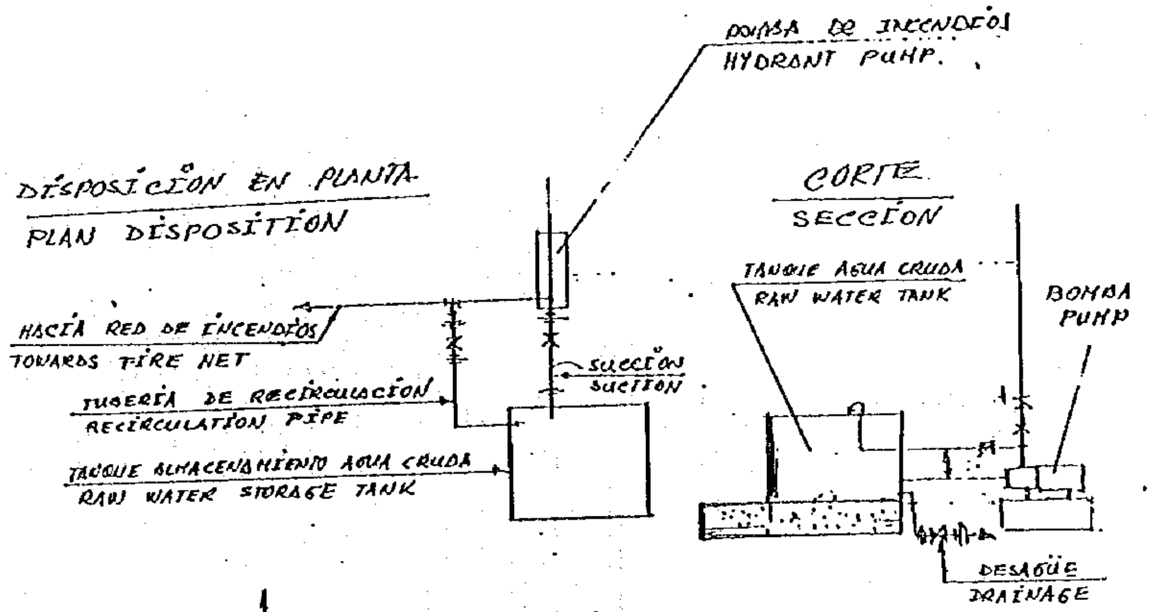
1-3-79

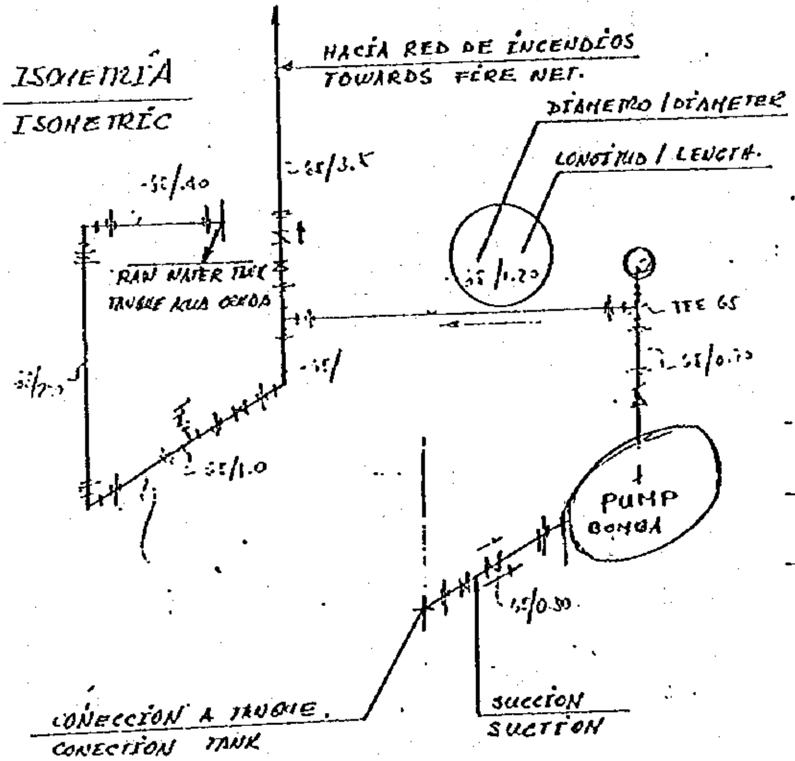
ESTACIÓN DE BOMBEO SEVERINO
ISOMETRÍA - RED DE INCENDIOS
SEVERINO PUMPING STATION
ISOMETRIC - FIRE FIGHTING NET

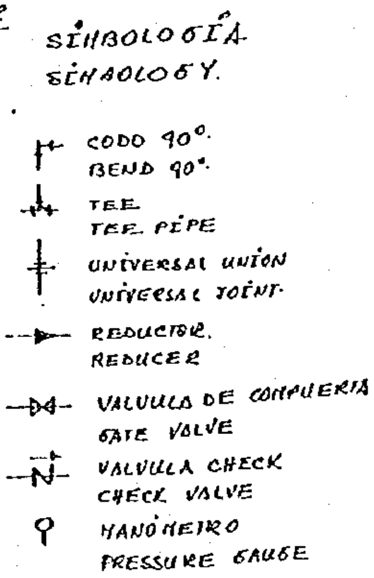


1-3-80

INSTALACIONES SANITARIAS / INCENDIOS
ISOMETRIA Y CONECCION . BOMBA - TANQUE - RED DE DISTRIBUCION
SANITARY INSTALATIONS / FIRE
ISOMETRIC AND CONECTION. PUMP - TANK - DISTRIBUTION SYSTEM

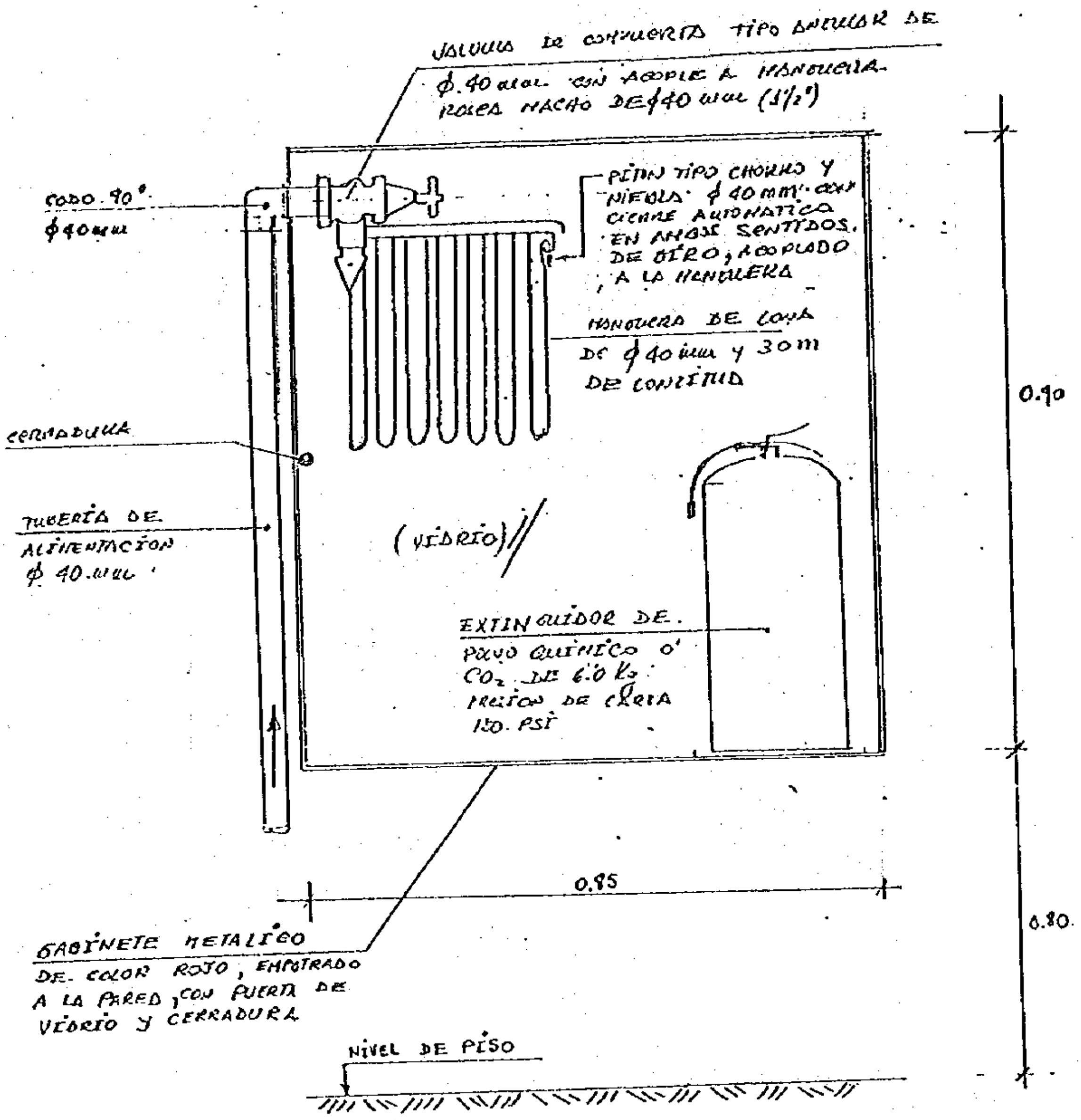






1-3-81

INSTALACIONES SANITARIAS / INCENDIOS
DETALLE TÍPICO DEL CAJETÍN CONTRA INCENDIOS
SANITARY INSTALATIONS / FIRE.
TYPIC DETAIL OF HYDRANT BOX.



1-3-82

(E) Sewerage and Ventilation Systems

1. GENERAL ASSUMPTIONS

- In the design it has been considered 28 l/min (0.47 l/s) as drainage unit.

- The drainage units considered for any used devices shall be the following:

Device	Symbology	Quantity	Minimum diameter of the drainage (mm)
Lavatory sink	L	2	50
Water closet	WC	5	100
Shower	SH	3	50
Slop sink	SK,S	3	50
Floor drain	FD	3	50
Urinal	U	2	50

- The water closet diversions shall have a 110 mm minimum diameter
- The collector branches shall discharge to independent check boxes
- The minimum slope collectors shall be 1%
- All drainage and ventilation piping shall be fabricated with PVC
- The couplings between branches shall be to 45°.

2. INSPECTION BOXES AND PIPING

RUN		QUANTITIES	DAY	LENGTH
From	To		mm	m
C-1	C-2	6	75	2.70
C-2	C-3	12	110	9.00
C-3	C-4	12	110	9.70
C-5	C-4	6	75	5.70
C-4	C-6	18	110	6.70
C-6	C-7	18	110	3.10
C-7	T.S.	18	110	1.10

1-3-89

RUN From	To	QUANTITIES	DAY mm	LENGTH m
CH-1	T.S.	17	110	0.6
T.S.	C-8	35	110	1.0
C-8	C-9	35	110	3.5
C-9	C-10	35	110	9.0
C-10	C-11	35	110	9.0
C-11	C-12	35	110	9.0
C-12	C-13	35	110	12.0
C-13	C14	35	110	13.0

Features of Inspection Boxes

Box No.	Inlet Elevation	Output Elevation	Dimensions
C-1	69.799	69.749	0.5 * 0.5
C-2	69.722	69.672	0.5 * 0.5
C-3	69.582	69.532	0.5 * 0.5
C-4	69.429	69.382	0.5 * 0.5
C-5	69.799	69.486	0.5 * 0.5
C-6	69.315	69.265	0.5 * 0.5
C-7	69.234	69.184	0.5 *0.5
C-8	69.500	69.450	0.5 * 0.5
C-9	69.415	69.365	0.5 * 0.5
C-10	69.275	69.225	0.5 * 0.5
C-11	69.135	69.085	0.7 * 0.7
C-12	68.995	68.945	0.7 * 0.7
C-13	68.825	68.825	0.7 * 0.7
C-14	68.645	68.595	0.7 * 0.7
CM-1	69.774	69.729	0.5 * 0.5

3. COMPUTATION SEPTIC TANK

- No. of persons: 30
- Sewage water production (c) : 50 l/day-hab
- Fresh sludge production (lf) : 0.20 l/day-hab

1-3-85

- Net volume : $1.3 * N * (C * T + 100 * lf)$

  Net volume : $1.3 * 30 * (50 * 1 + 100 * 0.2) = 2730$ lt//

4. DIMENSIONING AND OPERATION

- Minimum depth: 1.10 m
- Double chamber in series
- Chamber 1 volume $= \frac{2}{3} * 2730 = 1.82 \text{ m}^3$
- Chamber 2 volume $= \frac{1}{3} * 2730 = 0.91 \text{ m}^3$
- The filtration tank shall have granular material
- Oxidation chamber
- Contact deposit for desinfection
- Pumping equipment for treated water

  2 submergible pumps
  Q : 250 l/min
  HDT : 8.0 m
  P : 0.75 kW, 3Φ, 220v, 60 Hz, Φ 40 mm.

- Rectangular concrete of reinforced concrete of 2.33 m * 4.51 m
- The arrangement, inside distribution and dimensions are showed in respective drawings.

5. INFILTRATION DITCH SIZING

$$L = \frac{NQ}{2 * D * I}$$

L : Length (m)
N : Users number
Q : Flow l/hab-day
D : Net depth (m)
I : Infiltration speed

1-3-86

$$18\ \frac{1}{\text{day} * \text{m}^2}\ \text{(adopted in the design)}$$

$$L = 30\ \text{hab}\ 50\ \frac{1}{\text{hab} * \text{day}} * \frac{1}{2} * \frac{1}{1.0} * \frac{1\ \text{day}\ \text{m}^2}{18\ \text{l}} = 42\ \underline{\text{mm}}$$

Diameter piping Φ 1<u>10 mm</u>

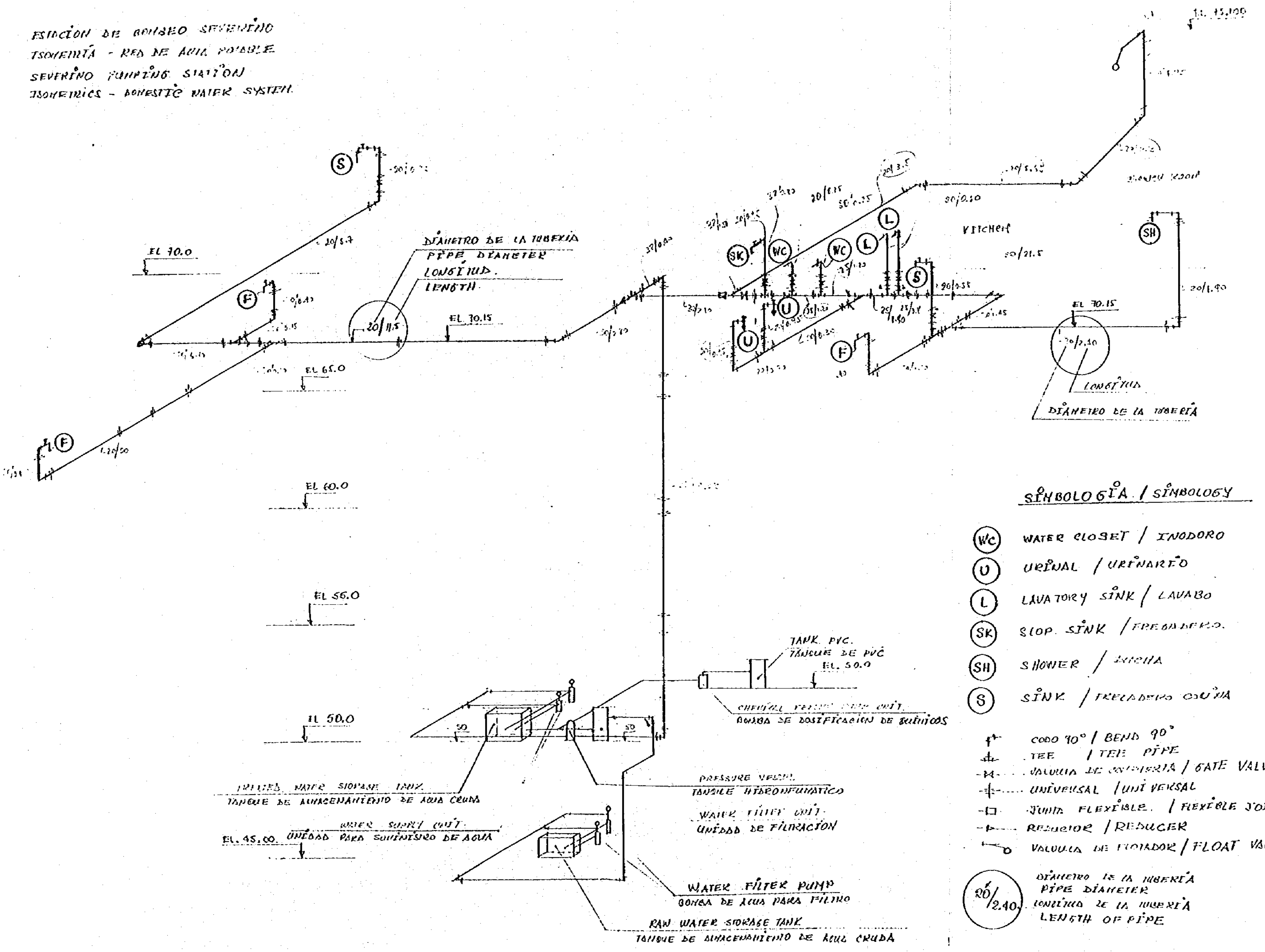
- Typical detail of infiltration trench

6. COMPUTATION PIPING OF VENTILATION

- All ventilation pipings shall be of 50 mm diameter and fabricated with PVC
- The ventilation there shall be only in rest room
- The ventilation camber shall have a slop to sanitary device of 0.5% and shall be connected to the ventilation column, which shall have a cap in its superior extreme.

1-3-87

ESTACION DE BOMBEO SEVERINO
ISOMETRIA - RED DE AGUA POTABLE
SEVERINO PUMPING STATION
ISOMETRICS - DOMESTIC WATER SYSTEM



SIMBOLOGIA / SIMBOLOGY

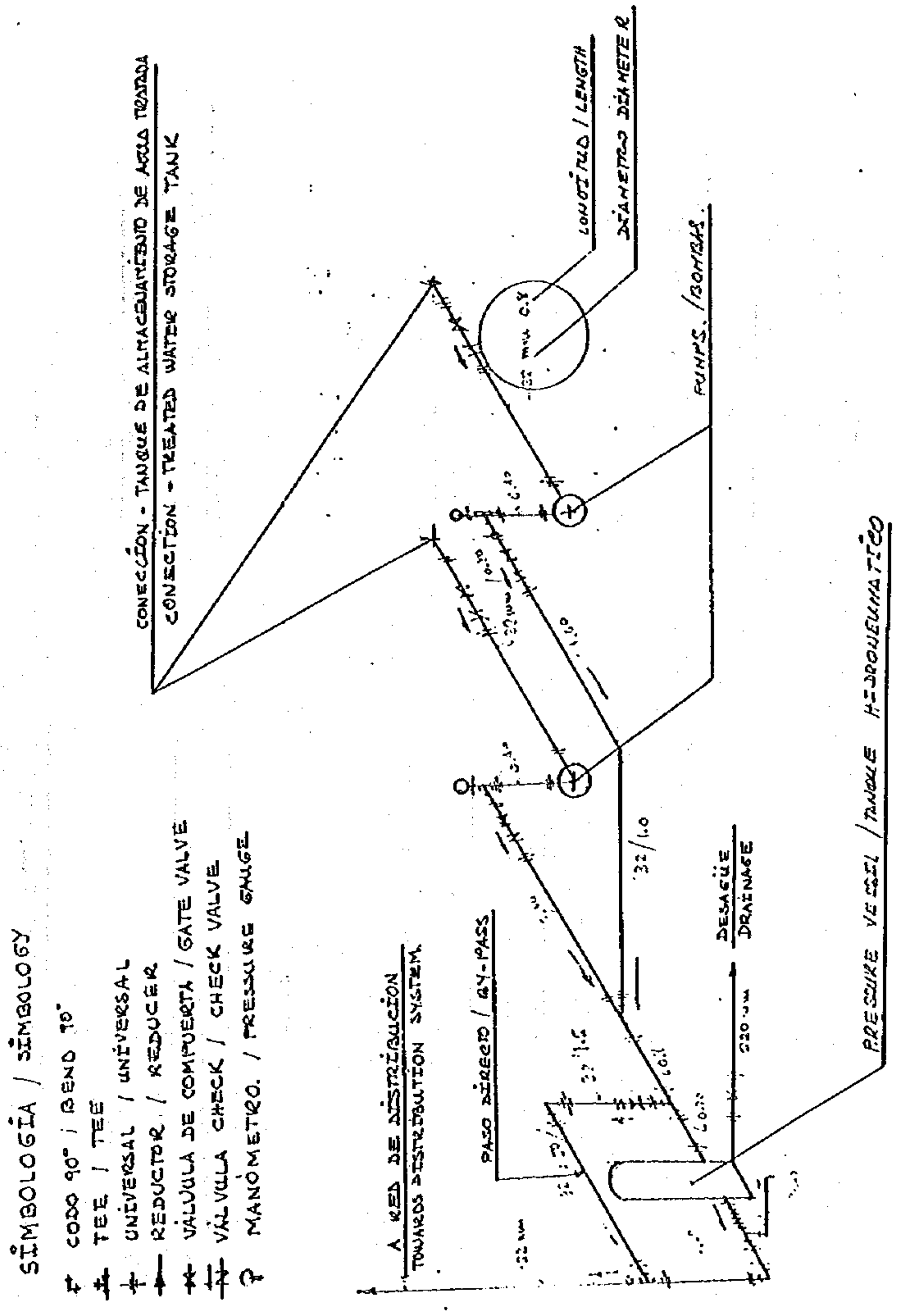
WC	WATER CLOSET / INODORO
U	URINAL / URINARIO
L	LAVATORY SINK / LAVABO
SK	SLOP SINK / FREGADERO.
SH	SHOWER / DUCHA
S	SINK / FREGADERO COCINA

CODO 90° / BEND 90°
TEE / TEE PIPE
VALVULA DE COMPUERTA / GATE VALVE
UNIVERSAL / UNIVERSAL
JUNTA FLEXIBLE. / FLEXIBLE JOINT
REDUCTOR / REDUCER
VALVULA DE FLOTADOR / FLOAT VALVE

20/2.40 DIAMETRO DE LA TUBERIA
PIPE DIAMETER
LONGITUD DE LA TUBERIA
LENGTH OF PIPE

1-3-88

INSTALACIONES SANITARIAS / AGUA POTABLE
CONEXION BOMBA - TANQUE HIDRONEUMATICO.
SANITARY INSTALATIONS / DOMESTIC WATER
CONECTION PUMP - PRESSURE VESSEL



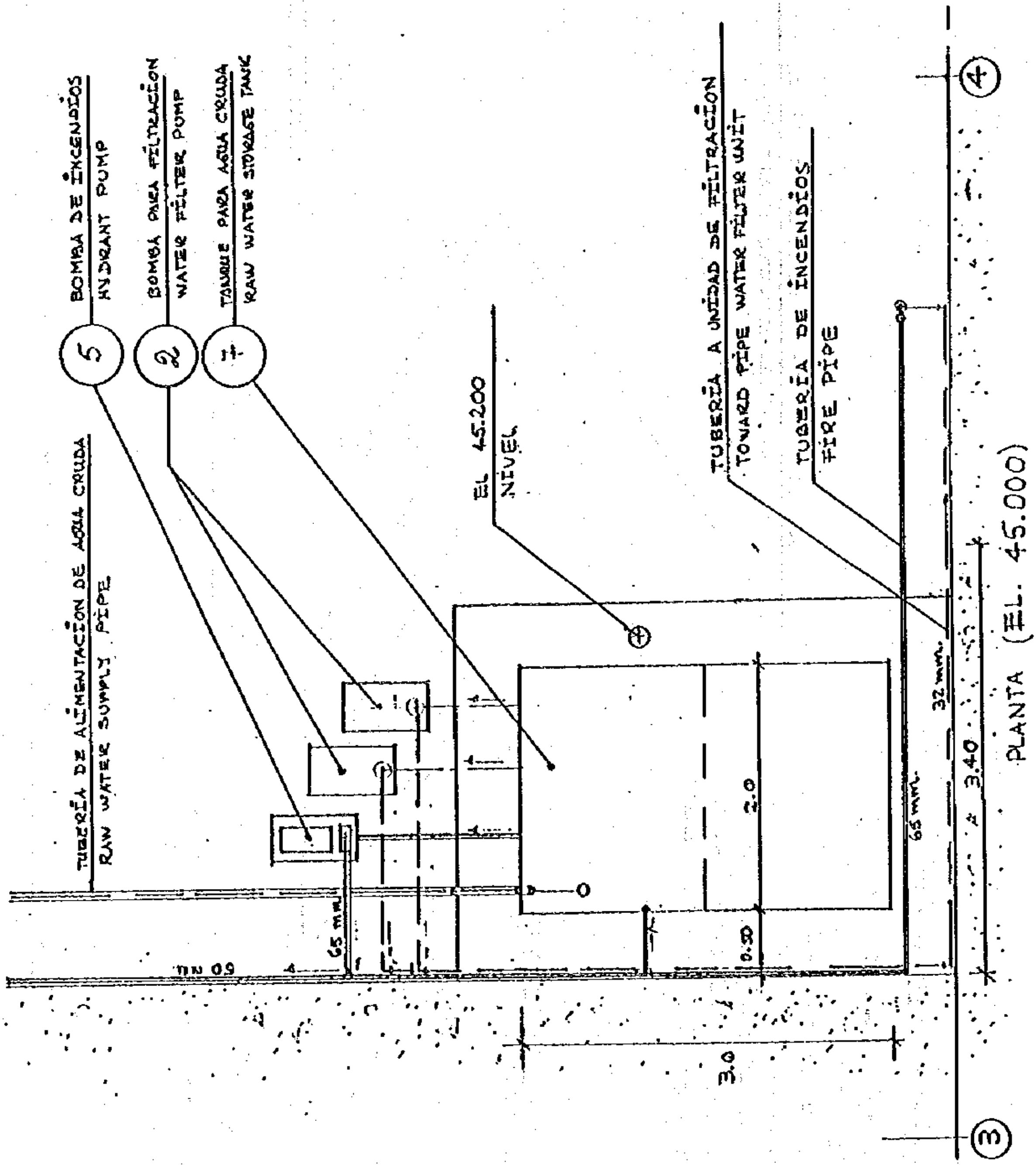
1-3-89

INSTALACIONES SANITARIAS

DISPOSICION EN PLANTA DE EQUIPOS

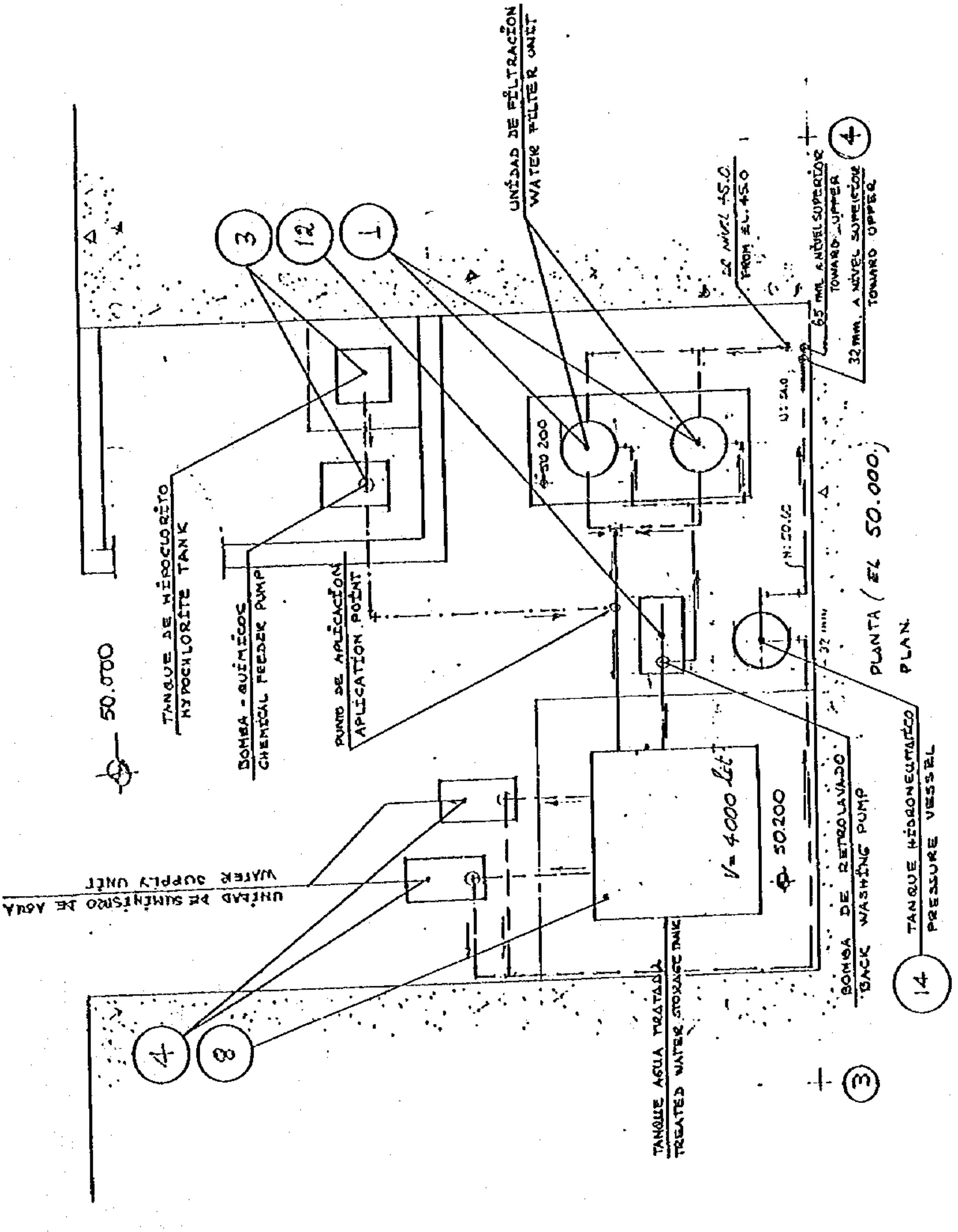
SANITARY INSTALATIONS

ARRANGEMENT OF EQUIPMENT PLAN.

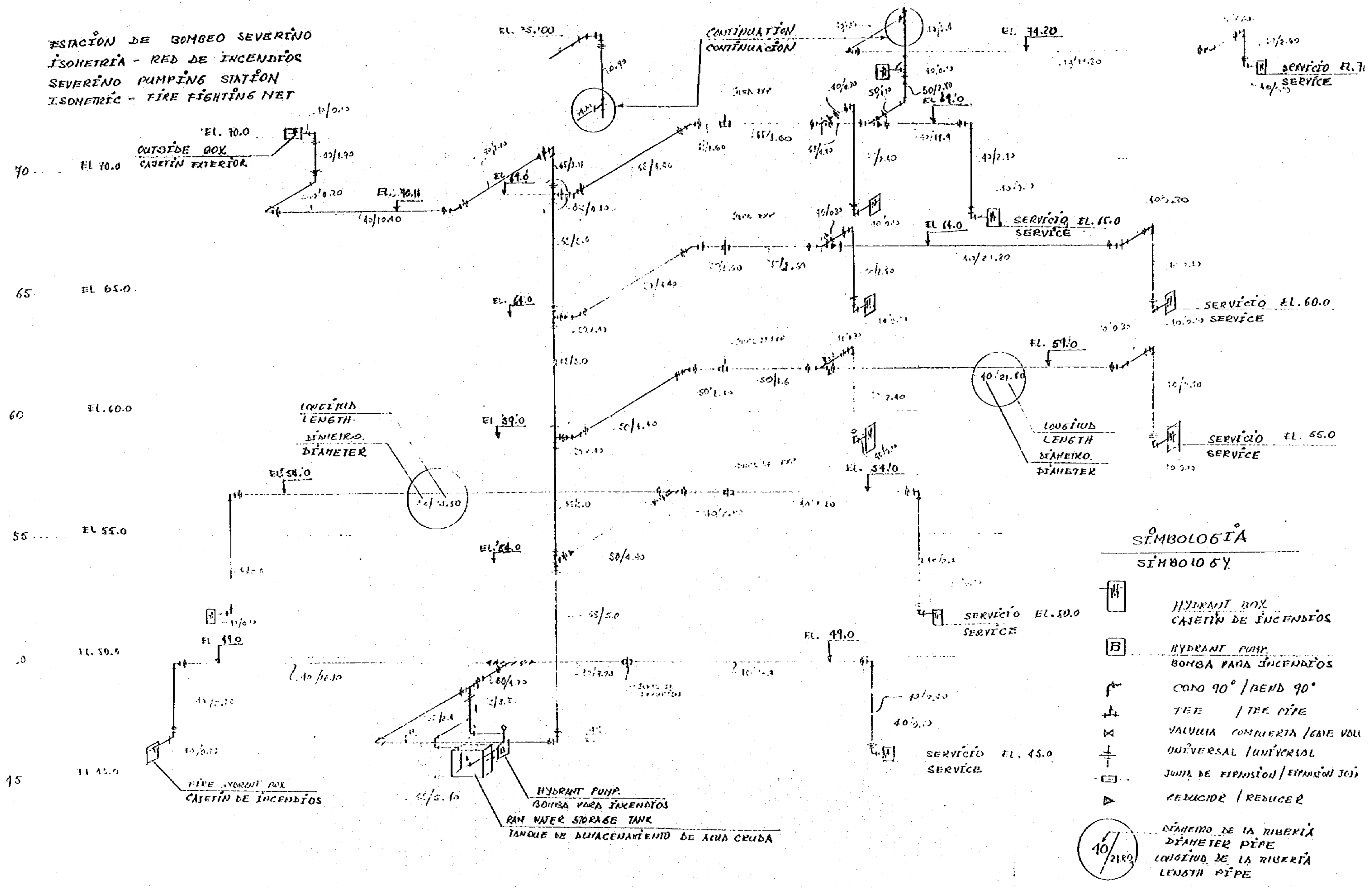


1-3-90

INSTALACIONES SANITARIAS
DISPOSICION EN PLANTA DE EQUIPOS
SANITARY INSTALATIONS
ARRANGEMENT OF EQUIPMENT PLAN.



ESTACIÓN DE BOMBEO SEVERINO
ISOMETRIA - RED DE INCENDIOS
SEVERINO PUMPING STATION
ISOMETRIC - FIRE FIGHTING NET

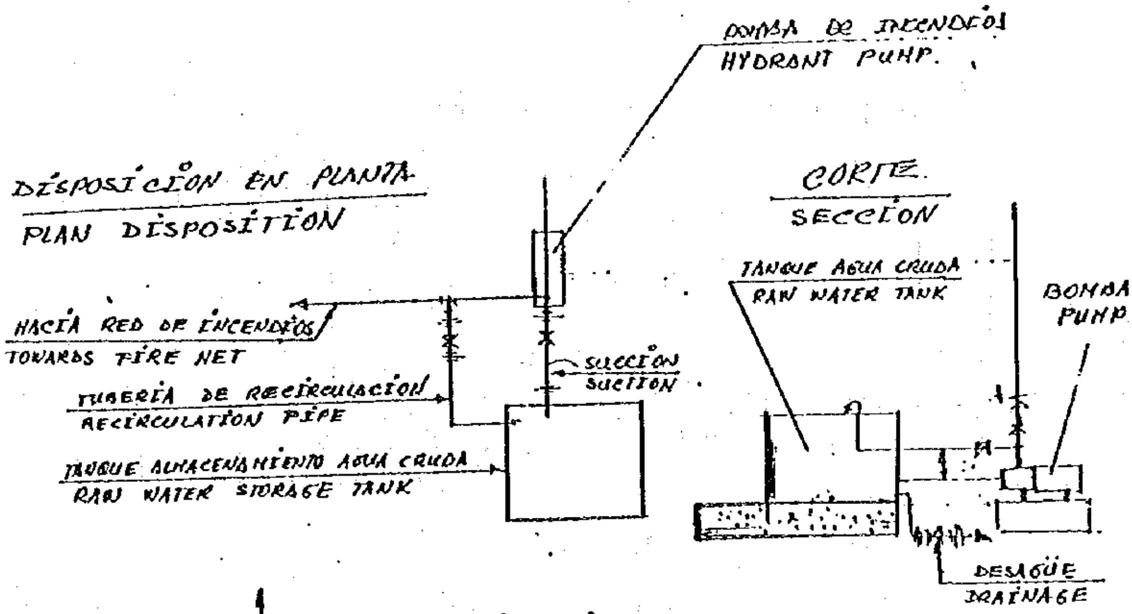


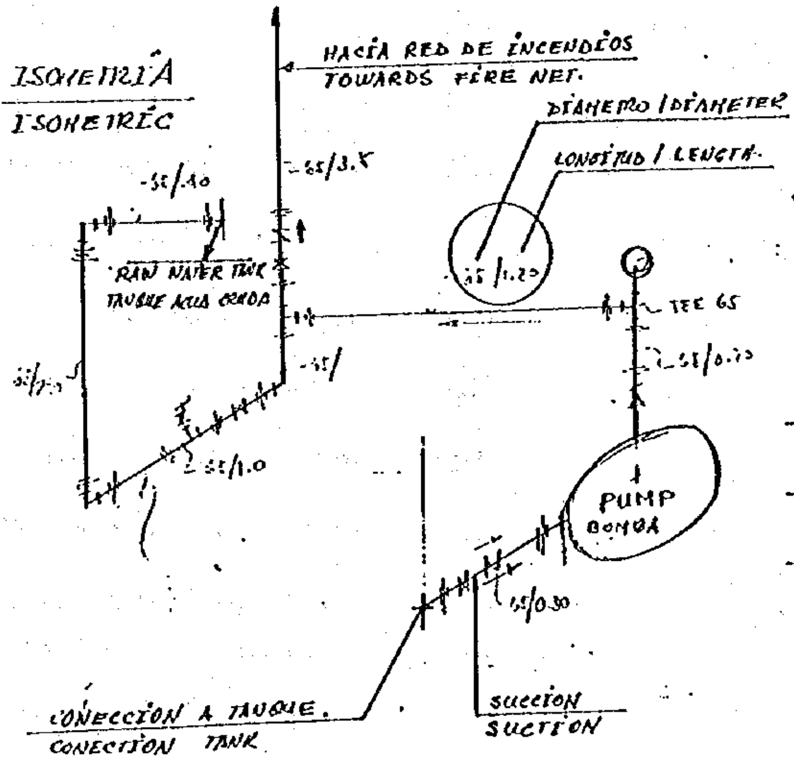
INSTALACIONES SANITARIAS / INCENDIOS

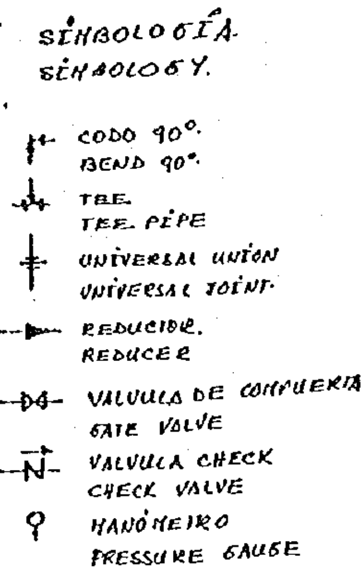
ISOMETRIA Y CONECCION . BOMBA - TANQUE - RED DE DISTRIBUCION

SANITARY INSTALATIONS / FIRE

ISOMETRIC AND CONECTION. PUMP - TANK - DISTRIBUTION SYSTEM

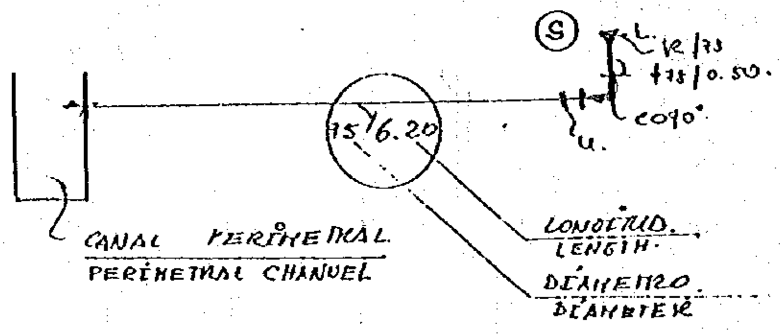






INSTALACIONES SANITARIAS / DESAGÜE
CALCULO DE TUBERIAS / ISOMETRIAS
SANITARY INSTALATIONS / DRAINAGE
CALCULATION OF PIPE DIAMETER / ISOMETRIC.

- BATTERY ROOM / CUARTO DE BATERIAS.



SIMBOLOGIA / SIMBOLOGY

Ⴎ	REJILLA Y SIFON. FLOOR TRAP.
□	ADAPTADOR / ADAPTER
┌	CODO 90° / BEND 90°
✕	CODO 45° / BEND 45°
▷	REDUCTOR / REDUCER
-‖-	UNION / JOINT
⊿	YEE / YEE
⊥	CODO 90° CON RAMAL DE VENTILACION BEND 90° WITH VENT BRANCH

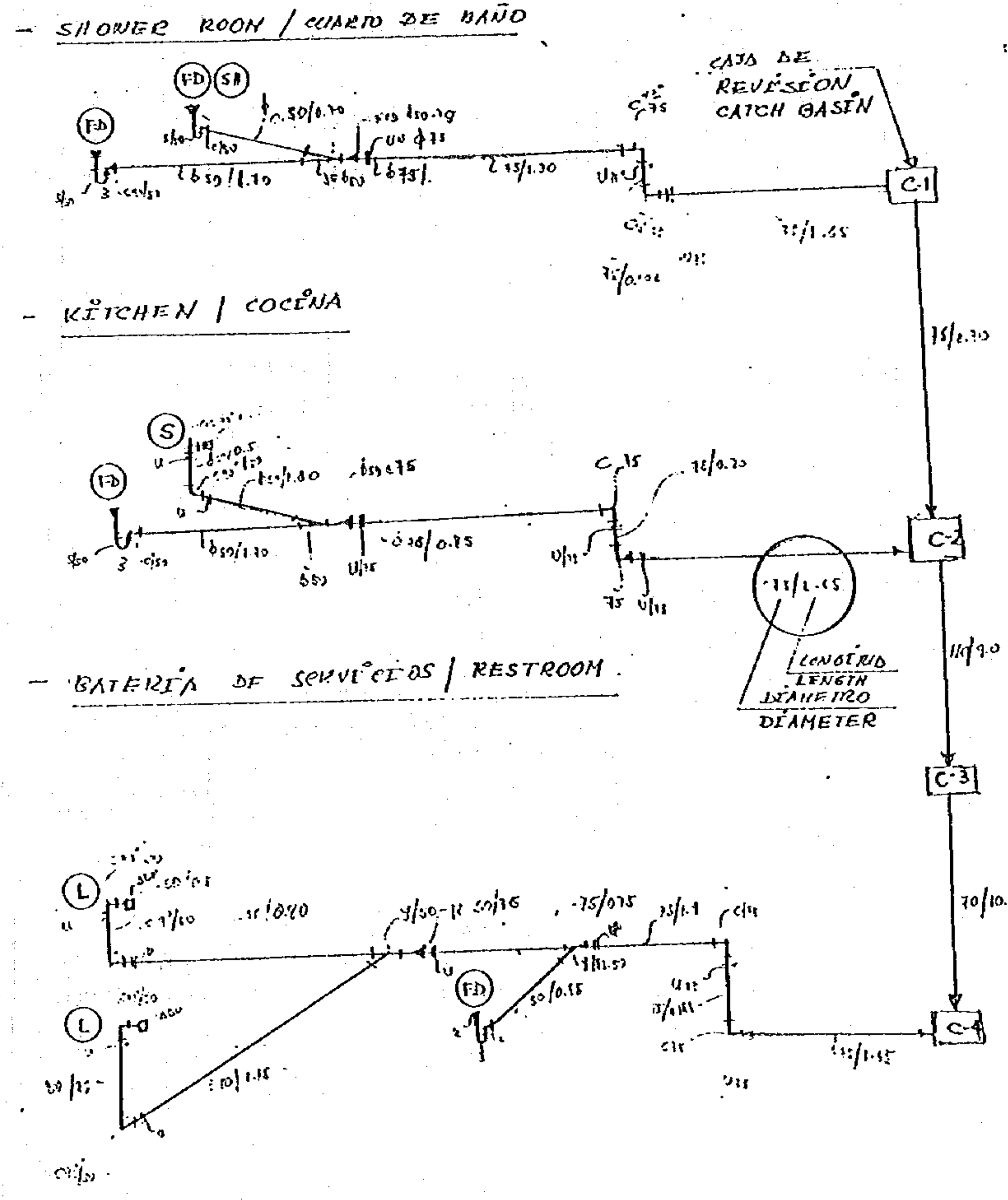
Ⓛ	LAVABO / LAVATORY SINK
(SH)	DUCHA / SHOWER
(WC)	INODORO / WATER CLOSET
(SK)	FREGADERO / SLOP SINK
Ⓢ	FREGADERO COSINA / SINK
(FD)	TRAMPA DE PISO. / FLOOR TRAP
Ⓤ	URINARIO. / URINAL
XX	CAJA DE REVISION / CATCH BASIN
75/6.20	LONGITUD (m) / LENGTH DIAMETRO (mm) / DIAMETER

INSTALACIONES SANITARIAS / DESAGÜE

CALCULO DE TUBERIAS / ISOMETRIAS

SANITARY INSTALATIONS / DRAINAGE

CALCULATION OF PIPE DIAMETER / ISOMETRIC.



1-3-95

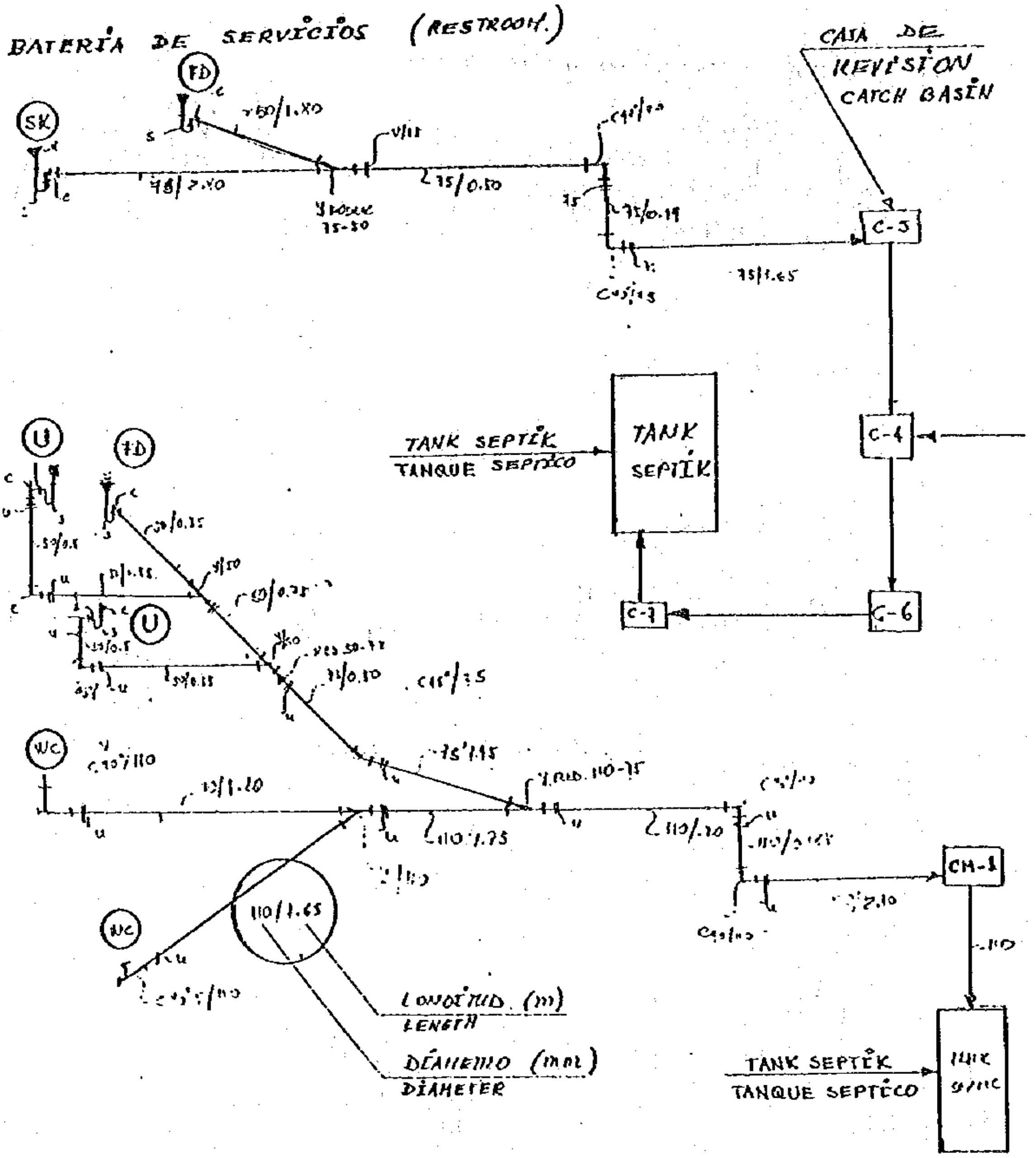
INSTALACIONES SANITARIAS / DESAGÜE

CALCULO DE TUBERIAS / ISOMETRIAS

SANITARY INSTALATIONS / DRAINAGE

CALCULATION OF PIPE DIAMETER / ISOMETRIC

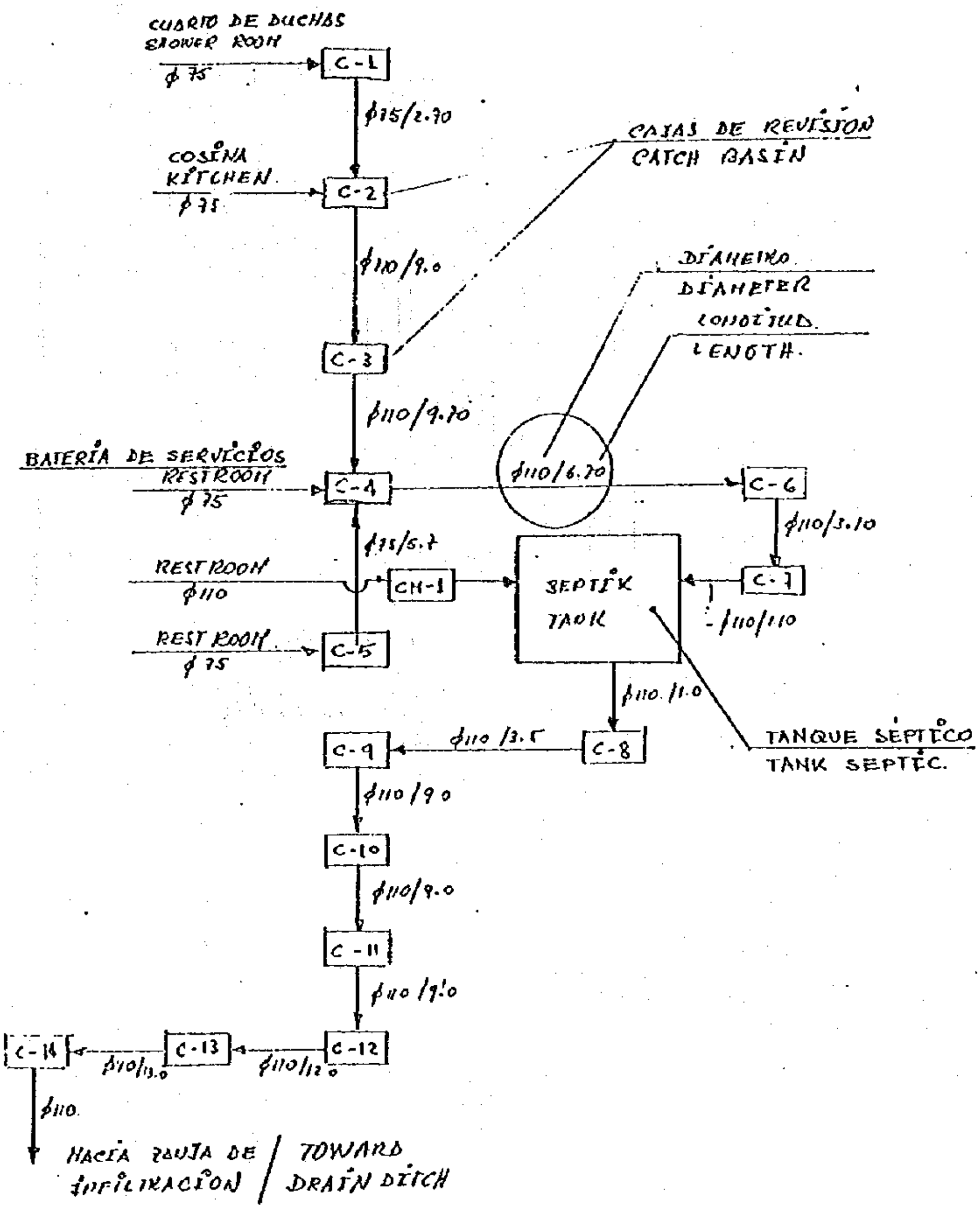
- BATERIA DE SERVICIOS (RESTROOM.)



1-3-96

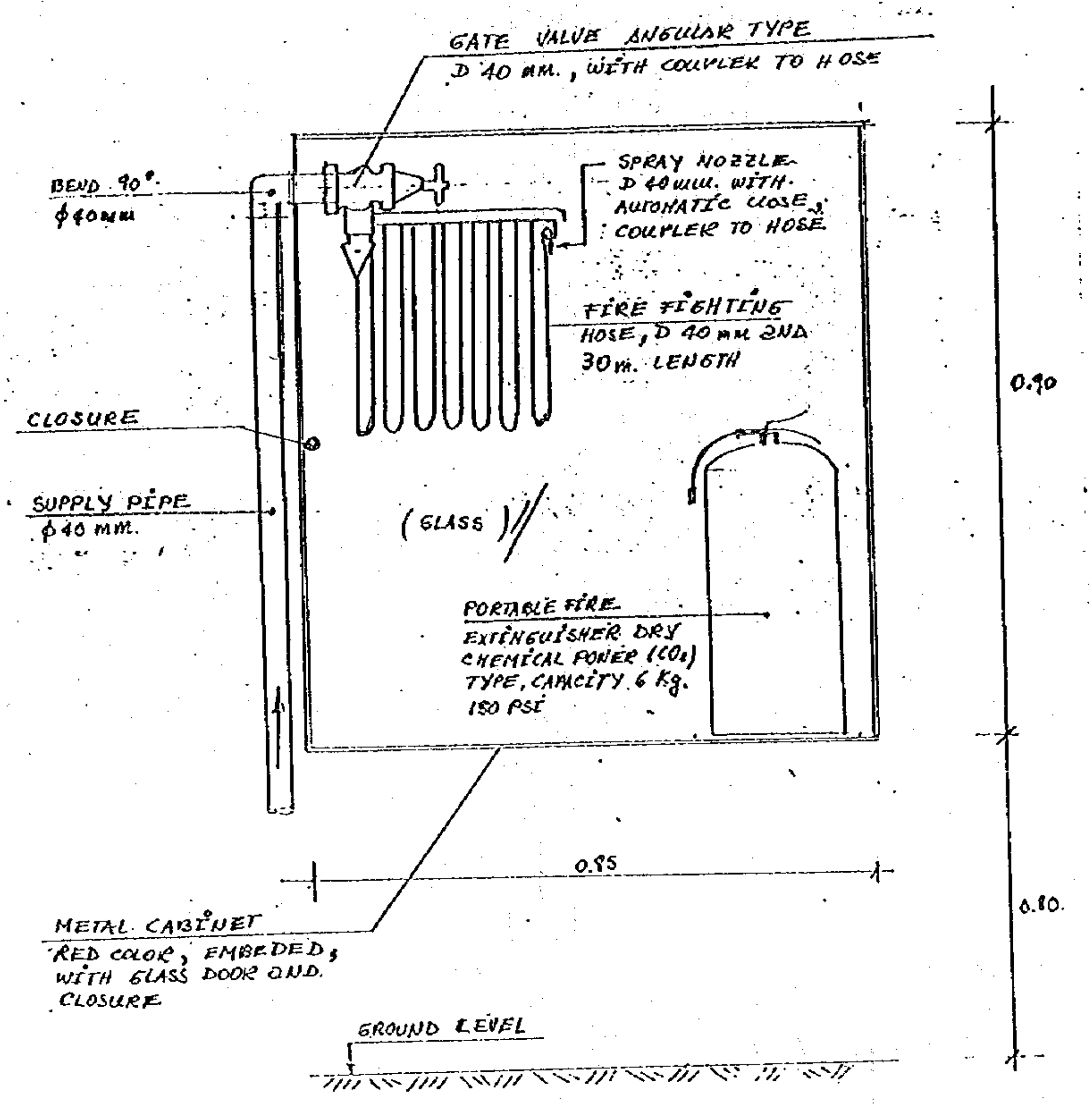
INSTALACIONES SANITARIAS / DESAGÜE
CALCULO DE TUBERIAS / ISOMETRIAS
SANITARY INSTALATIONS / DRAINAGE
CALCULATIONS OF PIPE DIAMETER / ISOMETRIC

ESQUEMA GENERAL DE LA RED EXTERIOR
GENERAL ARRAGEMENT OF THE EXTERIOR NET



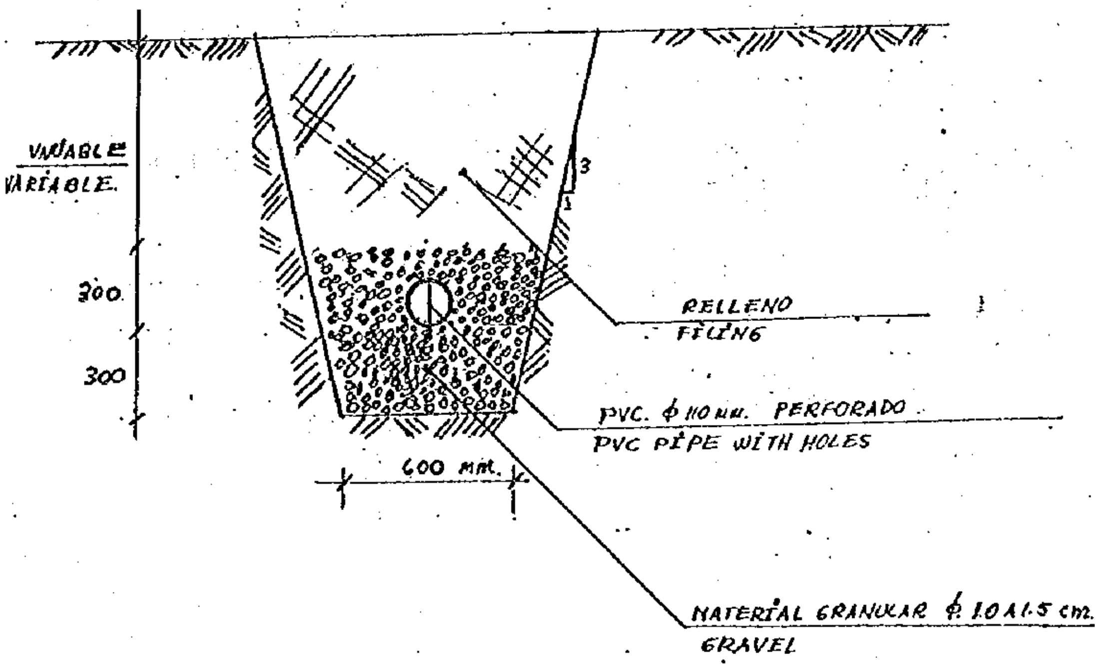
1-3-97

INSTALACIONES SANITARIAS / INCENDIOS
DETALLE TIPICO DEL CAJETIN CONTRA INCENDIOS
SANITARY INSTALATIONS / FIRE
TYPIC DETAIL OF HYDRANT BOX.

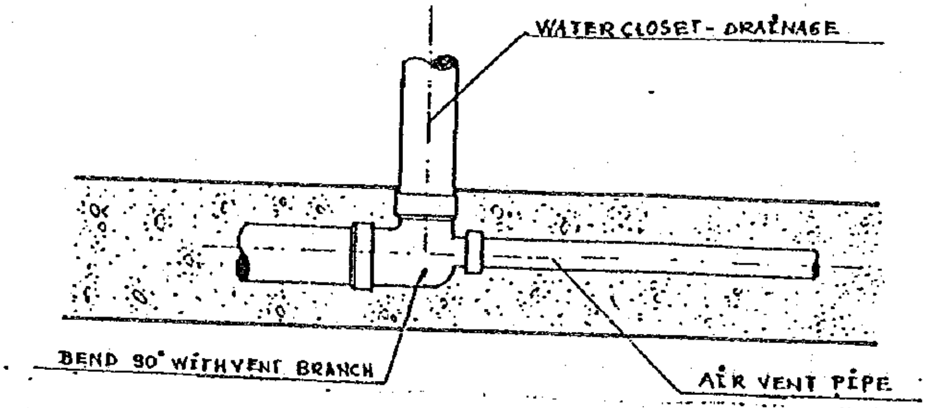


1-3-98

DETALLE TIPICO DE ZANJA DE INFILTRACION
TIPIC DETAIL OF INFILTRATION TRENCH



1-3-99



CONECTION DRAINAGE - VENTILATION DETAIL