Enve 422- Wastewater Engineering Design

Design of Inlet Pumping Stations, Screens, Grit Chambers

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DESIGN OF INLET PUMPING STATIONS

- Pump selection

Qmin, Qave , **Qpeak** flows

Calculation of system losses (for valves, fittings, elbows , especially in the force main)

Calculation of friction loss

Preparation of system curve

Pump characteristic and efficiency curves (given by manufacturer)

Preparation of modified pump characteristic curve (obtained by substracting headlosses in suction and discharge piping)

Static head

Parallel connection, series connection

DESIGN OF INLET PUMPING STATIONS

- Qmin, Qave , **Qpeak** flows

Variable speed pumps, combination of constant speed pumps

- Diameter, invert level, slope of inlet sewer pipe

calculate (h/D) ratio of inlet sewer pipe

calculate water height before coarse screens

decide concrete elevation of wet well floor

- Ground elevation of manhole just before the enterance of wet well

Effluent discharge elevation of the plant

(in case of river discharge → overflow elevation of river)

decide by-pass overflow weir elevation

- All dimensions for locating the pumps given by pumps manufacturers

minimum clearance required between two pump casings

minimum clearance between the side wall and pump casing

minimum depth of water in the wet well

mimimum opening size before pumps

DESIGN OF INLET PUMPING STATIONS

Centrifugal pumps

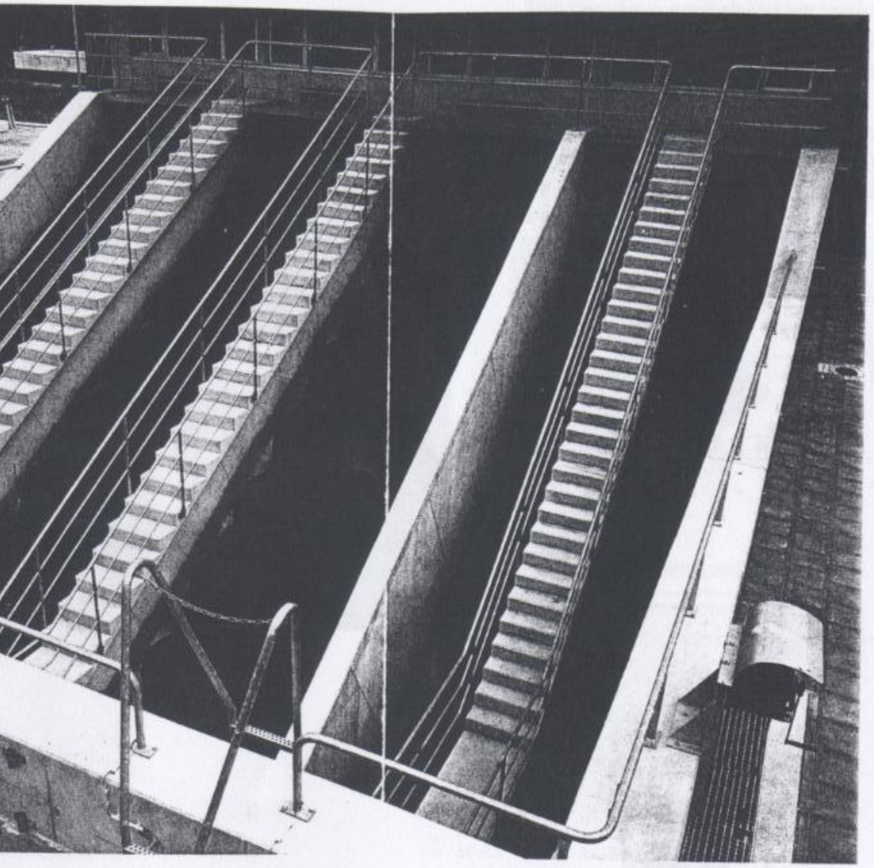
-vertical shaft, horizantal shaft, submerged pump, submersible pump

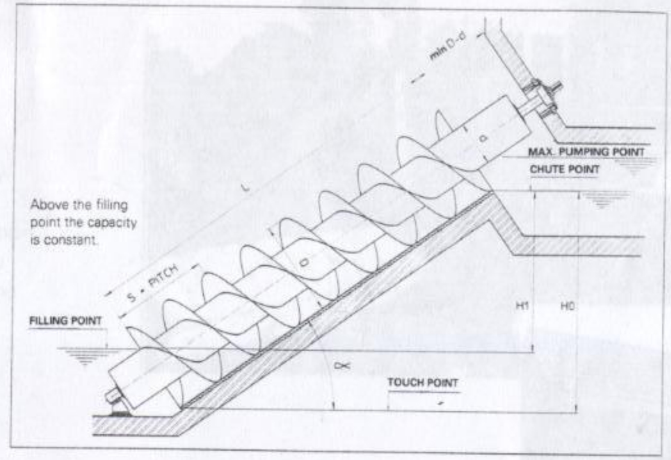
-Variable speed pumps, combination of constant speed pumps

(Qmin, Qave , **Qpeak** flows)

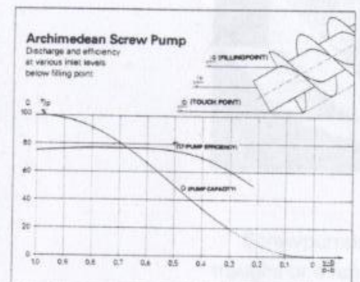
Archimedian Pumps

The quality of a Landustrie screwpump is given by its calculation method and safety factors. A maximum tensile stress of the





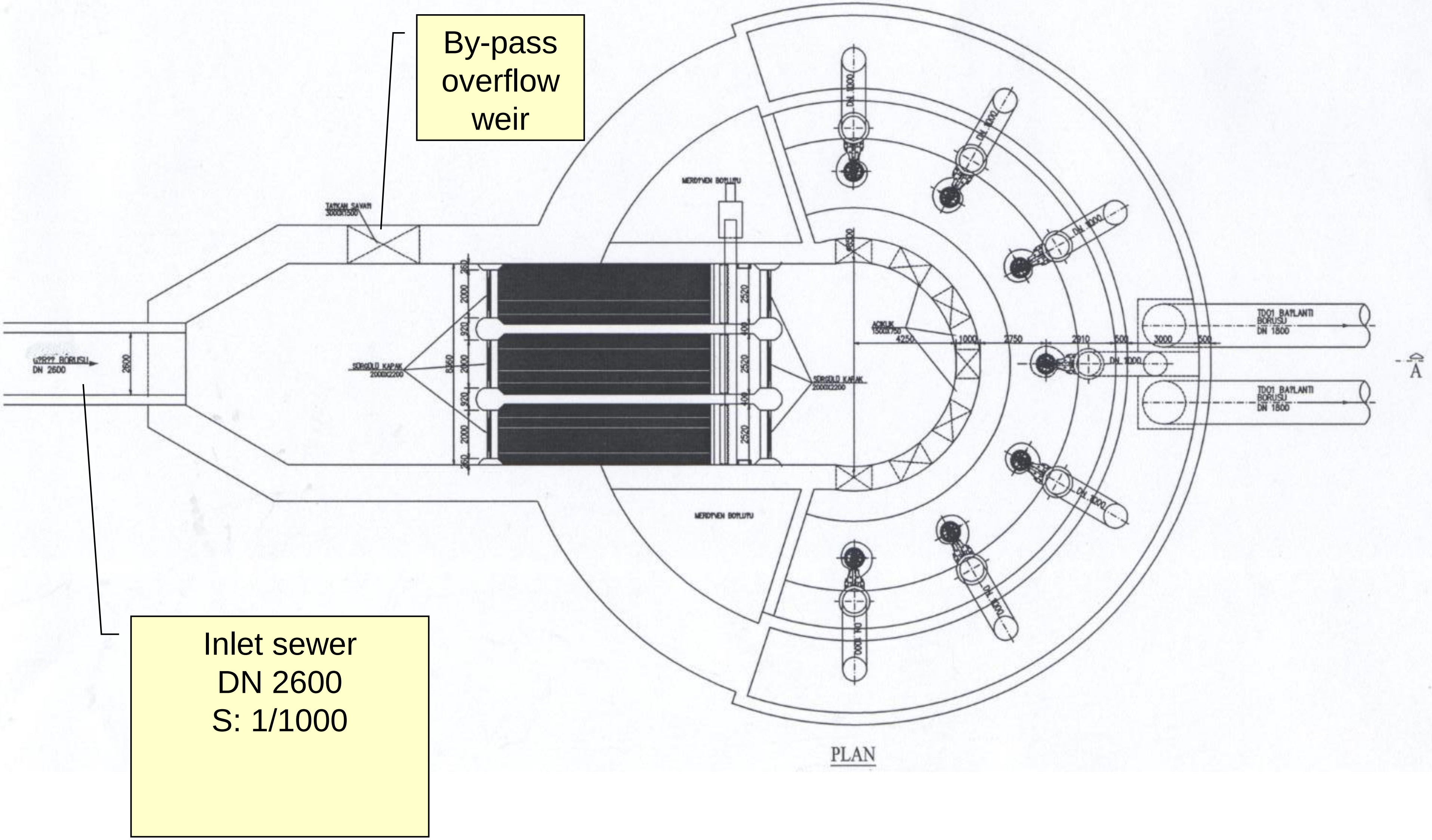
The experience of Landustrie goes back more than 75 years and numerous measurements on 2-flight as well as on 3-flight screwpumps have proven that design parameters used by the engineering staff of Landustrie are correct and reliable. Standard inclinations vary from 30° to 38°

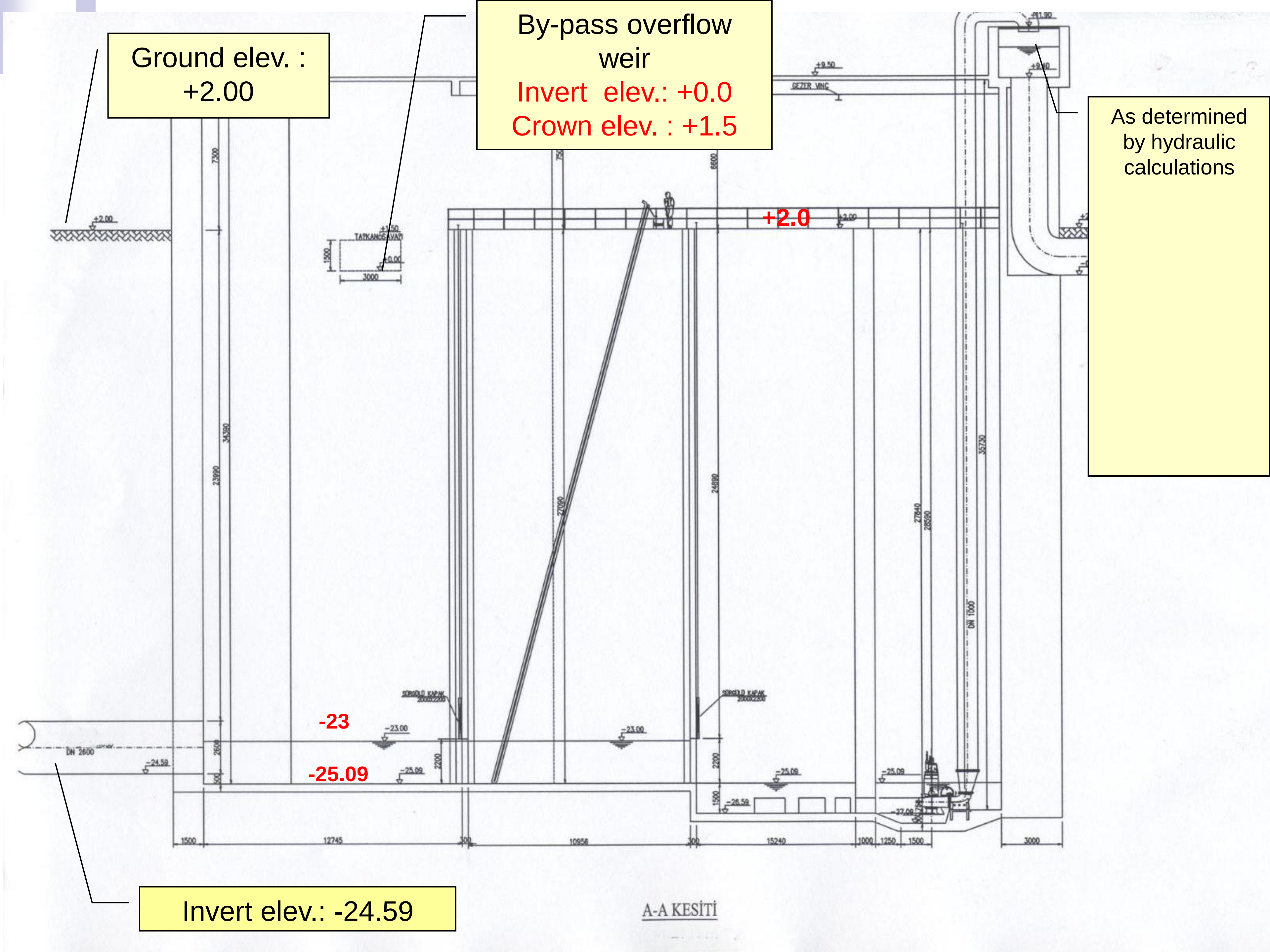


Screw diameter (mm)	Max. speed (r.p.m.)	30°		35°		38°	
		Capacity max. (m³/sec)	Ho max. (mm)	Capacity max. (m³/sec)	Ho max. (mm)	Capacity max. (m³/sec)	Ho max. (mm)
300	118	0,016	2800	0,012	3200	0,011	3500
450	98	0,041	4000	0,033	4600	0,029	5000
600	75	0,082	4700	0,066	5400	0,059	5900
800	62	0,154	5500	0,125	6300	0,0112	6900
1000	53	0,272	6700	0,218	7700	0,196	8400
1250	46	0,430	7700	0,360	8900	0,312	9700
1500	40	0,690	8600	0,556	10000	0,500	10900
1800	36	1,080	9800	0,866	11400	0,777	12500
2100	32	1,500	9200	1,210	10500	1,087	11500
2450	29	2,210	8000	1,770	9100	1,591	10000
2800	26	2,980	10500	2,390	12100	2,150	13300
3200	24	4,070	10600	3,273	12100	2,940	13300
3600	22	5,360	11000	4,306	12600	3,860	13800
4050	21	7,060	11400	5,670	13000	5,090	14200
4500	19	9,000	11700	7,240	13300	6,500	14600
5000	18	11,530	12000	9,260	13600	8,320	14900

Above list is not complete and is only an overview of possible screwpumps with Landustrie. Angles below 30° and above 38° on request.

DESIGN OF PUMPING STATION




Ground elev. : +2.00
By-pass overflow weir
Invert elev.: +0.0
Crown elev. : +1.5
As determined by hydraulic calculations
+2.0
-23
-25.09
Invert elev.: -24.59
+2.00
+1.50
+0.00
3000
1500
+9.50
GEZER VINÇ
-23.00
-25.09
-24.59
DN 2600
-26.59
DN 1000
12745
10958
15240
A-A KESİTİ

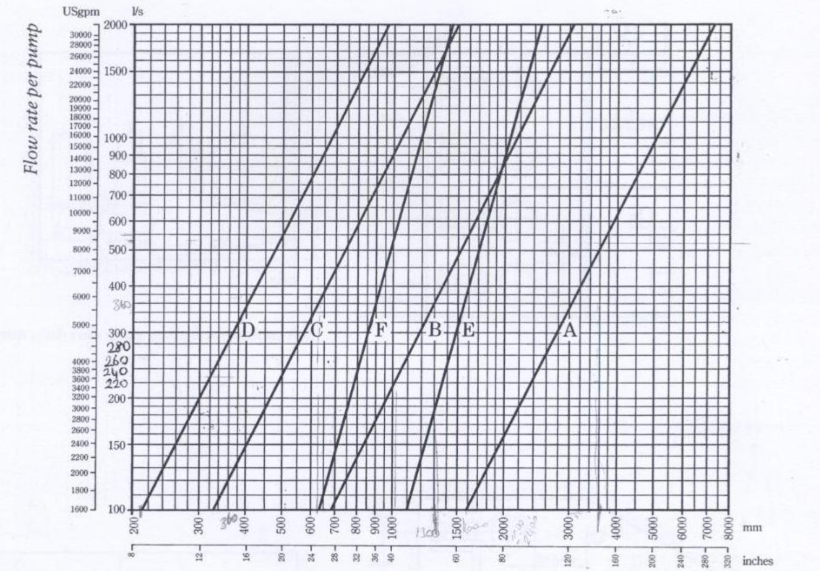


Fig. 3 Sump dimensions

Dimensions A-F

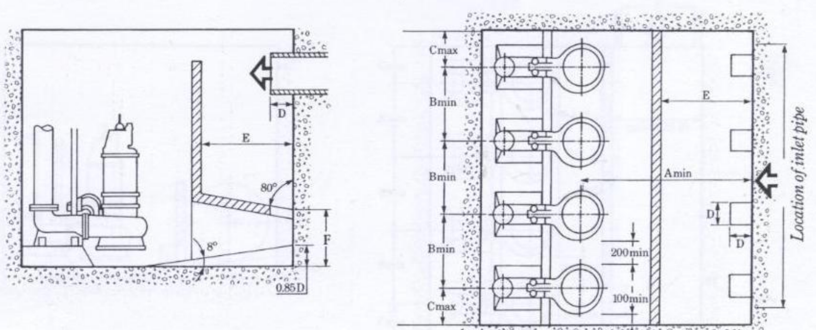


Fig. 4 Sump with front entry at high elevation, A-1

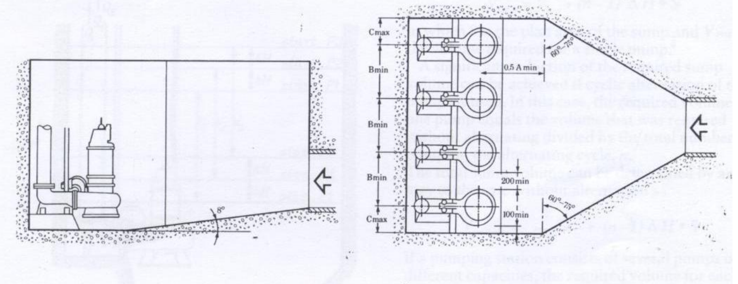


Fig. 6 Sump with front entry at low elevation, B-1

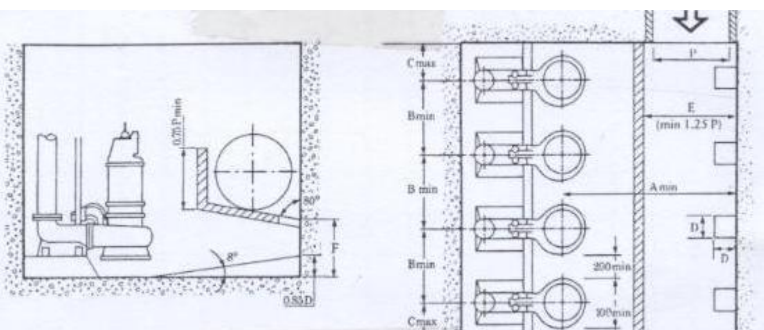


Fig. 5 Sump with side entry at high elevation, A-2

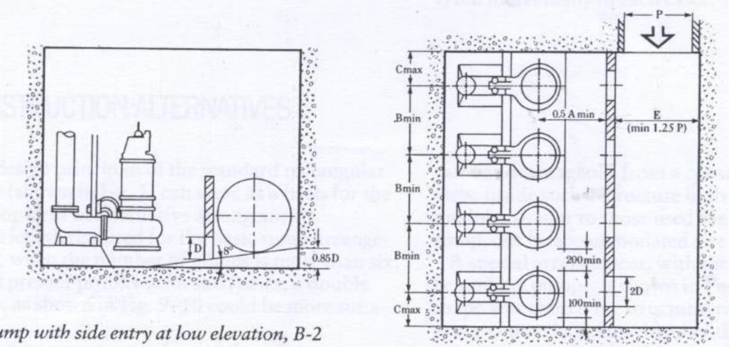


Fig. 7 Sump with side entry at low elevation, B-2

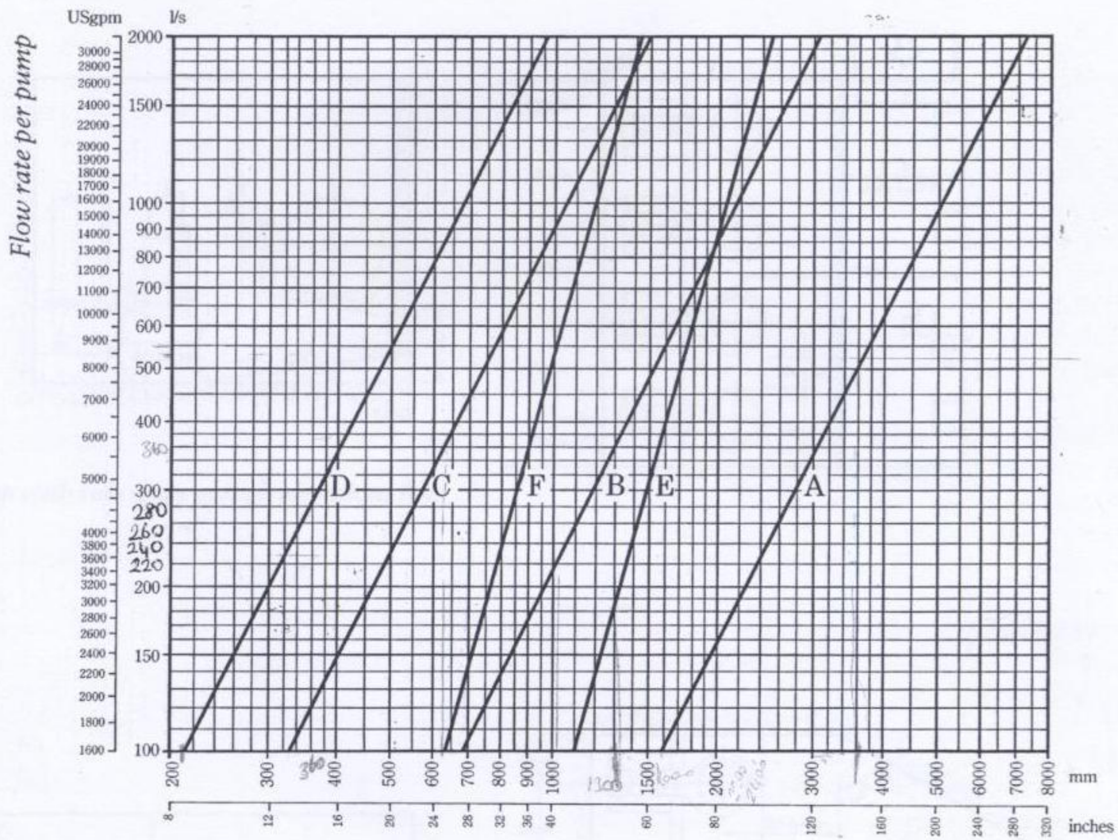


Fig. 3 Sump dimensions *Dimensions A-F*

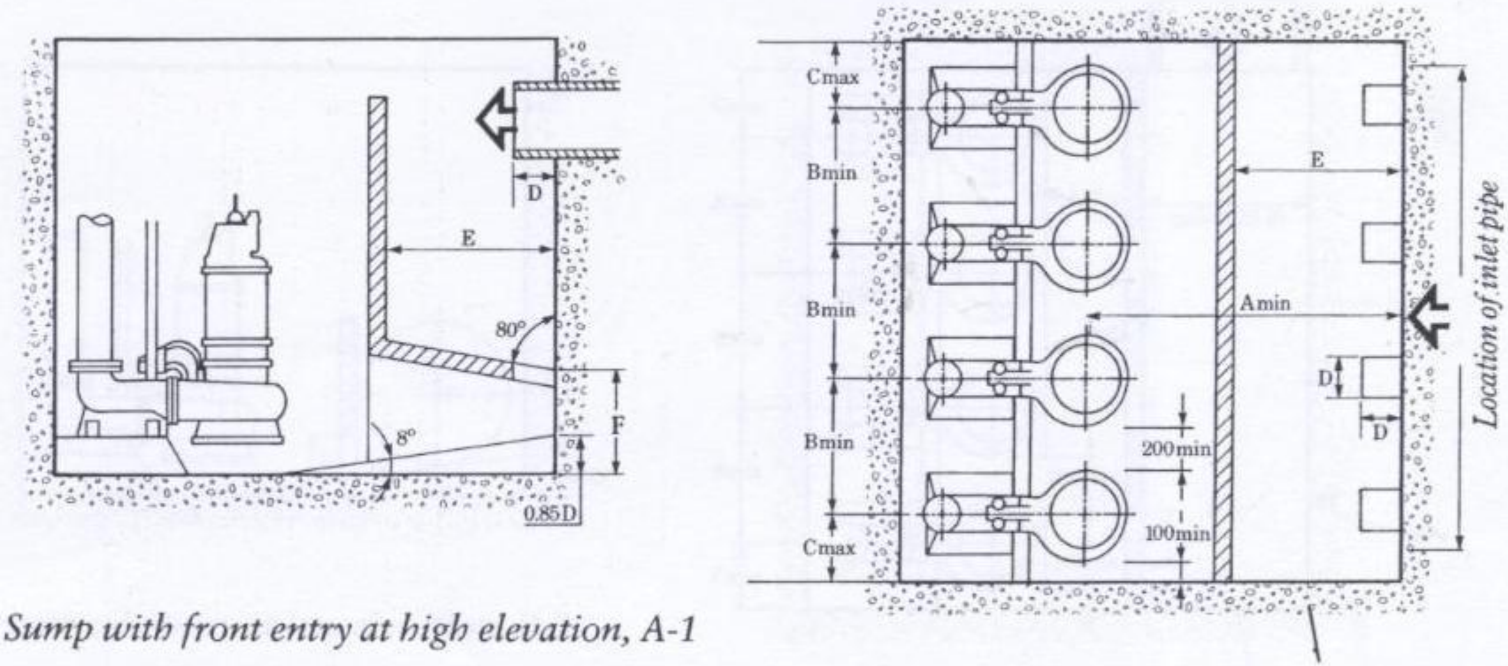


Fig. 4 Sump with front entry at high elevation, A-1

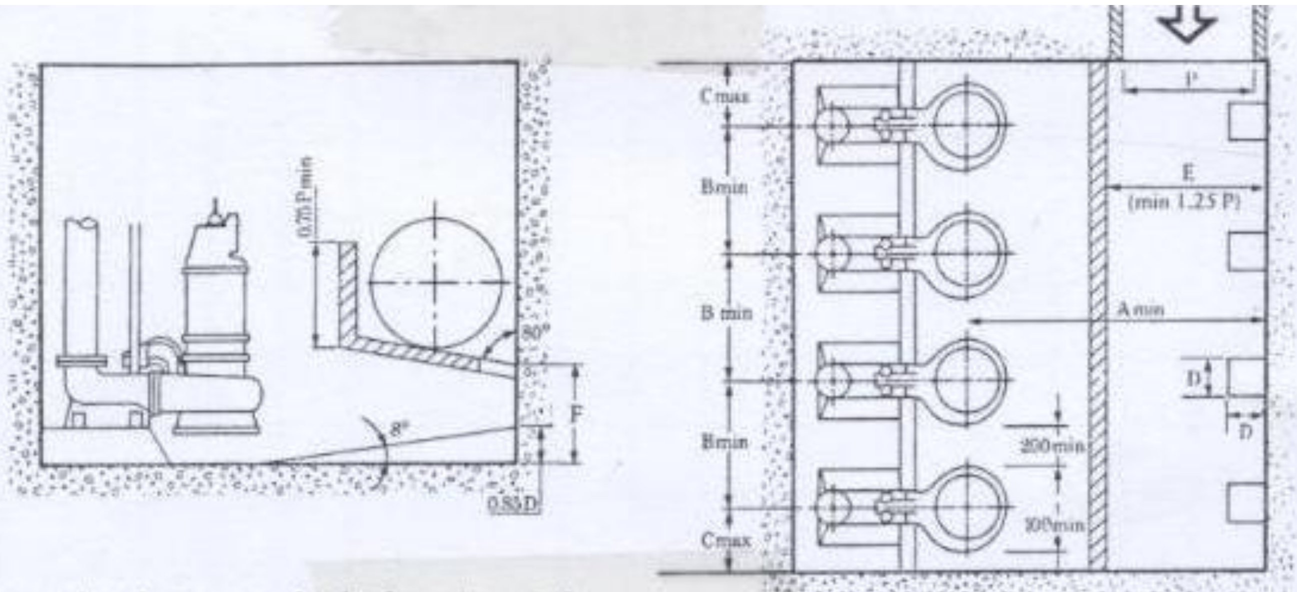


Fig. 5 Sump with side entry at high elevation, A-2

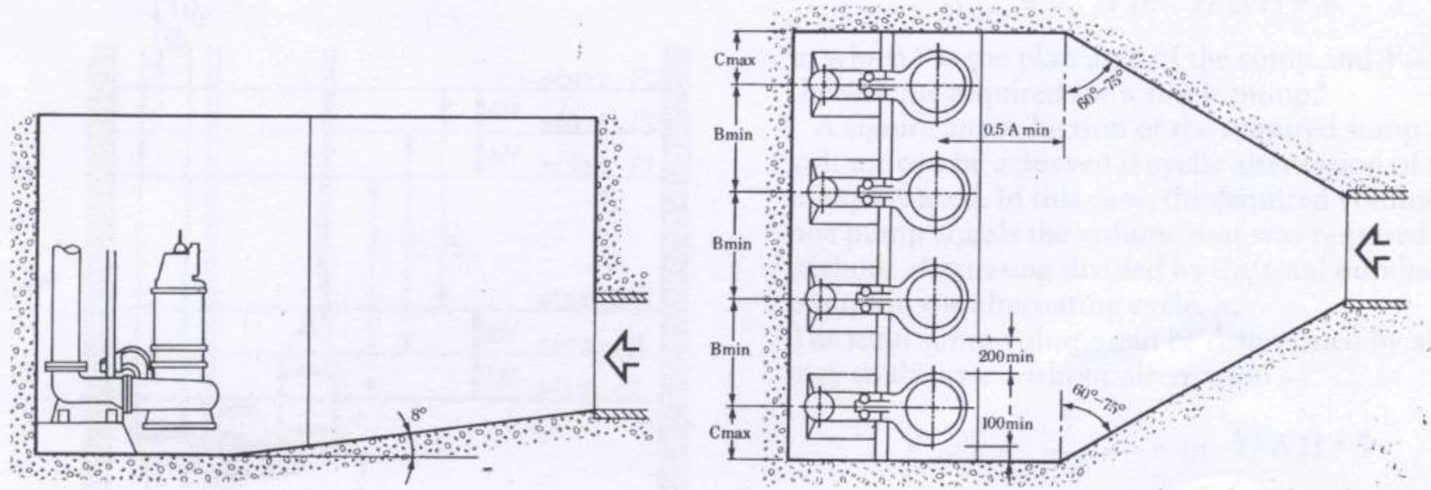


Fig. 6 Sump with front entry at low elevation, B-1

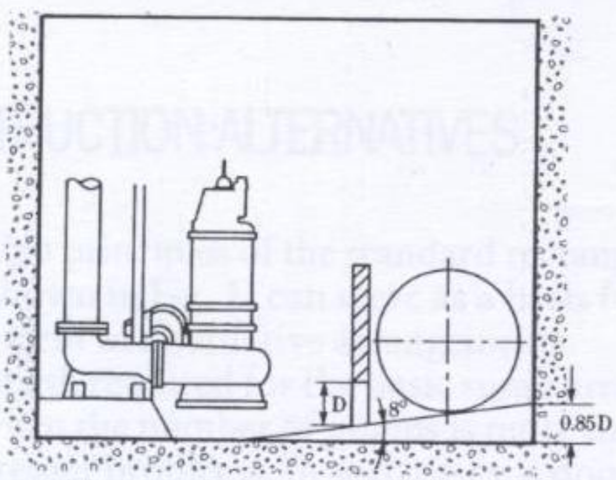
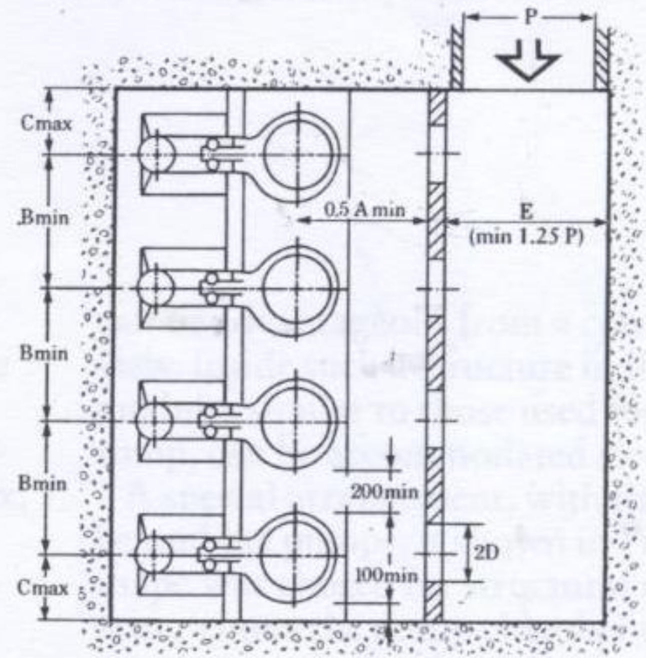


Fig. 7 *Sump with side entry at low elevation, B-2*

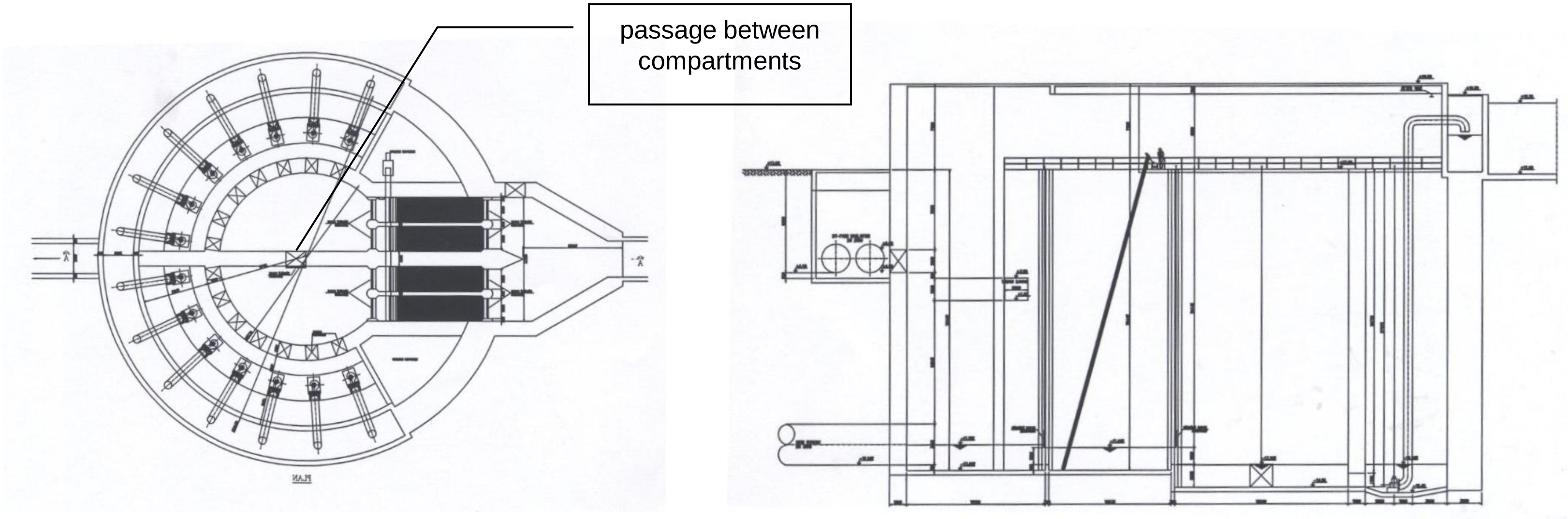


DESIGN OF INLET PUMPING STATIONS

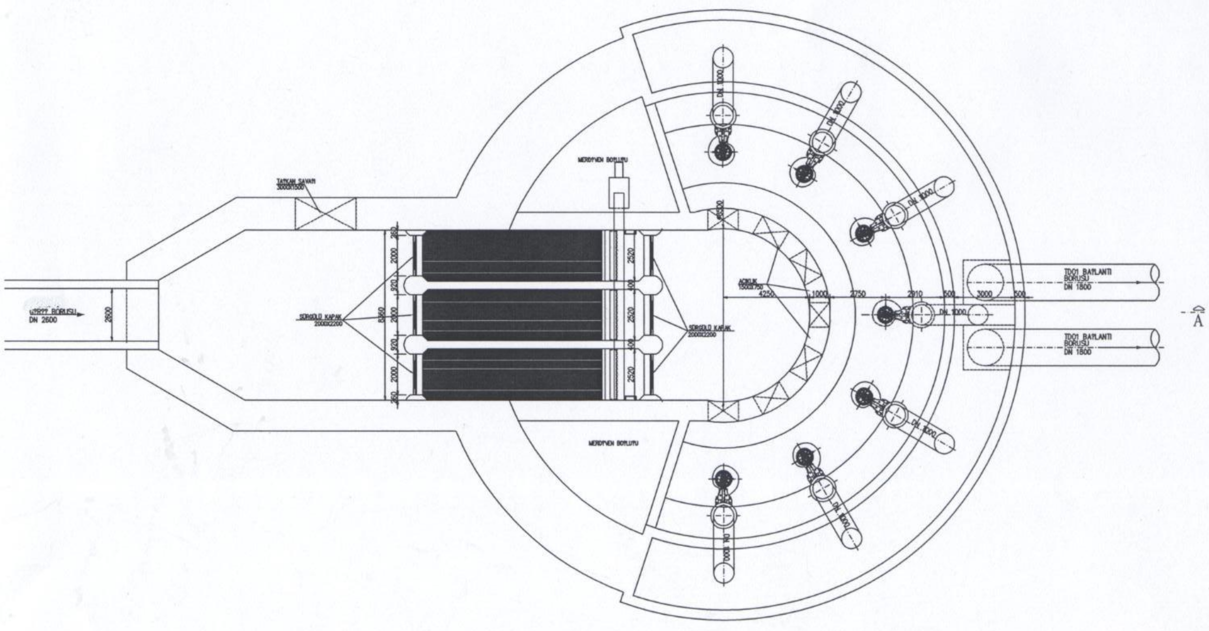
- deep wet well → cylindrical

- at least two compartments (for maintenance)

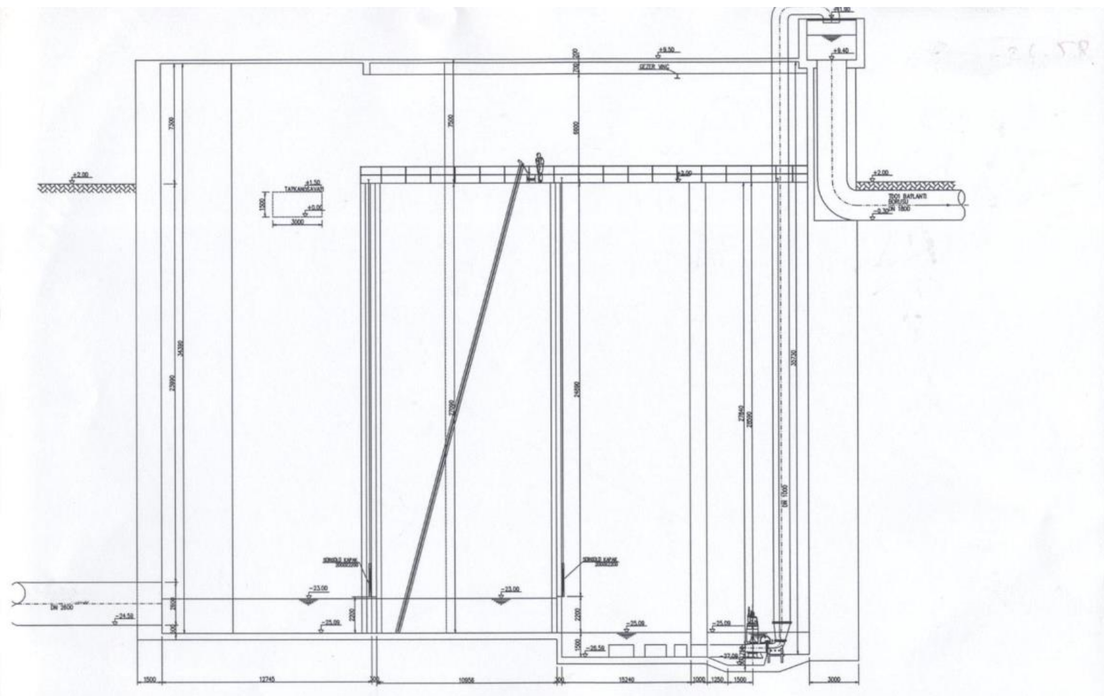
  passage between compartments



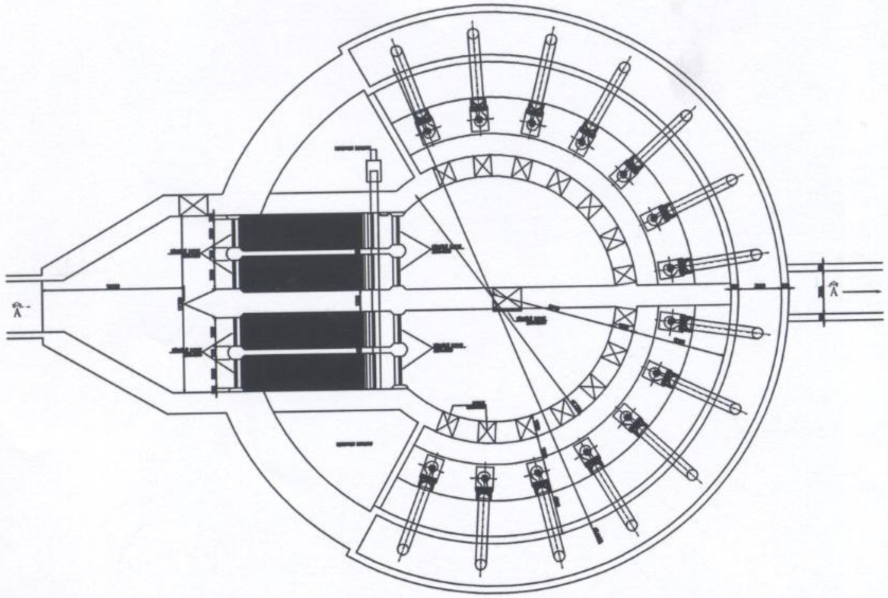
- ventilation
- H_2S and CH_4 measurement and alarm sytems
- level sensors



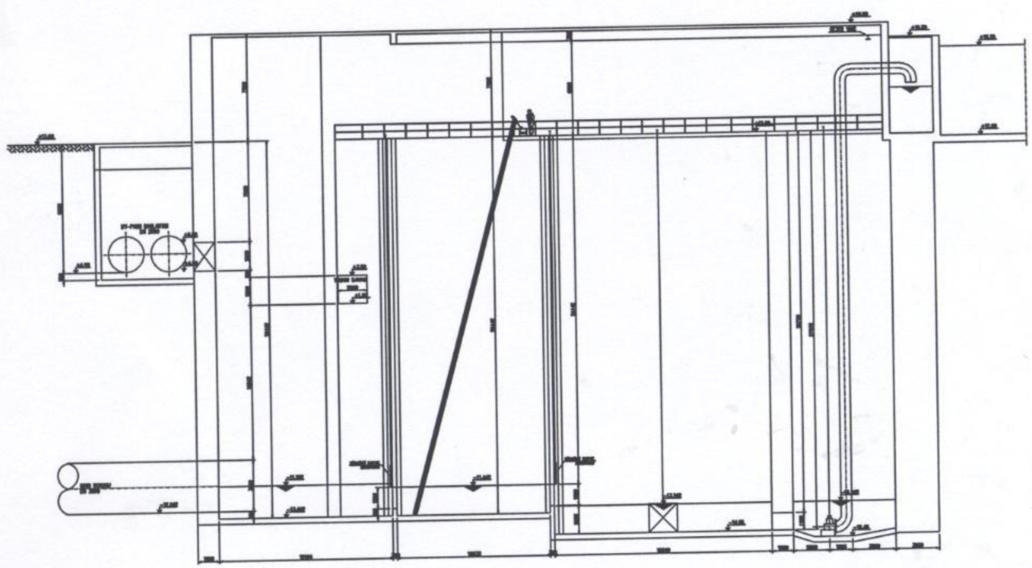
PLAN



A-A KESİTİ



PLAN



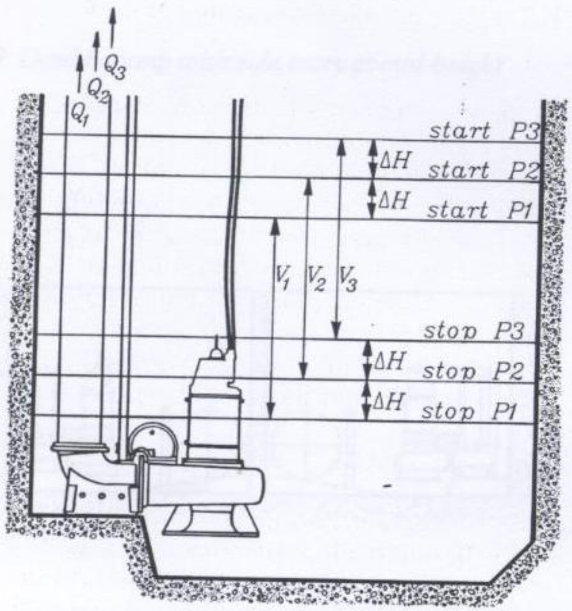


Fig. 8 Operating scheme for three identical pumps

$$V_{req} = \frac{T_{min}\, Q}{4}$$

For a pumping station with several identical pumps, the required volume is a minimum if the pumps start in sequence as the water level rises due to increasing inflow and stop in the reverse order as the water level drops due to decreasing inflow, as shown in Fig. 8.

The start and stop levels of all pumps differ by a constant value ΔH that is determined by the characteristics of the control system. ΔH should be large enough to eliminate accidental pump starts that could be caused by surface waves or imprecise level sensors.

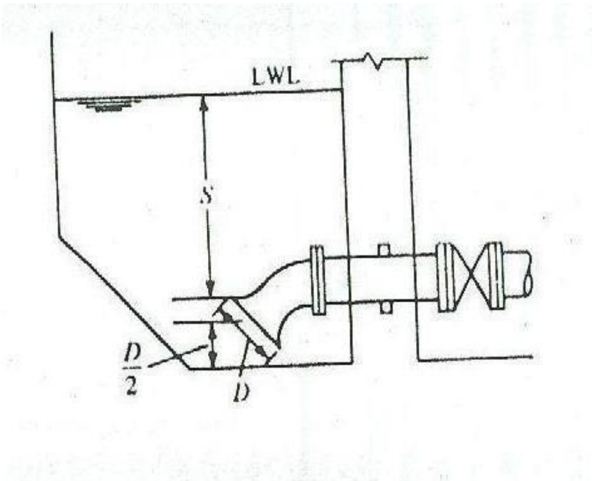
In general, the total volume required for a sump with n pumps and a constant value ΔH is

$$V_{tot,n} = V_{req} + (n-1)\ \Delta H \bullet S$$

in which S is the plan area of the sump and V_{req} is the volume required for a single pump.

Minimum cycle time

(15-75 kw→ > 15 min, > 75 kw→ > *20-30min*



Suction pipe diameter

Suction pipe velocity → 1.2 – 1.8 m/sec

Minimum distance between floor and suction pipe= Dsuction/2

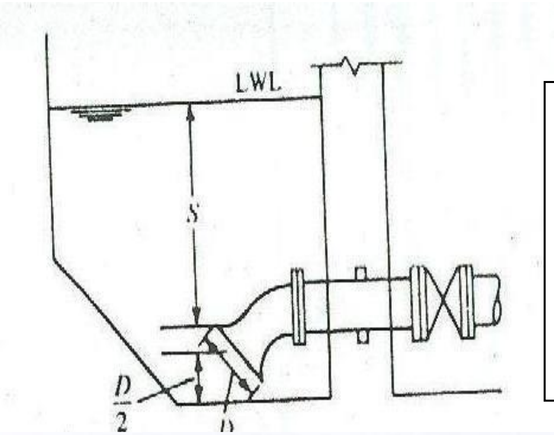
Submergence depth (S)

Distance between LWL and suction pipe

To prevent vortexing

Metcalf & Eddy Pumping → Table 9.3

$1.098\ (V_{emme)})^{-0.4896}$



Min. Water depth , m

S (submergence) + Dsuction / 2

ΔH = start-stop level

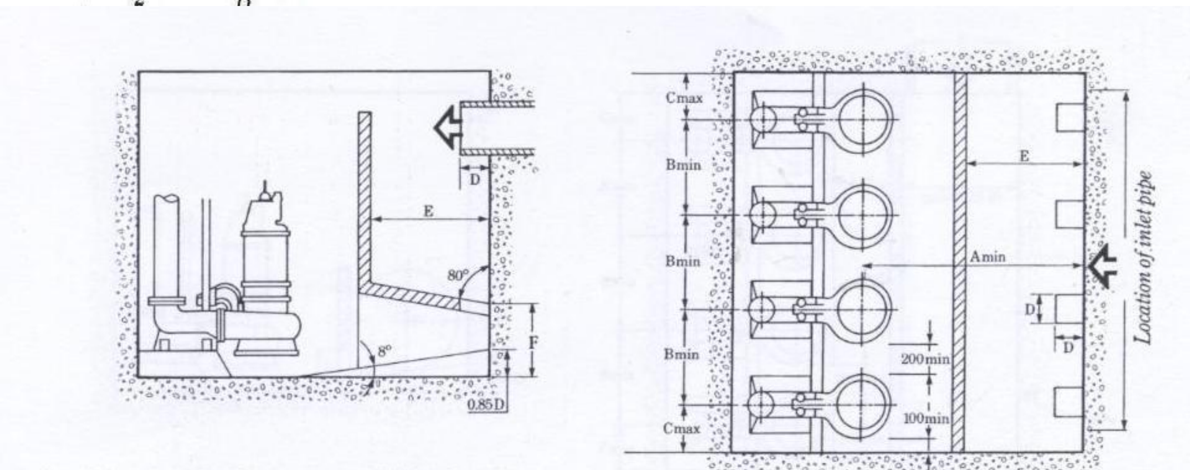


Fig. 4 Sump with front entry at high elevation, A-1

Width of wet well (w) , m

(no of pumps) x B + 2 x C

Length of wet well (L), m

A + 2 x B

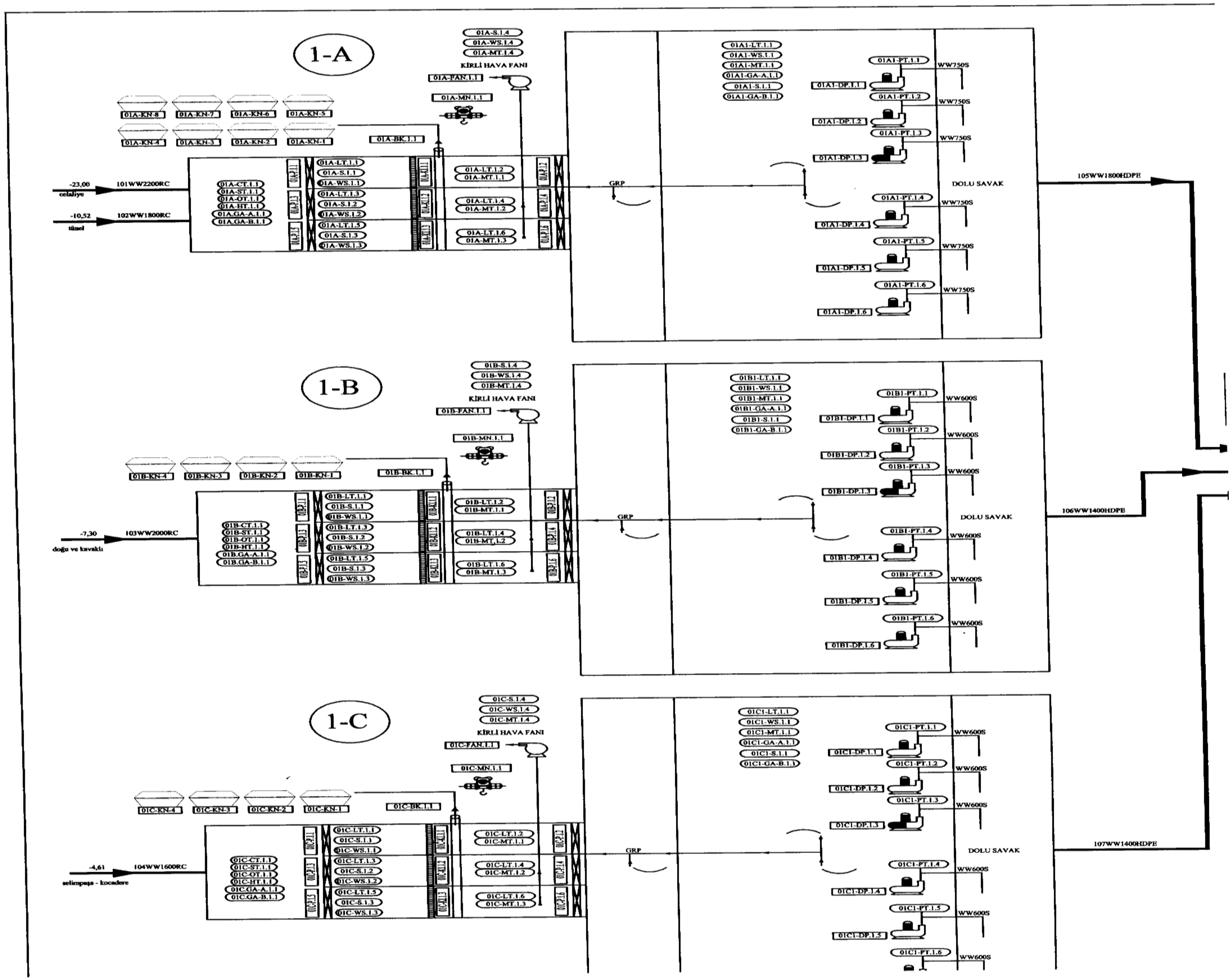
Surface Area of wet well , m²

w x L

Minimum volume required for wet well

$$V_{req} = \frac{T_{min} Q}{4}$$

Total volume of wet well = Minimum active volume + (no. Of pump -1) x ΔH x surface area of wet well



1-A
KİRLİ HAVA FANI
-23,00
celaliye
101WW2200RC
-10,52
tünel
102WW1800RC
GRP
DOLU SAVAK
105WW1800HDPE
1-B
KİRLİ HAVA FANI
-7,30
doğu ve kavaklı
103WW2000RC
GRP
DOLU SAVAK
106WW1400HDPE
1-C
KİRLİ HAVA FANI
-4,61
selimpaşa - kocadere
104WW1600RC
GRP
DOLU SAVAK
107WW1400HDPE

DESIGN OF SCREENS

- Coarse screens (3-5 cm) , fine screens (1-3 cm), micro screens (<1 cm)
- Manually cleaned , mechanically cleaned
- Mechanically cleaned

  scraper , at regular time intervals

  5 m/min-10 m/min

Coarse screenings → mechanical band conveyor →container

Fine screenings → mechanical band conveyor →screening press→container

40% decrease in volume

Moisture = 40%- 50%

Leachate → recyle back to the inlet


27 5 2003

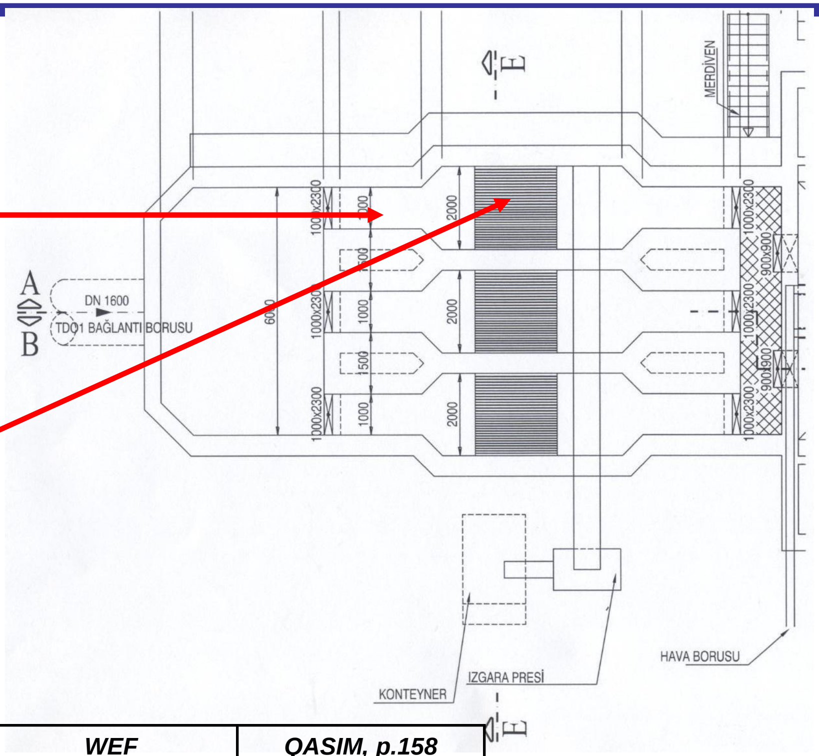

Scraper
Band conveyor
27 5 2003

DESIGN OF SCREENS

Major design criteria:

Approach velocity

Velocity between bars



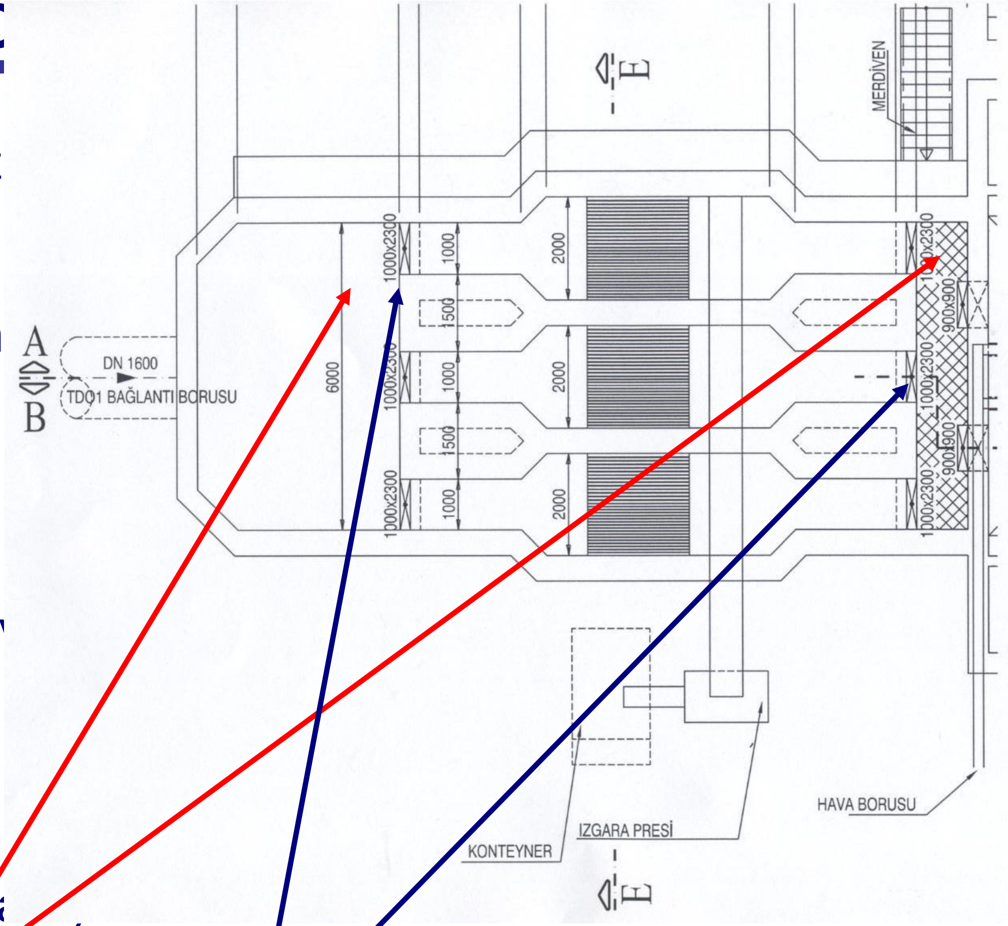
		M&E, 4th ed., p.316-320		*WEF*		*QASIM, p.158*	
		manual	**mechanical**	**manual**	**mechanical**	**manual**	**mechanical**
Bar size							
width	mm	5-15	5-15			4-8	8-10
depth	mm	25-38	25-38			25-50	50-75
Clear spacing between bars	mm	25-50	15-75	25-50	6-38	25-75	10-50
Slope from vertical	degree	30-45	0-30	30-45	0-30	40-45	5-15
Approach velocity							
maximum	m/s	0.3-0.6	0.6-1	0.3-0.6	0.6-1.2		
minimum	m/s		0.3-0.5		0.3-0.6		
Velocity between bars						0.3-0.6	0.6 - 1
at peak flow	m/s		<0.9				
Allowable headloss, clogged screen	mm	150	150-600			150	150
Cycle time of cleaning	min		app. 15 min				

DESIGN C

- Velocity check when one channel is out
- Velocity check under clogging condition
- Minimum 2 channels

    flexibility in operation (Qmin, Qa

    repair,maintanance



- to take each channel out of operation e

    inlet and outlet → common channel

    to the inlet and outlet of each screen channel →penstock

DESIGN OF SCREENS

HEAD LOSS CALCULATION

a) Clean and Dirty Screen ***(Ref: Metcalf & Eddy, 2003 ve Qasım, 1985)***

Head Loss $$= \frac{1}{c}\frac{(V^2 - v^2)}{2g}$$

c= emprical discharge coefficient accounting turbulence and eddy losses for clean screen 0.7, for dirty (clogged screen) 0.6

V= velocity between bars (m/sec)

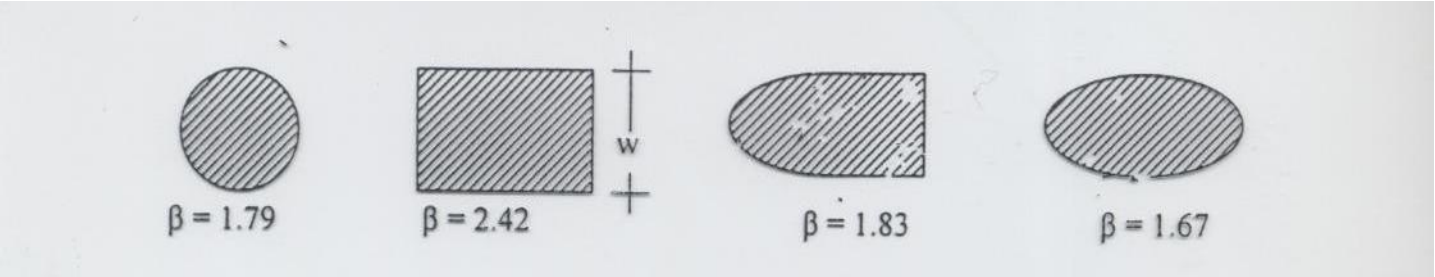
v= approach velocity (m/sec)

DESIGN OF SCREENS

b) Clean screen head loss ***(Ref: Qasım, 1985)***

Head Loss $= \beta \left(\frac{w}{b} \right)^{4/3} h_v \sin \theta$

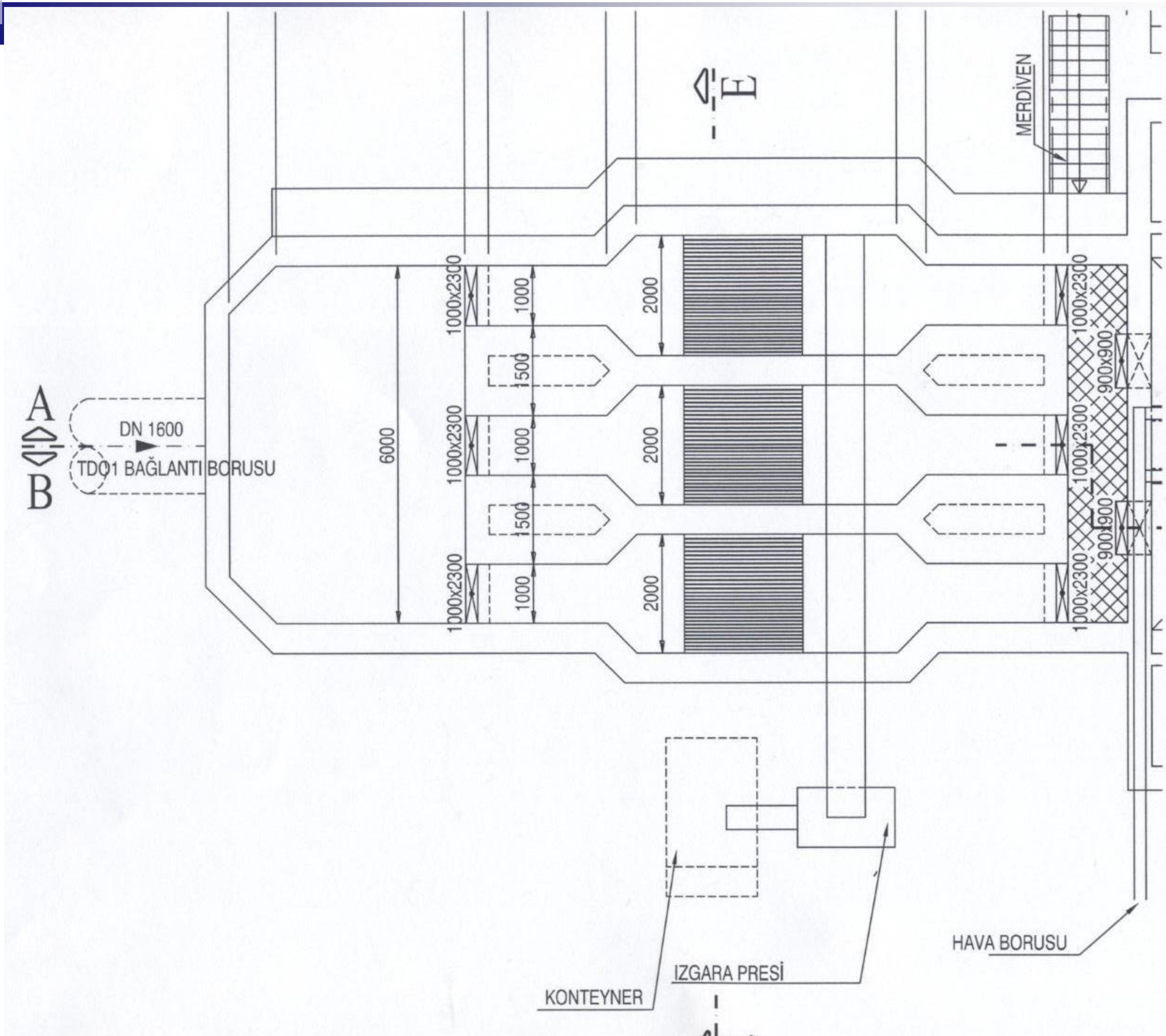
β= shape factor



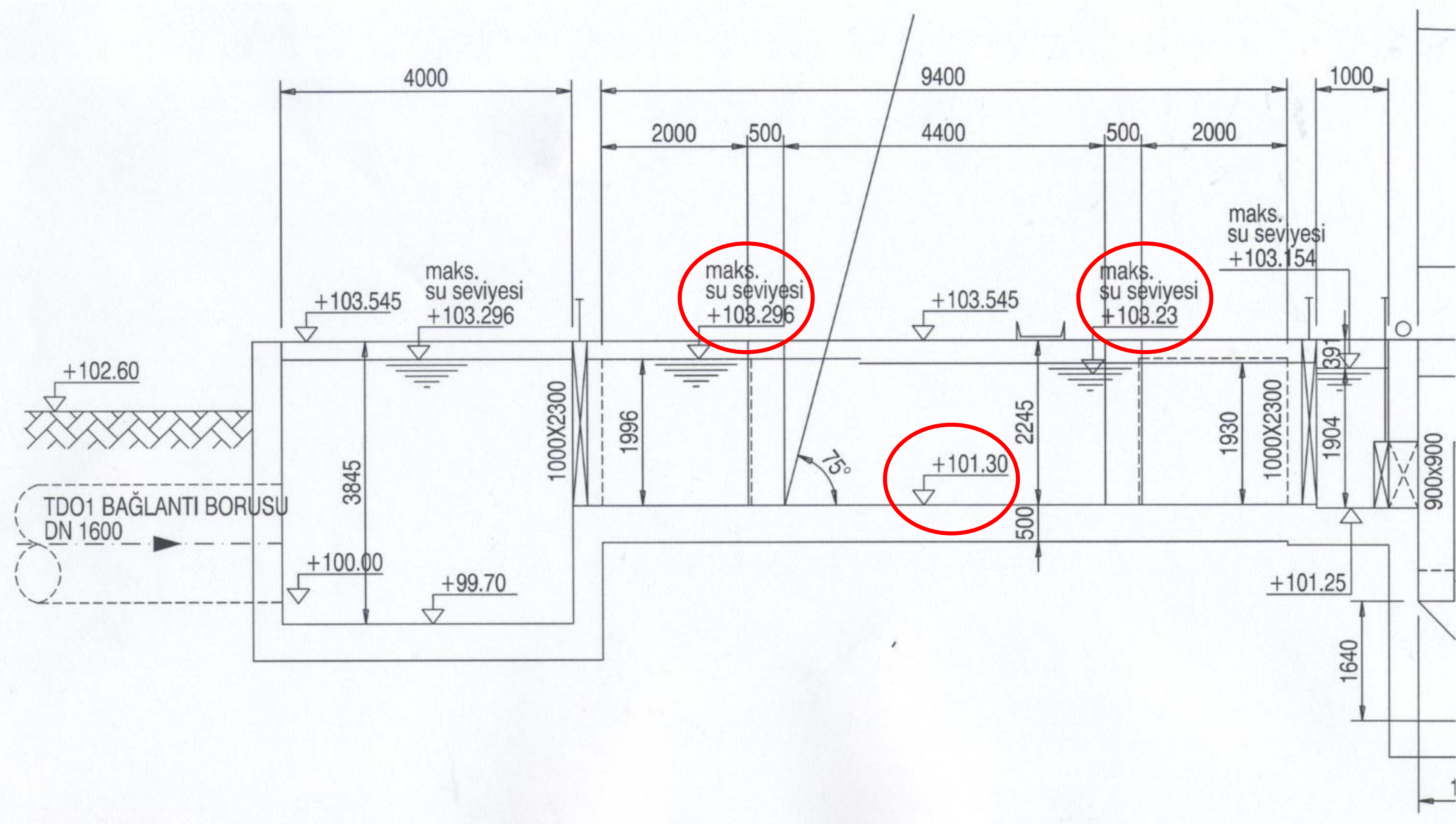
W/b= total spacing between bars, m

hv= velocity head (according to velocity between bars), m

θ = angle of screen with horizantal , degree



E
MERDİVEN
A
B
DN 1600
TD01 BAĞLANTI BORUSU
6000
1000x2300
1000
1500
2000
900x900
KONTEYNER
IZGARA PRESİ
HAVA BORUSU


4000
9400
1000
2000
500
4400
500
2000
maks.
su seviyesi
+103.154
maks.
su seviyesi
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maks.
su seviyesi
+103.296
+103.545
+103.545
maks.
su seviyesi
+103.23
+102.60
3845
1000X2300
1996
2245
1930
1000X2300
1904
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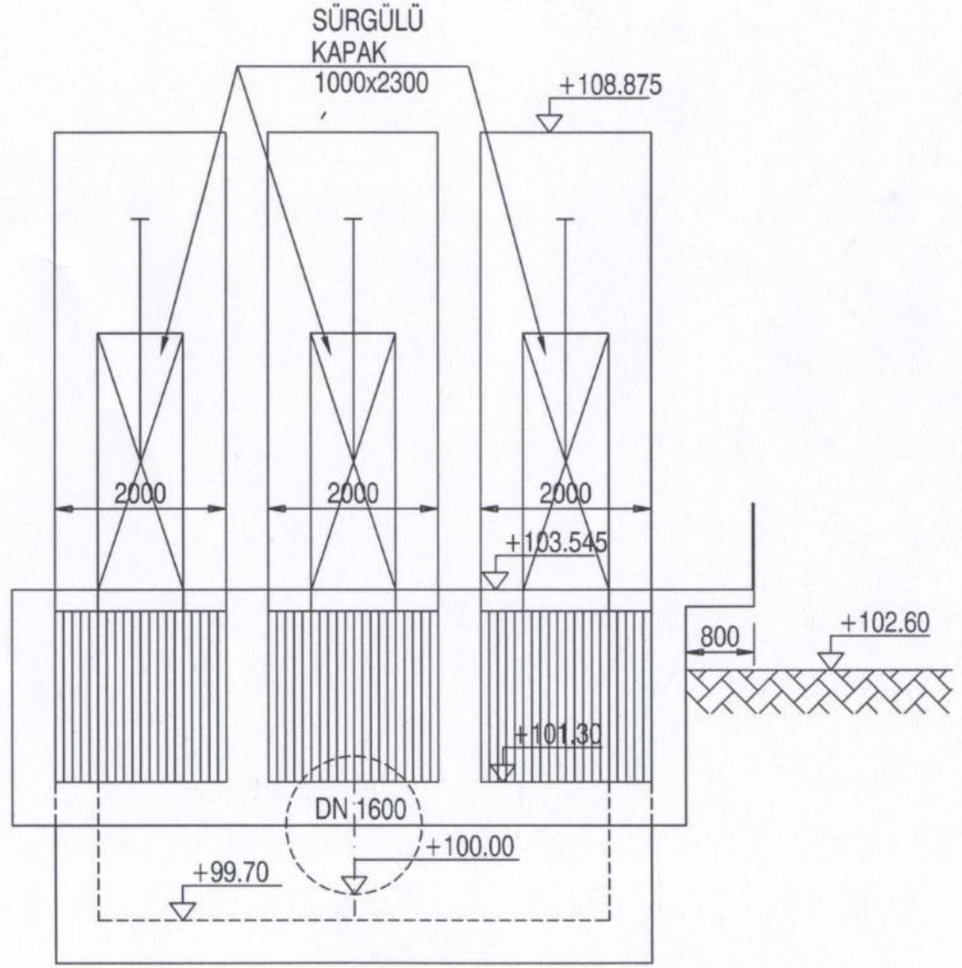
+101.30
500
TDO1 BAĞLANTI BORUSU
DN 1600
+100.00
+99.70
+101.25
1640


SÜRGÜLÜ
KAPAK
1000x2300
+108.875
2000
2000
2000
+103.545
800
+102.60
+101.30
DN 1600
+100.00
+99.70

KESİT E-E

Qaverage	
peak Factor	
Qpeak (m3/d)	
Q min(m3/d)	
Total no of stages	
No of stages in operation	
@ Qpeak	
@ Qave	
@ Qmin	

SCREENS

Q peak(1 stage) m3/s	
Q ave(1 stage) m3/s	
Q min(1 stage) m3/s	
According to Q peak	
v (m/s) bw bars	
v (m/s) approach	
Bar width (cm)	
Bar spacing (cm)	
Teta	
Shape factor	
Depth of flow (m) @Qpeak	
@Qave	
@Qmin	

FOR SCREEN PART		
Selected screen width		m
Total frame width		mm
Channel width for screen		m
# of bars due to selected width		
Selected # of bars		
New # of spacings		
Final screen width		

FOR APPROACH CHANNEL			
Channel width before screen		m	
Approach velocity			
@Qpeak	m/sec	0.6-1 m/sec	
@Qave	m/sec		
@Qmin		0.3-0.5 m/sec	

Flow Area (clean screen)		
@Qpeak		m2
@Qave		m2
@Qmin		

Flow Area (% 20 clogged screen)		
@Qpeak		m2
@Qave		m2
@Qmin		m2

Clean Screen	
Velocity between bars @Q peak	
Velocity between bars @ Q ave	
Velocity between bars @ Q min	

% 20 clogged screen		
Velocity between bars @ Q peak		m/sec
Velocity between bars @ Q ave		m/sec
Velocity between bars @ Q min		m/sec

Clean Headloss Calculation	
@ Qpeak	
@ Qave	
@Qmin	

% 20 clogged head loss calculation		
@ Qpeak		m
@ Qave		m
@Qmin		m

Depth of flow after Screen	
Clean screen	
@Qpeak	
@Qave	
@Qmin	

Depth of flow after Screen		
% 20 clogged		
@Qpeak		m
@Qave		m
@Qmin		m

DESIGN OF GRIT CHAMBERS

- for the removal of inorganics like sand, pebble, silt, glass,metal

(organics like egg shell, coffee grinds)

WHY NOT ARE THEY REMOVED IN PRIMARY SEDIMENTATION BASINS?

Primary sludge → Digesters

Sand, silt etc inorganics→ nondegradable

occupy volume in digesters

volume increase of digesters

-

DESIGN OF GRIT CHAMBERS

- HORIZANTAL FLOW, VORTEX TYPE, AERATED

Horizantal Flow

0.3m/sec horizantal velocity at all flow conditions → settlement of inorganics

Velocity control → at the exit of chamber (ex: parabolic weir)

Vortex type

Circular

Centrifugal force

Aerated Grit Chambers

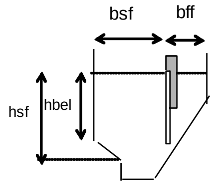
Spiral movement of water

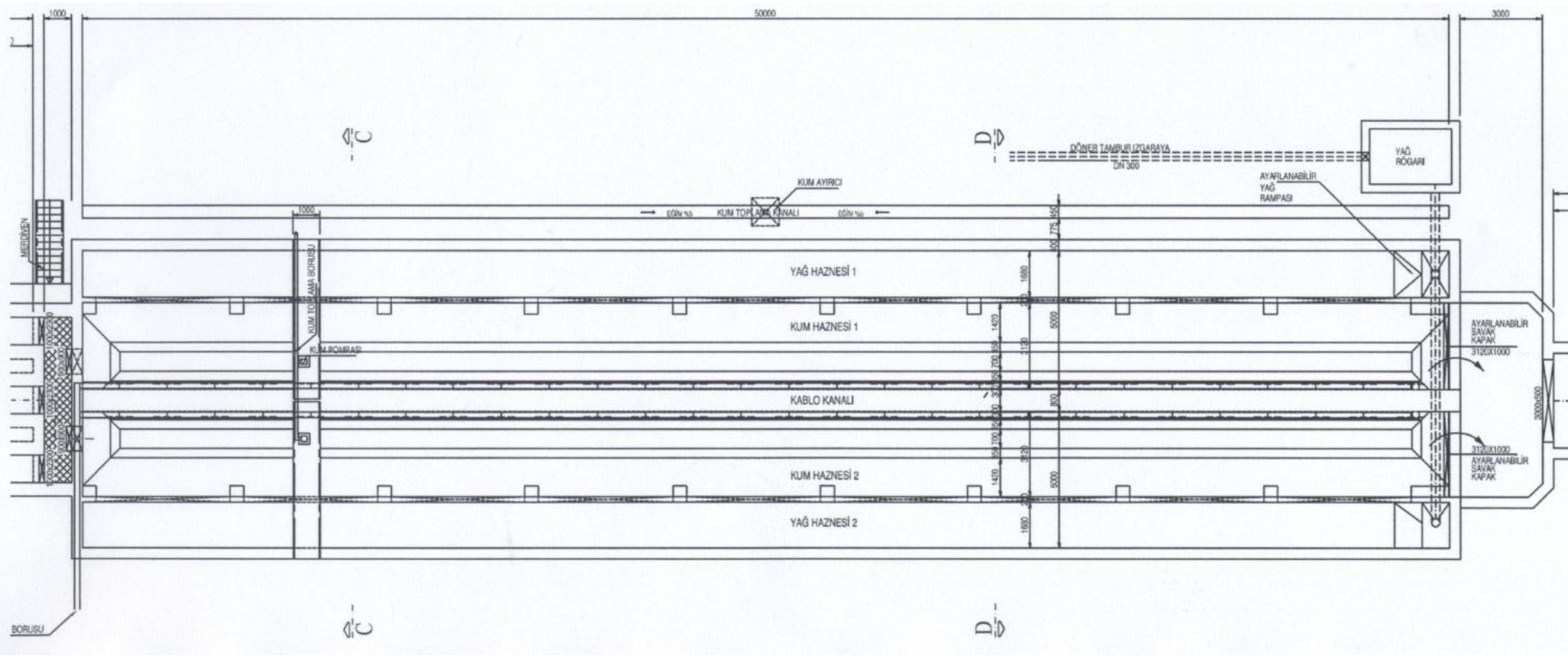
Blowers → positive displacement rotary type or centrifugal type

Diffusers → tubular, coarse or medium bubble

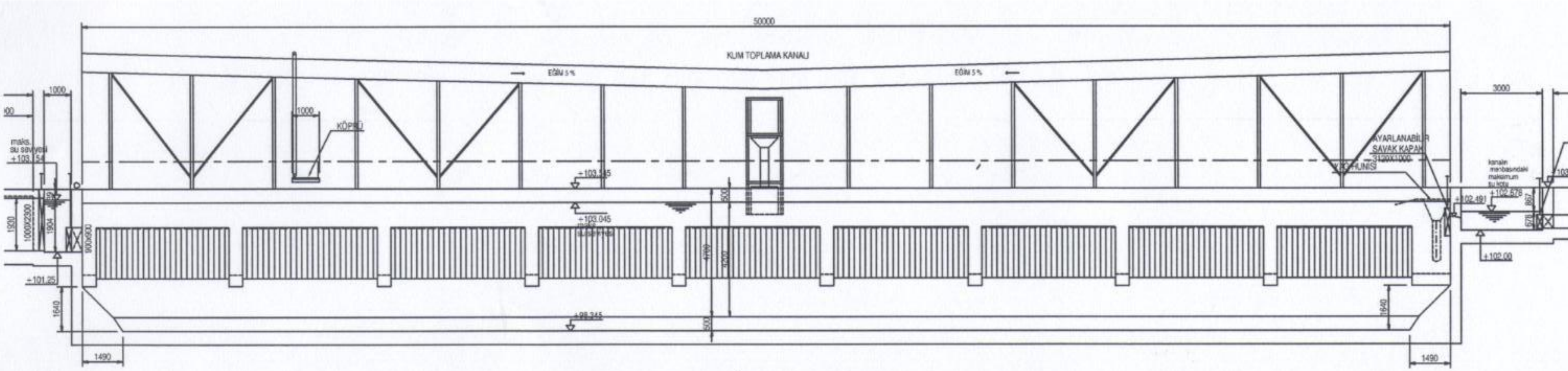
Aerated Grit Chambers

	AMERICAN APPROACH (NO GREASE REMOVAL)		EUROPEAN APPROACH (GREASE REMOVAL)
	Metcalf & Eddy, 2003, p389	**Qasım, 1985 p. 243**	**ATV,** Korrezpondenz Abwasser1998 (45) Nr.3
Depth	2... 5 m	2... 5 m	
Length	7.5…20 m	7.5…20 m	10 - 50 m
Width	2.5 - 7 m		grease part w (bff) / grit part w (bsf)=0.2 to 0.5
Width/Depth	1:1 - 5:1	1:1 - 5:1	bsf/hsf <1 w/supply of dry weather bsf/hsf <0.8 w/ supply of rain weather
Length/Width	3:1 - 5:1	2.5:1 - 5:1	cross section area (w/o fat catch 1-15 m2) L = approx. Tenfold width
Detention Time	2…5 min(at peak)	2…5 min(at peak) If grit chamber is used for pre-aeration or to remove grit less than 0.21 mm (65 mesh) longer det. time may be provided	approx. 10 min w/small requirements approx. 5 min w/ high requirements of the sand support approx. 20 min
Horizontal velocity			< 0.2 m/sec
Transverse velocity at the surface		0.6 -0.8 m/s	
Grease part surface loading			q aff < 25 m/hr
Air Requirement	3.33…8.33 L/ sec m	4.6…12.4 L/sec m Higher air rate should be used for wider and deeper tanks. Provision should be made to vary the air flow. An air flowrate of 4.6 - 8 L/sec m in a 3.5 to 5 m wide and 4.5 m deep tank give surface velocity of approx. 0.5 - 0. 7 m/sec. The vel. at the floor of the tank is 75% of the surface velocity. A velocity of 0.23 m/s is required to move a 0.2 mm sand particle along the tank bottom.	0.5 -1.3 m3/m3.hr It is suggested an air entry of approx not to exceed 0.8 m3/m3.hr with grit chambers under 3 m2 cross section area and 1.3 m3/m3.hr with larger grit chambers
Grit Amount	4 …200 m3/million m3 water	5…200 m3/million m3 water	
Diffuser location	located about 0.45 to 0.6 m above the normal plane of the bottom.	normally located approx. 0.6 m above the sloping tank bottom.	hsf - h bel = 30 cm (over the sand gutter upper edge)
Bottom slope		along width (toward spiral conveyor) 3 horizontal : 1 vertical	35 - 45 degree

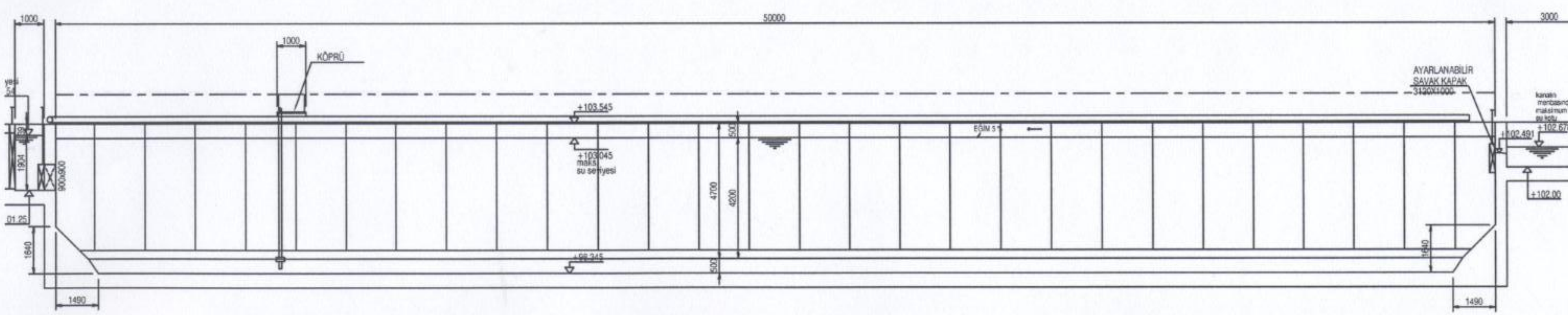




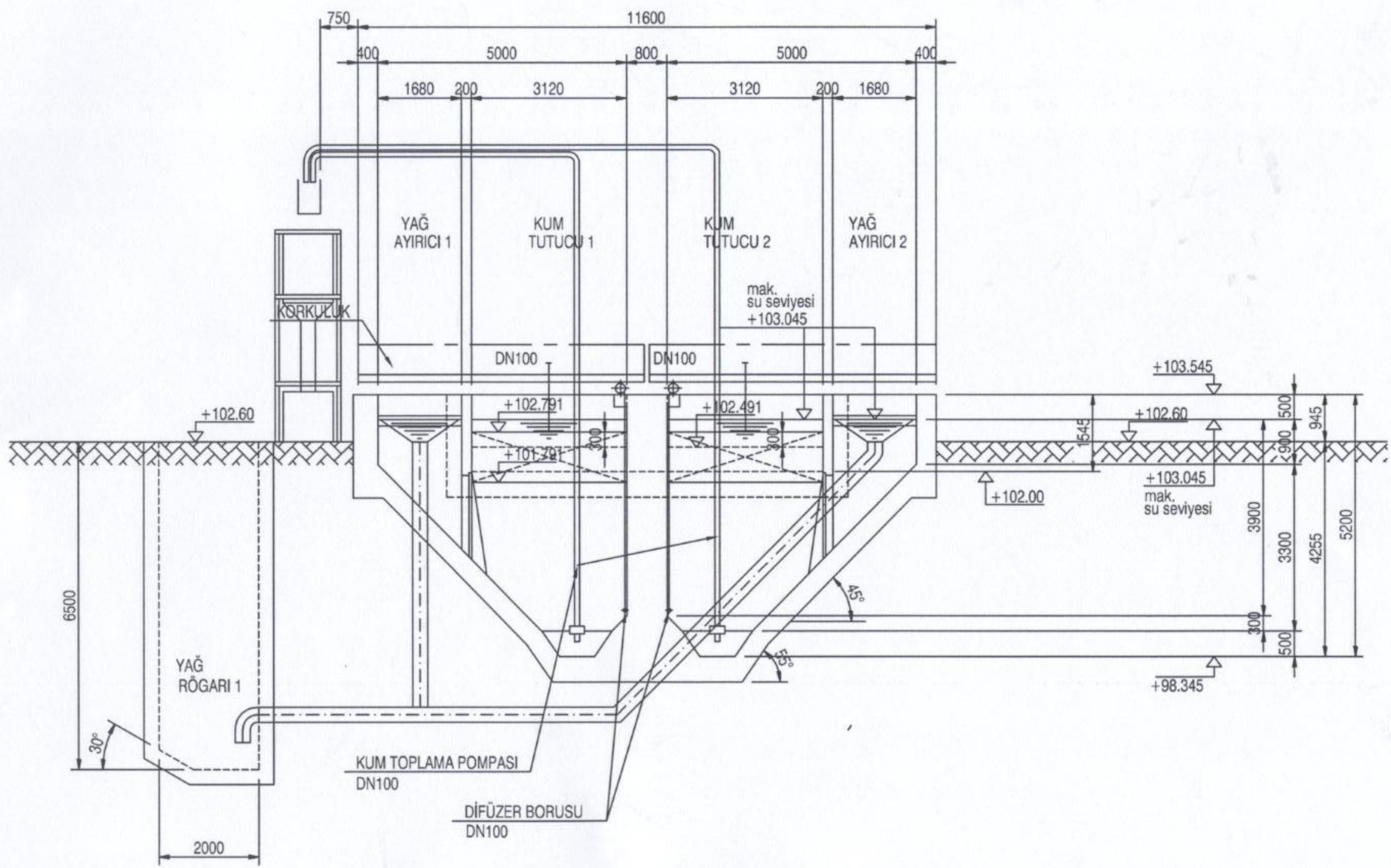
1000
50000
3000
YAĞ RÖGARI
DÖNER TAMBUR IZGARAYA
DN 300
AYARLANABİLİR YAĞ RAMPASI
KUM AYIRICI
KUM TOPLAMA KANALI
KUM TOPLAMA BORUSU
KUM POMPASI
MERDİVEN
YAĞ HAZNESİ 1
KUM HAZNESİ 1
KABLO KANALI
KUM HAZNESİ 2
YAĞ HAZNESİ 2
AYARLANABİLİR SAVAK KAPAK
3120X1000
BORUSU


50000
KLIM TOPLAMA KANALI
EĞİM 5 %
EĞİM 5 %
KÖPRÜ
1000
1000
3000
1490
1490

KESİT A-A


1000
50000
3000
1000
KÖPRÜ
AYARLANABİLİR
SAVAK KAPAK
+103.545
+103.045
maks.
su seviyesi
+102.491
+102.00
1904
900x900
1640
4700
4200
500
+98.345
1490
1490

KESİT B-B

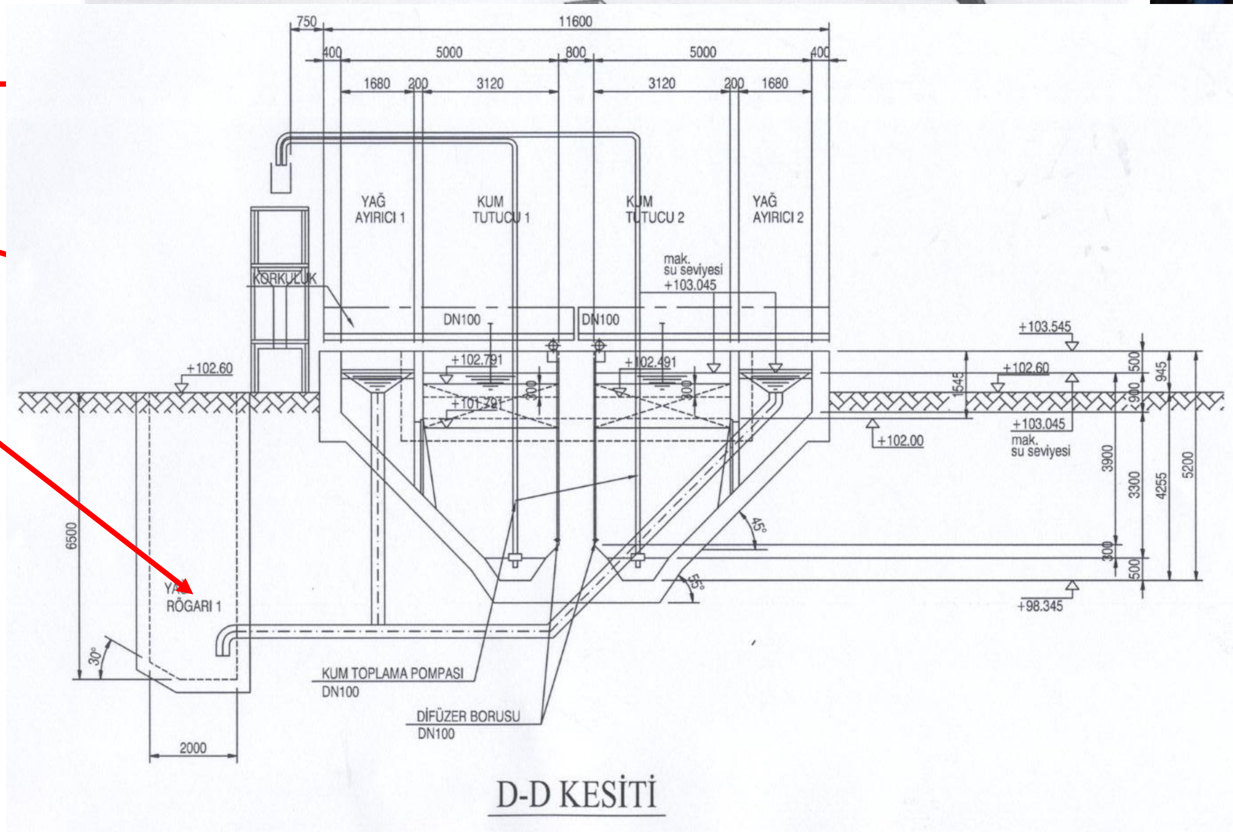


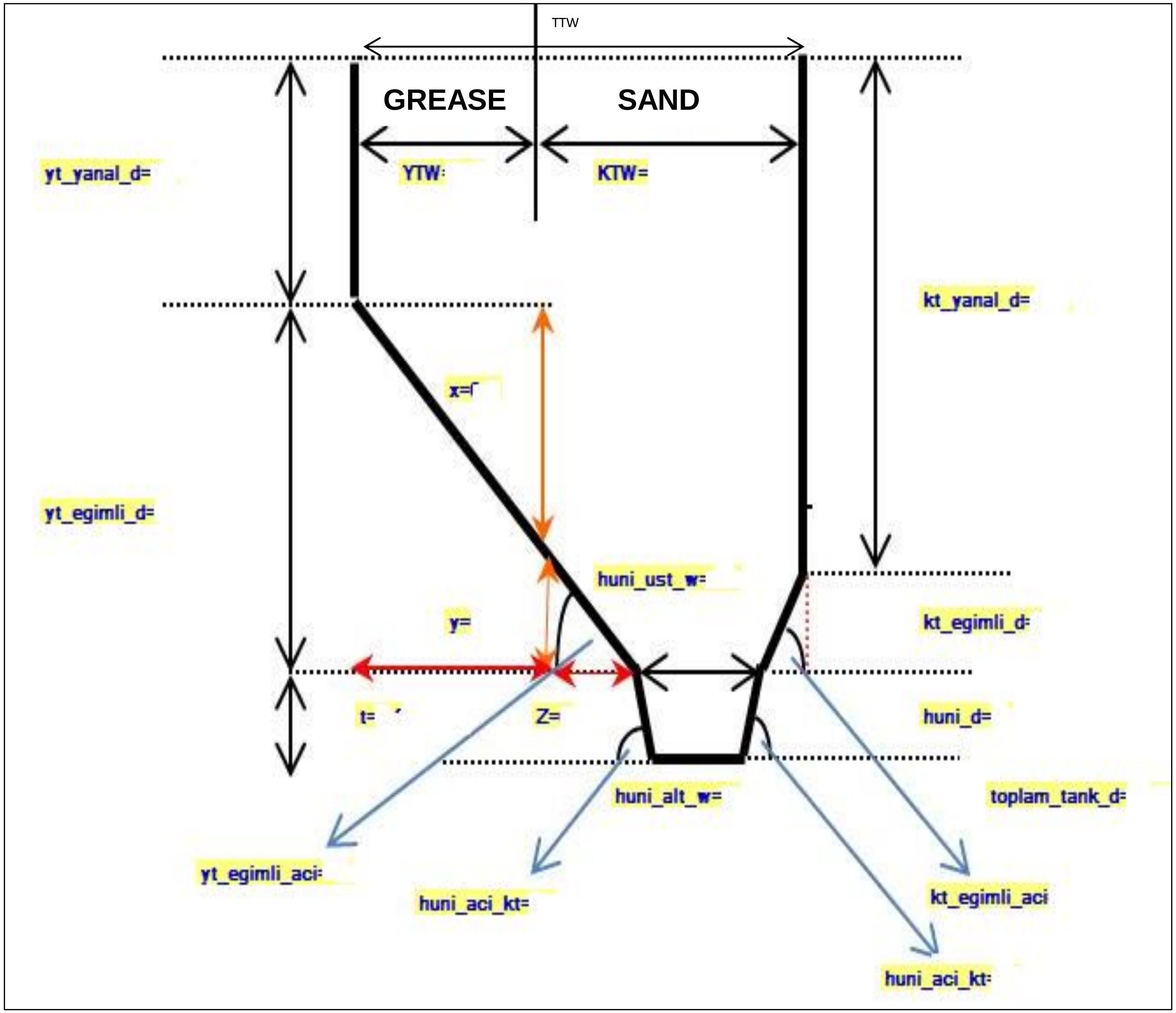
750
11600
400
5000
800
5000
400
1680
200
3120
3120
200
1680
YAĞ AYIRICI 1
KUM TUTUCU 1
KUM TUTUCU 2
YAĞ AYIRICI 2
mak. su seviyesi +103.045
KORKULUK
DN100
DN100
+103.545
+102.791
+102.491
+102.60
+102.60
300
300
+101.791
1545
500
945
900
+103.045 mak. su seviyesi
+102.00
3900
3300
4255
5200
6500
45°
300
500
55°
+98.345
YAĞ RÖGARI 1
30°
KUM TOPLAMA POMPASI DN100
DİFÜZER BORUSU DN100
2000

D-D KESİTİ

Mechanical Equipment List fo

- Blowers
- Travelling Bridge
- Sand pumps
- Grit classifier
- Grease pumps
- Rotary screen




TTW
GREASE
SAND
yt_yanal_d=
YTW=
KTW=
kt_yanal_d=
x=
yt_egimli_d=
huni_ust_w=
y=
kt_egimli_d=
t=
Z=
huni_d=
huni_alt_w=
toplam_tank_d=
yt_egimli_aci=
huni_aci_kt=
kt_egimli_aci
huni_aci_kt=

Total number of grıt chamber (NKT) → Input

Number of grıt chamber ın operatıon at Qpeak

(npKT) → Input

Number of grıt chamber ın operatıon at Qave

(nOKT) → Input

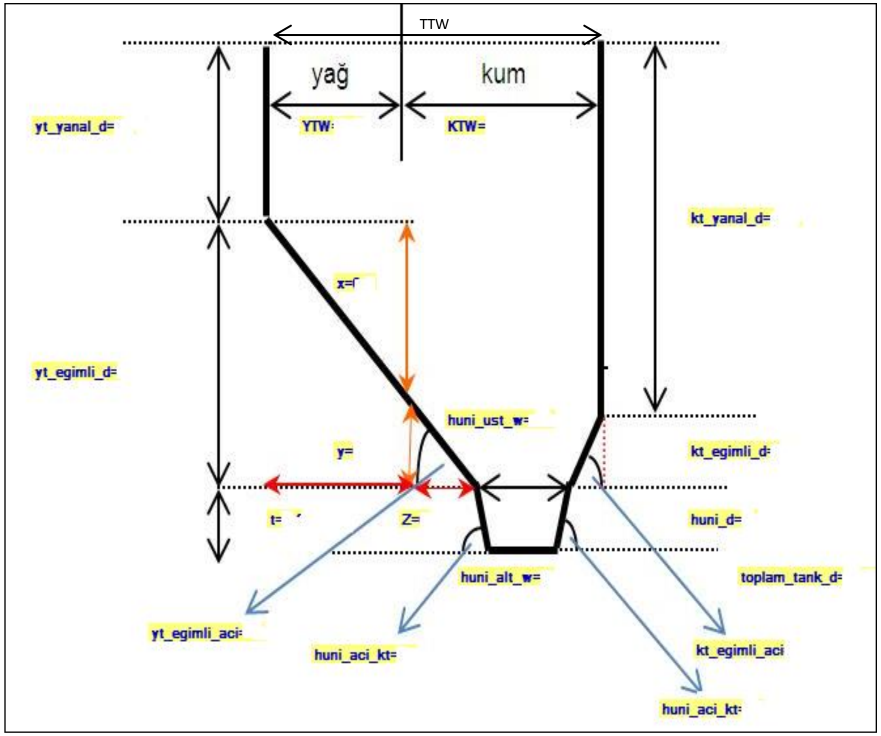
Number of grıt chamber ın operatıon at Qmın

(nMKT) → Input

Qpeak / tank (QPKT), m^3/g = Qpik/ NP

Qave/tank (QOKT), m^3/g = Qort/NO

Qmin/tank (QMKT), m^3/g = Qmin/NM

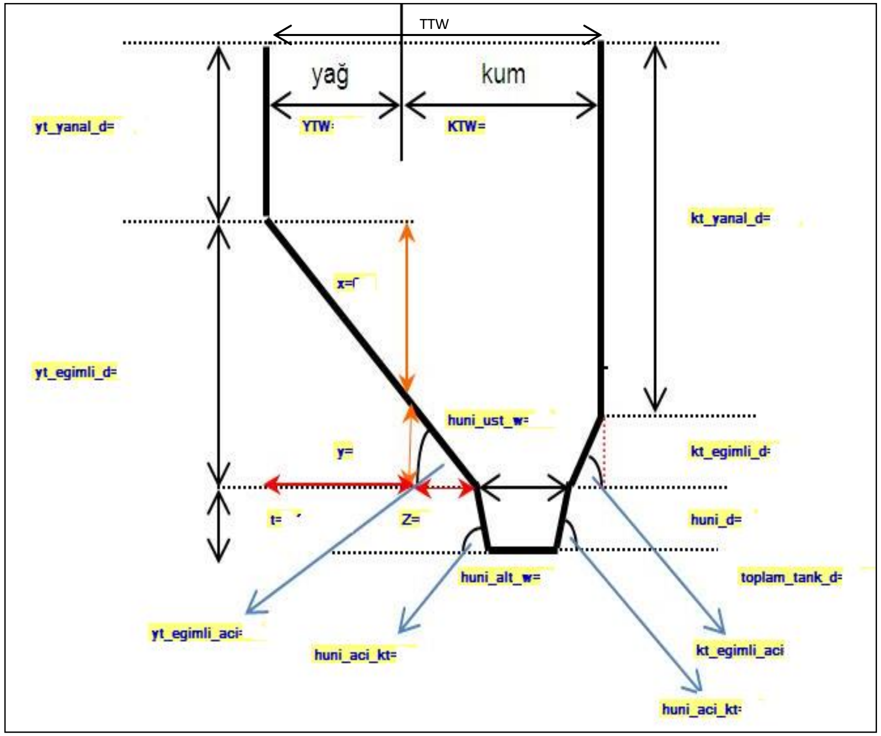


Herbir tankın toplam genişliği (TTW), m → **Input**

Yağ tutma kısmı / Kum tutma kısmı (YTKT_ORAN) → **Input**

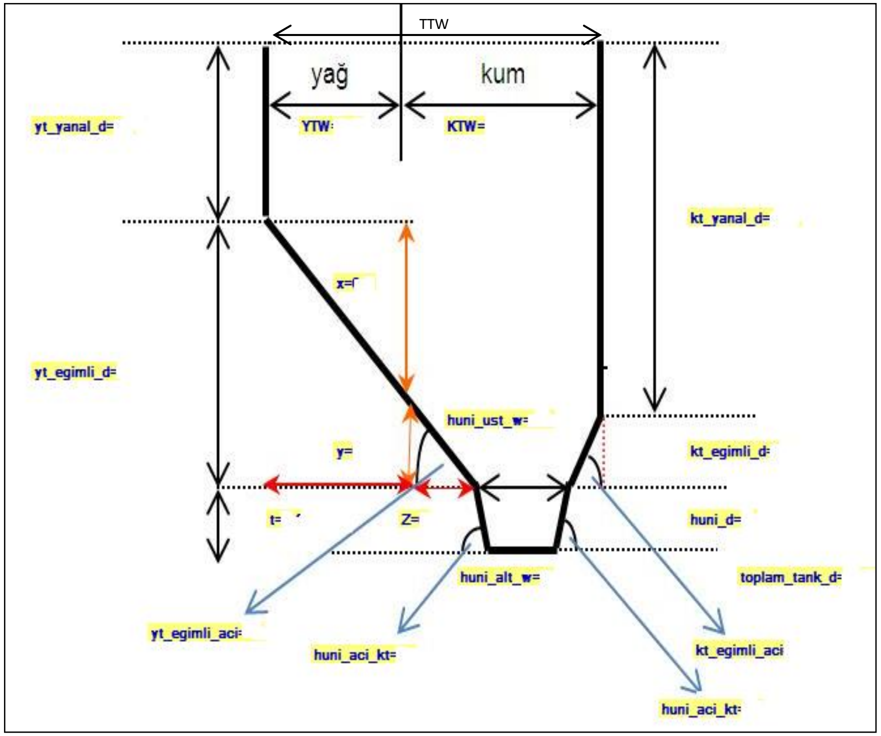
Herbir tankın kum tutucu kısmı genişliği(KTW), m = ttW/(ytkt_oran+1)

Herbir tankın yağ tutucu kısmı genişliği(YTW), m = KTW x ytkt_oran



Herbir tankın kum tutucu kısmı genişliği(KTW), m = ttW/(ytkt_oran+1)

Herbir tankın yağ tutucu kısmı genişliği(YTW), m = KTW x ytkt_oran



Tank uzunluğu (Ltank), m → **Input**

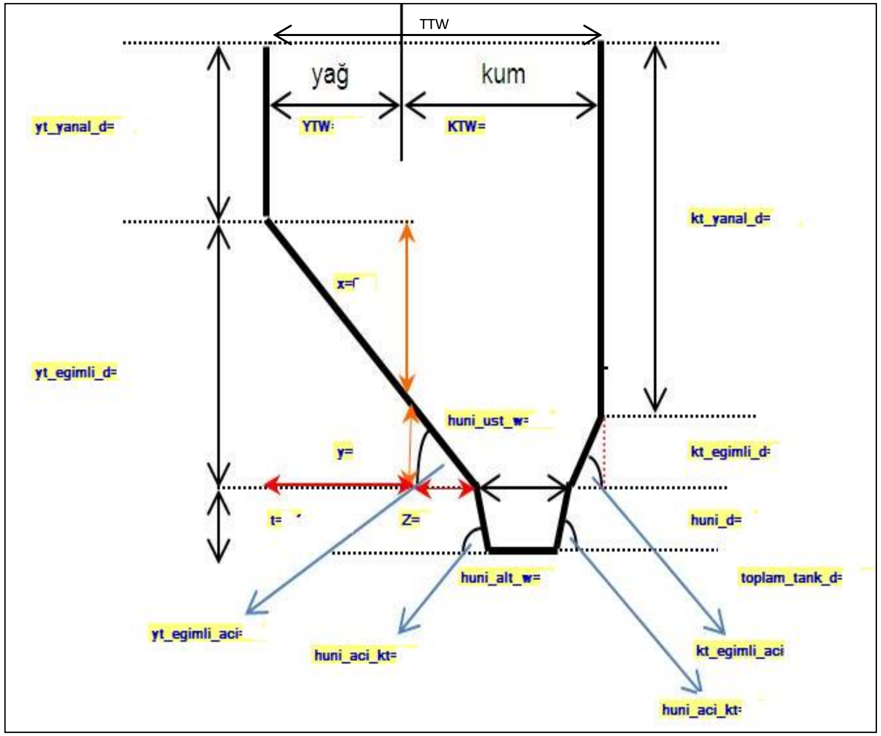
Yağ toplama kısmındaki rampa uzunluğu (YRL), m → **Input**

↓

Ltank= 10 x TTW

↓

Yağ toplama kısmı tank uzunluğu(Ltank_yag_toplama), m =Ltank-YRL



Kum tutucu tarafı yanal derinlik(*kt_yanal_d*)

Kum tutucu kısmı yan duvarın yatayla yaptığı açı (*kt_egimli_acı*)

Kum tutucu kısmı yan duvar eğimli kısım derinliği(*kt_egimli_d*)

Kum toplama hunisi kum tutucu tarafı yatayla yaptığı açı (*huni_acı_kt*)

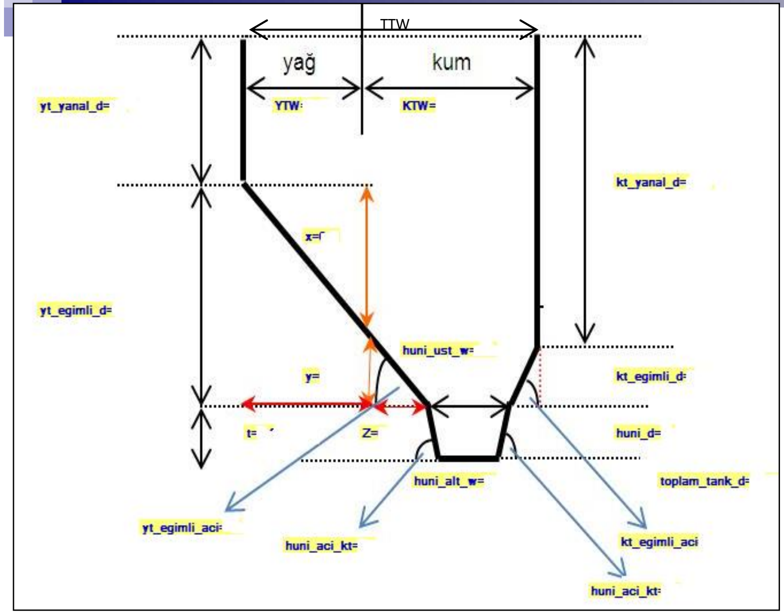
Kum toplama hunisi yağ tutucu tarafı yatayla yaptığı açı (*huni_acı_yt*)

Kum toplama hunisi derinliği(*huni_d*)

Kum toplama hunisi ust genislik (*huni_ust_w*)

Yag tutucu kısmı yan duvarın yatayla yaptığı açı(*yt_egimli_acı*)

Input



Kum toplama hunisi alt genislik(*huni_alt_w*)**, m**

= huni_ust_w-2*(huni_d/tan(huni_acı_yt)

Yag tutucu tarafı yanal derinlik(*yt_egimli_d*)**, m**

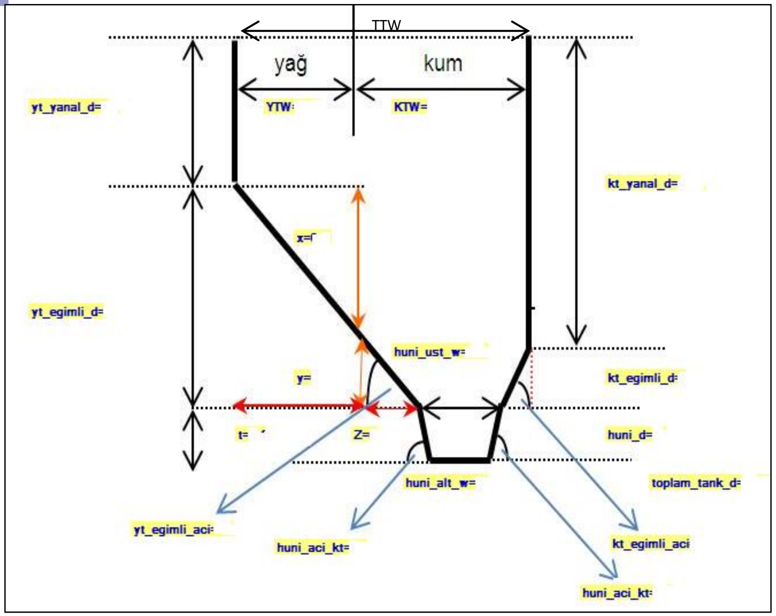
=(ktw+ytw)-(kt_egimli_d/tan(kt_egimli_acı)-huni_ust_w)*tan(yt_egimli_acı)

Yag tutucu kısmı yan duvar eğimli kısım derinliği *(yt_yanal_d)*, **m**

=kt_yanal_d+kt_egimli_d-yt_egimli_d

Toplam tank derinligi *(toplam_tank_d)*, **m (kum toplama hunisi dahil)**

=yt_yanal_d+yt_egimli_d+huni_d



Pik debide yag tutucu kısmı yuzey yuku (yk_yag_pik), m/sa

= (qpkt/24) / (Ltank_yag_toplama x ytw)

Ortalama debide yag tutucu kısmı yuzey yuku (yk_yag_ort), m/sa

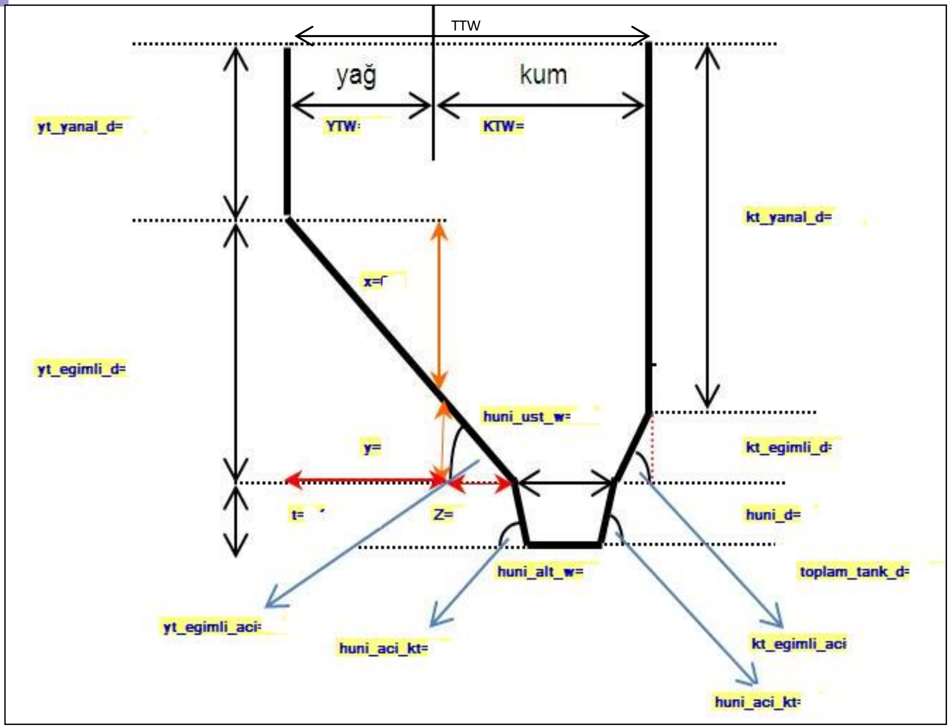
=(qokt/24) / (Ltank_yag-toplama x ytw)

Pik debide tüm yüzey yükü (yk_tum_pik), m/sa

=(qpkt/24) / (Ltank x ttw)

Ortalama debide tüm yüzey yükü (yk_tum_ort), m/sa

=(qokt/24) / (Ltank x ttw)



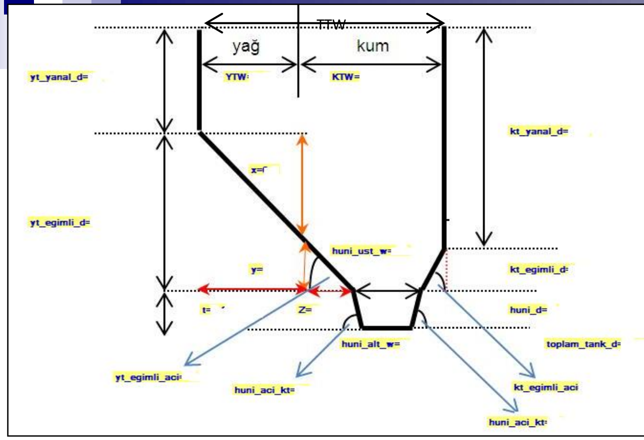
X=(ytw x TAN(yt_egimli_acı x Pİ()/180))

Y=(yt_egimli_d + yt_yanal_d) - (yt_yanal_d+x)

Z=y/tan(yt_egimli_acı x pi()/180)

W=kt_egimli_d/tan(kt_egimli_acı*pi()/180)

T=(ytw+ktw)-(huni_ust_w+z)



Kum tutucu yanal alanı (yanal_alan), m^2

=((ktw*(kt_yanal_d+huni_d))-(y*z/2)-(kt_egimli_d*w/2))+((ytw*(yt_yanal_d+yt_egimli_d))-(y+yt_egimli_d)*t/2))

Kum toplama kısmı tank hacmi(kth), m^3

=((ktw*(kt_yanal_d+huni_d))-(y*z/2)-(kt_egimli_d*w/2))*LTANK

Yağ toplama kısmı tank hacmi (yth), m^3

= ((ytw*(yt_yanal_d+yt_egimli_d))-(y+yt_egimli_d)*t/2))*ltank_yag_toplama

Toplam tank hacmi (tth), m^3 (kum toplama hunisi hacmi hariç)

=kth+yth

Kum toplama hunisi hacmi(hh), m^3 = ((huni_alt_w+huni_ust_w)*huni_d/2)*Ltank

Hydraulic retention time at Qpeak (Tr_pik), min =(TTH / qpkt) x 24 x 60

Hydraulic retention time at QaveTr_ort), min =TR_ort=(TTH / qokt) x 24 x 60

Horizantal velocity at Qpeak (yatay_hız_pik), m/sn=(qpkt / 86400) / yanal_alan

Horizantal velocity at Qave (yatay_hız-ort), m/sn= (qokt/86400) / yanal_alan

Chosen air flow per tank (birim_hava_sarf) m^3/sa/m^3 tank su hacmi → **Input**

Air requirement per tank at Q (ave ort_hava_ihtiyacı), m^3/sa = birim_hava_sarf x tth

Total air requirement (toplam_hava_ihtiyacı), m^3/sa= ort_hava_ihtiyacı x nkt