APPLIED AND FLUID MECHANICS 2
7460

CAMEROON GENERAL CERTIFICATE OF EDUCATION BOARD

Technical and Vocational Education Examinations

JUNE XXXX **ADVANCED LEVEL**

Specialty Name (Specialty Code)	
Subject Title	**APPLIED AND FLUID MECHANICS**
Paper No.	**2**
Subject Code No.	**7460**

Three hours

INSTRUCTIONS TO CANDIDATES

You are reminded of the necessity for good English and orderly presentation in your answers.

You are advised to read carefully through the question paper, before you begin your answers.

The paper is made up of (07) SEVEN sections, you are requested to choose (04) section from fluid mechanic and (1) section of applied mechanic (compulsory).

The compulsory sections for fluids mechanic are: FLUID PROPERTIES AND HYDRAULIC MACHINES.

Take g= $10m/s^2$

All sections carry equal marks (25 marks)

The paper is scored on 100 marks

Leave all answers to two places of decimals

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1. PROPERTIES OF FLUIDS

1.1 Match the pairs

Set *A*	**Set *B***
A. Ideal fluid	1. Irreversible flow
B. Steady flow	2. Incompressible flow
C. Low velocity gas flow	3. Zero viscosity
D. Friction	4. Velocity at a point is constant.

(1x4 = 04 marks)

1.2 Define atmospheric pressure **(02 marks)**

1.3 At the sea level, give the equivalent of the atmospheric pressure in meter column of mercury. **(03 marks)**

1.4 Explain the properties given below with the variation of temperature increase:

1.4.1 The viscosity of a liquid,

1.4.2 The temperature,

1.4.3 The velocity

(2 x3 = 06 marks)

1.5 In a perfect fluid, name each of the four different types of energy represented in the Bernoulli's equation as expressed in the formulas below:

- $\frac{V^2}{2g} + \frac{P}{\rho g} + Z$,
- $\frac{V^2}{2g}$,
- $\frac{P}{\rho g}$,
- Z**,**
- $\frac{P}{\rho g} + Z$**.**

(1.5 x 5 = 7.5 marks)

1.6 Differentiate between hydrostatics and hydrodynamics **(2.5 marks)**

(25 Marks)

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2. HYDROSTATICS

For the design of a reinforced concrete septic tank shown in the Figure 1, the structural engineer consults you as Hydraulic assistant.

<u>Technical specifications of the septic tank</u>

- External length: 4,45 m
- Internal width : 1,35 m
- Height of soluble matter (AB) : 0,60 m
- Height of water (BC) : 1,25 m
- Relative density of water: 1
- Relative density of soluble matter: 0,9

- I_G (rectangle) = $\frac{bd^3}{12}$ $Z_p = z + \frac{IG\ Sin\theta}{AZ}$ $g = 10\ m/s^2$

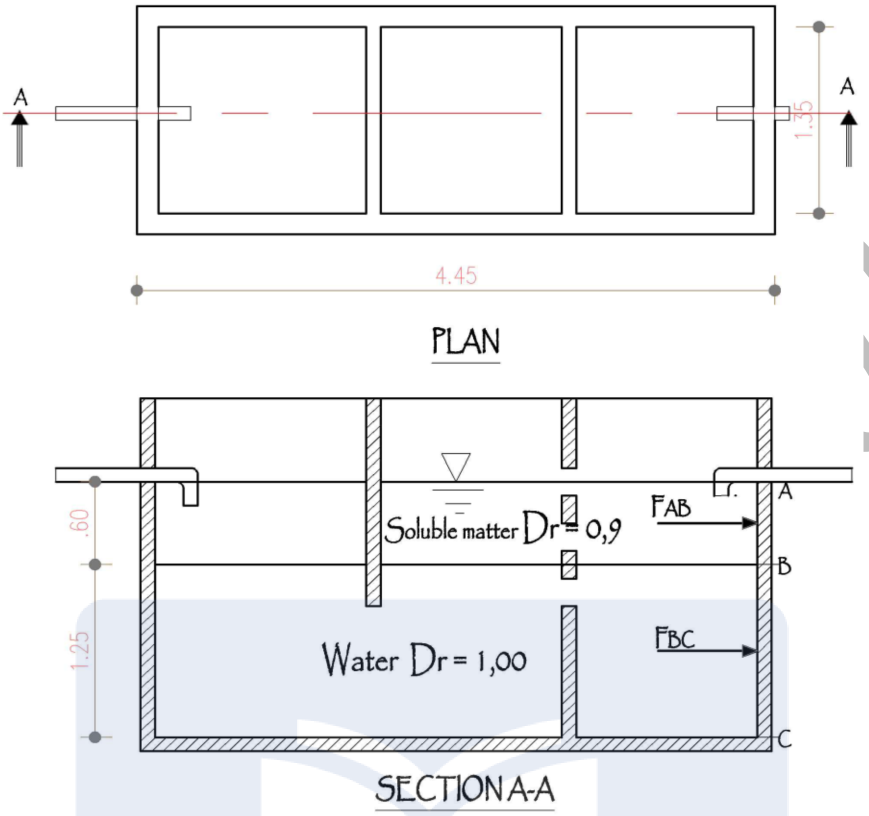

Figure 1

Assuming that the septic tank is waterproof, the structural Engineer assigns you to:

2.1 Calculate the pressure P_{AB} at B **(2.5 marks)**

2.2 Calculate the intensity of the horizontal force F_{AB} of soluble matter acting on the surface AB and its point of application. **(06 marks)**

2.3 Draw the pressure chart on AB and represent the horizontal force AB and its point of application **(06 marks)**

2.4 The pressure PC at C. **(04 marks)**

2.5 The intensity of the force F_{BC} of water acting on the surface BC and its point of application. **(04 marks)**

2.6 The resultant intensity force F_{AC} and its point of application. **(2.5 marks)**

(25 Marks)

3. HYDRODYNAMICS

The system in the Figure 2 consist of a cast iron pipe of 50 mm diameter, two 45° and four 90° elbows, a fully open valve, and a sharp exit into a reservoir.

Pipe characteristics

- *Length L= 1000 m*
- *Diameter D = 50 mm*
- *Specific roughness ε = 0.00026*
- *45° elbow coefficient* $K_1 = 0.20$
- *90° elbow cofficient* $K_2 = 0.30$
- *Open valve* $K_3 = 8.5$
- *Tank exit* $K_4 = 1$

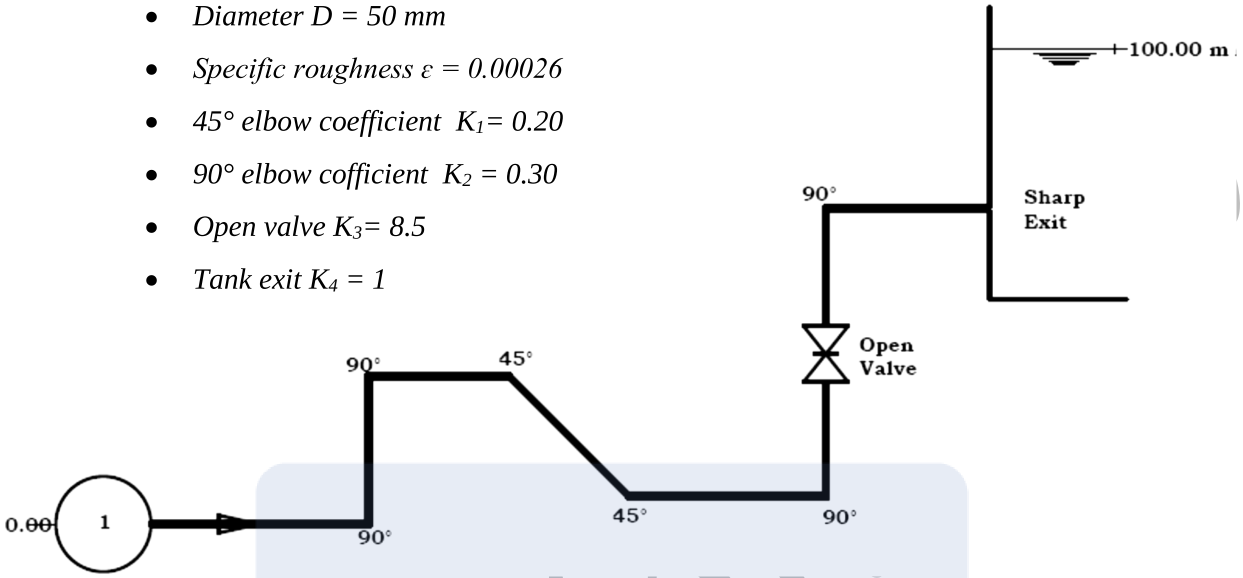

Figure 2

Fluid characteristics

- *Volume flow rate Q= 5 l/s*
- *Density* $\rho = 1000\ kg/m^3$
- *Kinematic viscosity* $v = 1.02 \times 10^{-6}\ m^2/s$
- *Atmospheric pressure Po = 0*
- $g = 10 m/s^2$

3.1 Give the nature of the flow. **(05 marks)**

3.2 From Moody Chart determine the friction factor f. **(07 marks)**

3.3 Calculate the total head loss in the system ($h_L = h_f + h_m$). **(07 marks)**

3.4 Calculate the gage pressure required at point 1 to deliver the given flow rate into the reservoir, whose free surface lies above point 1. **(06 marks)**

(25marks)

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4. HYDRO KINEMATICS

A drink Company wish to study the installation of an industrial boiler system constituted of five (5) boilers with different roles.

In the study, we will focus on only one steam boiler. The Figure 3 gives a simplify sketch of the installation principle.

The boiler is supply with viscous fuel stocked in a cylindrical tank of 900 m³. The fuel is transported to boilers by a centrifugal pump through a conduit of Nominal Diameter D = 65mm.

During its transportation, it crosses a heat exchanger (not represent on the sketch) that rises its temperature to 65°C. This operation is necessary because it add considerable fluidity to the fuel, which prevents the difficulty created by high viscosity during the transportation inside the conduct and the injection in the burners.

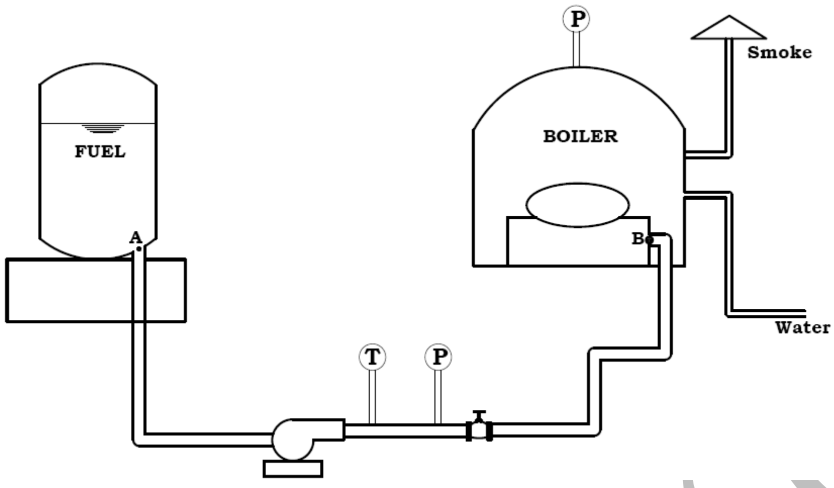

Figure 3

Fuel characteristics

- *Fuel flow rate Q= 1.20 m^3/hr.*
- *Density ρ = 883 kg /m^3*
- *Kinematic viscosity at 65°c ν = 45 x 10^{-5} m^2/s*
- *g = 10 m/s^2*
- *Pressure at A at any given time P_A = 1.60 bars*
- *Pressure at B at any given time P_B = 20 bars*

Circuit characteristics

- Fuel tank volume = 900 m^3
- Conduit diameter D = 65 mm
- $Z_A = Z_B$

4.1 Calculate the fuel velocity in the conduit. **(04 marks)**

4.2 Determine the Reynolds number. **(04 marks)**

4.3 Deduce the nature of the flow. **(04 marks)**

4.4 Calculate the friction factor of loses λ for this flow. **(05 marks)**

4.5 From the Appendix 1, find the equivalent length Le associate to whole welded 90° elbows of average curvatures and to one direct gate valve completely open. **(05 marks)**

4.6 If the real length of the installed conduit is L= 60 m, calculate the total loses associate to the fuel flow. **(03 marks)**

(25marks)

5. OPEN CHANNEL FLOW

For construction of gutters for the drainage of rain water, the Company in charge of the studies of project consults you as hydraulics Engineer because they want you to set the different calculations that will give:

5.1 The flow rate through the cross section, **(20 marks)**

5.2 The nature of flow through Froude's Number. **(05 marks)**

Technical specifications of the gutter:

- Geometrical section: Isosceles triangle of 90° angle at the bottom,
- Longitudinal slope: 1/1000
- Roughness of masonry: 0.011
- Maximum height of the water inside the gutter during raining season: 51 cm
- $Q = \frac{1}{n} Rh^{0,67} S^{0,5} A$ $F_r = \frac{V}{\sqrt{gy}}$ g = 10 m/s

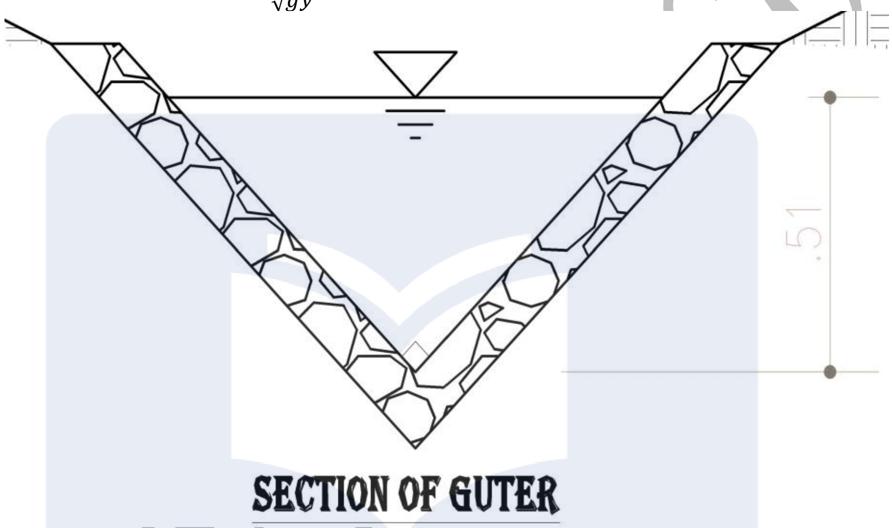

Figure 4

(25 marks)

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6. HYDRAULICS PUMPS

For the water supply of an agricultural installation, we use a channel whose static height is located at 2 meters below the horizontal axis of the pump (see the figure 5).
Between the channel and the pump, we installed rigid PVC canalization on which are fitted an elbow C and a strainer F placed at the end of suction canalization.
To verify the good functioning of the pump (absence of cavitation's), we will process to the calculation of the available NPSH, in order to compare to the required NPSH, recommended by the constructor.

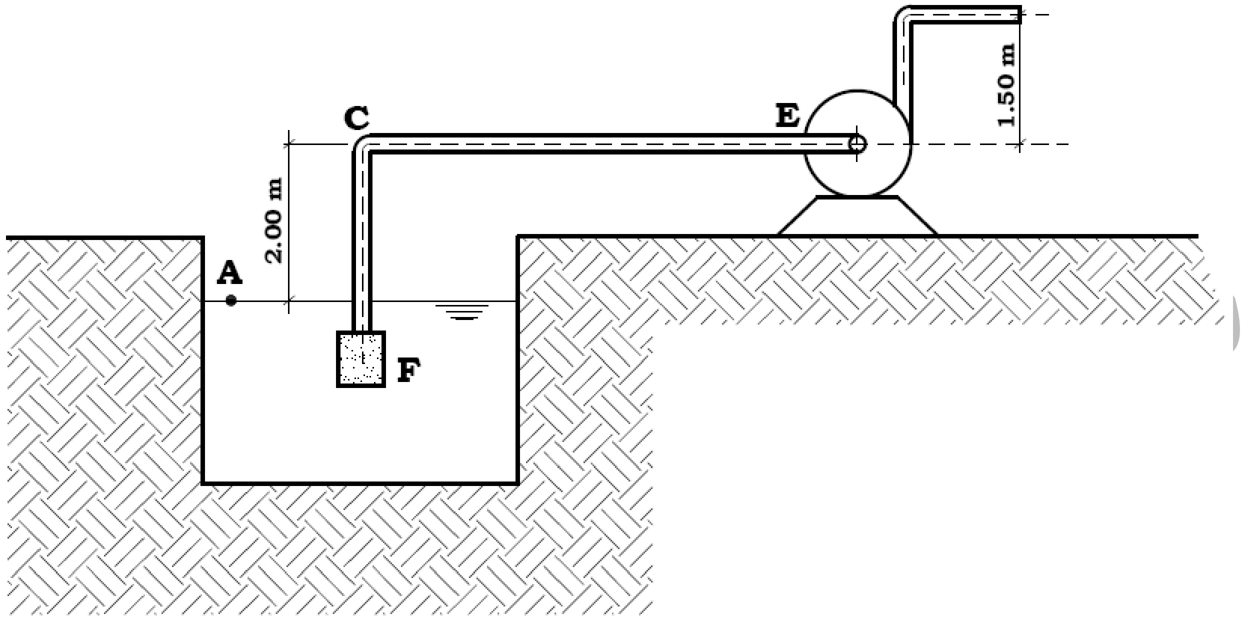

Figure 5

Pipe Characteristics

- *Length L = 80.00 m*
- *Diameter D= 143.2 mm*
- *Roughness coefficient k=0.03 mm*
- *Elbow coefficient* $K_C = 0.30$
- *Strainer losses coefficient* $K_F = 2.50$

Fluid characteristics

- *Volume flow rate* $Q = 139\ m^3/hr$
- *Density* $\rho = 1000\ kg/m^3$
- *Kinematic viscosity* $\nu = 0.897 \times 10^{-6}\ m^2/s$
- *Pressure saturated (steam or vapor)* $P_{VS} = 2930\ Pa$
- *Atmospheric pressure Po = 10 1000 Pa*
- $g = 9.81\ m/s^2$

Reminders:

Available NPSH is given by the formula $NPSH_{Available} = \left(\frac{PE}{\rho g} + \frac{V^2}{2g}\right) - \frac{Pvs}{\rho g}$

Minors losses $[j_{minors}] = \frac{K}{2g} V^2$

6.1 Explain the cavitation phenomenon **(04 marks)**

6.2 Calculate the fluid average velocity V. **(03 marks)**

6.3 Calculations of the total loss J_{total} in the suction canalization

6.3.1 Calculate the minor's loss J_{minors} **(03 marks)**

6.3.2 Using the value of the Appendix 1, calculate the frictional loss J_{frict} **(03 marks)**

6.3.3 Verify that $[J_{Total}] = 3.54$ **(03 marks)**

6.4 By applying the general relation of Bernoulli calculate the total pressure at E, then the available NPHS in the above conditions. **(03 marks)**

6.5 Verification of the good functioning of the pump

6.5.1 Using the pump characteristics gives in Appendix 2, determine the required NPSH. **(03 marks)**

6.5.2 Is the pump adapted to the circuit? Justify your answer. **(03 marks)**

(25 marks)

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7. APPIED MECHANICS

7.1 A ladder 20 m long and 400 N heavy, leans on a perfect smooth wall 16 m above the floor level as shown on the figure below. Its center of gravity is situated at 1/3 of its length from the bottom. A worker weighing 700 N climb on the ladder until its middle and stand there to work.

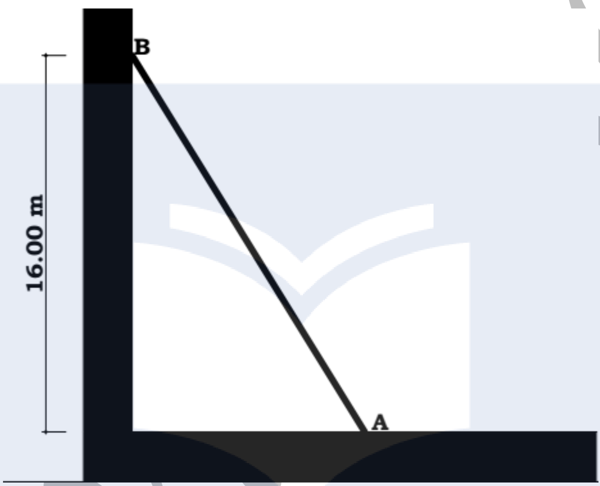


Figure 6

Assuming the floor is rough,

7.1.1 Represent the mechanical sketch of the structure **(05 marks)**

7.1. 2 Determine the reactions of the contacts; RA and RB between the ladder, the wall and the floor.

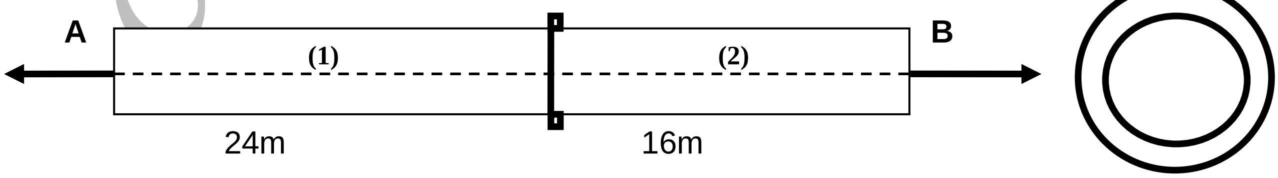
(4 x 2 = 08 marks)

7.2 You are called to the install two sections of a flanged cast iron pipe (1 and 2) as shown on the Figure below.

The tensile strength of the pipe is $\sigma_T = 425\ MPa$

The section is hollows and circular A=2826 mm^2

The Young modulus is E= 10^5 MPa



7.2.1 Calculate the effort that causes the stretch resistance. **(06 marks)**

7.2.2 Calculate the stretching of the pipe **(06 marks)**

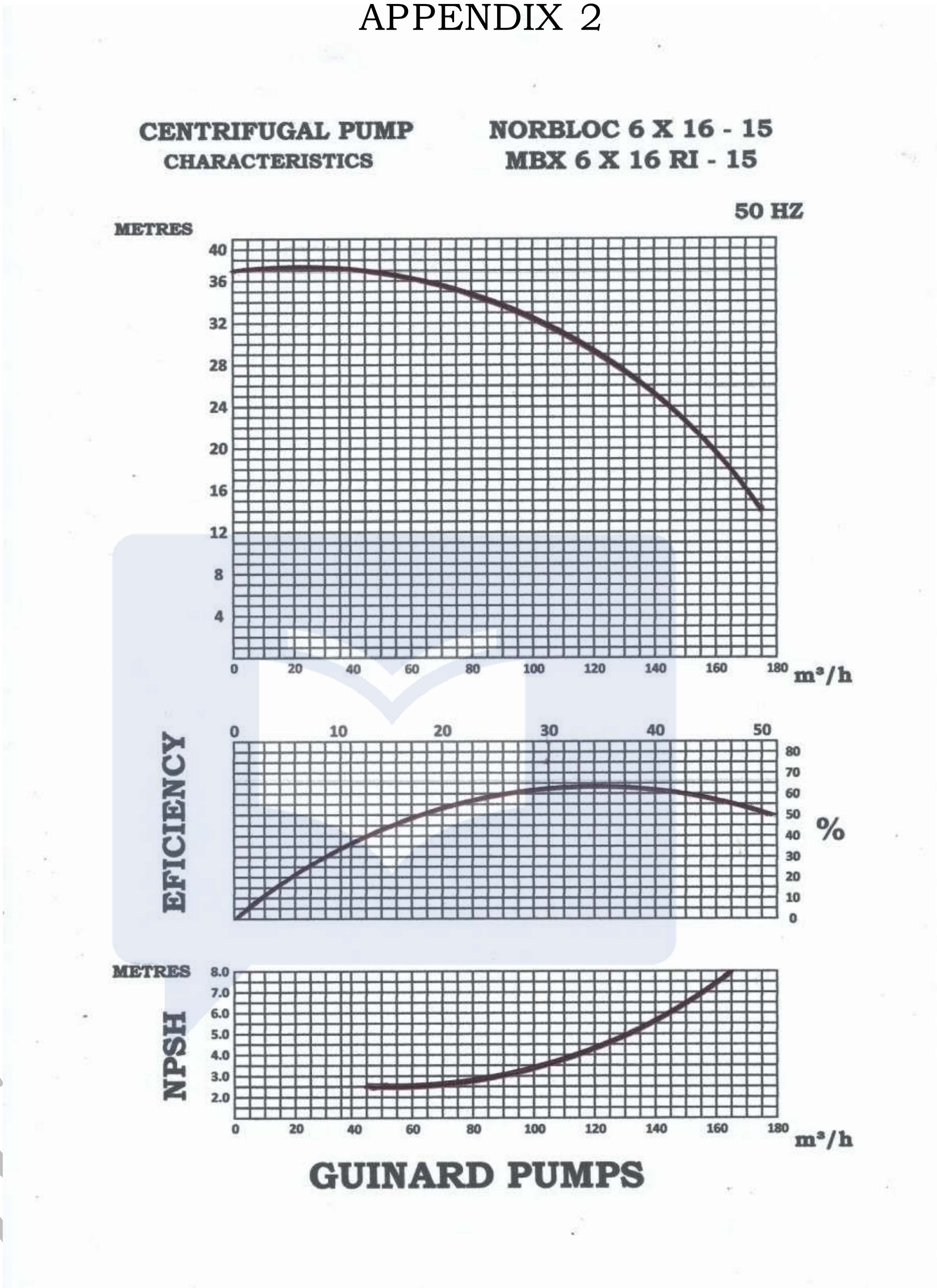
APPENDIX 1

HEAD LOSSES TABLE: PARTICULAR CASE OF RIGID PVC

The losses are given in meter column of fluid per linear meter of pipe (m/m)
EX: D= 179 mm, k=0.1 mm, V= 1.00 m/s. Losses = 0.00564 m/m

	Internal Diameter 143,2 mm Section 0,016106 m^2			Internal Diameter 179 mm Section 0,025165 m^2			Internal Diameter 187 mm Section 0,027465 m^2		
Average Velocity	Losses		Flow rate	Losses		Flow rate	Losses		Flow rate
	K = 0,03 mm	K= 0,1 mm		K = 0,03 mm	K= 0,1 mm		K = 0,03 mm	K= 0,1 mm	
m / s	m / m	m / m	l / s	m / m	m / m	l / s	m / m	m / m	l / s
0,10	0,00011	0.00011	1,611	0.000082	0.000084	2.516	0.000077	0.000079	2.746
0,15	0,00022	0.00023	2,416	0,00017	0.00017	3.775	0.00016	0.00016	4.120
0,20	0,00037	0.00038	3,221	0,00028	0.00029	5.033	0.00026	0.00027	5.493
0,25	0,00055	0.00057	4,026	0,00041	0.00043	6.291	0.00039	0.00041	6.866
0,30	0,00075	0.00080	4,832	0,00057	0.00060	7.549	0.00054	0.00057	8.239
0,35	0,00099	0.00105	5,637	0,00075	0.00080	8.808	0.00072	0.00076	9.613
0,40	0,00126	0.00135	6,442	0,00096	0.00102	10.07	0.00091	0.00097	10.99
0,45	0,00156	0.00167	7,247	0,00119	0.00127	11.32	0.00113	0.00120	12.36
0,55	0,00224	0.00242	8,858	0,00171	0.00184	13.84	0.00162	0.00174	15.11
0,60	0,00263	0.00265	9,663	0,00200	0.00216	15.10	0.00190	0.00205	16.48
0,65	0,00304	0.00331	10,47	0,00231	0.00251	16.36	0.00219	0.00238	17.85
0,70	0,00346	0.00380	11,27	0,00265	0.00286	17.62	0.00251	0.00273	19.23
0,75	0,00394	0.00432	12,08	0,00300	0.00328	18.87	0.00285	0.00311	20.60
0,80	0,00443	0.00488	12,88	0,00338	0.00370	20.13	0.00320	0.00351	21.97
0,85	0,00495	0.00547	13,69	0,00377	0.00415	21.39	0.00358	0.00393	23.34
0,90	0,00550	0.00609	14,49	0,00419	0.00462	22.65	0.00398	0.00438	24.72
0,95	0,00607	0.00674	15,3	0,00463	0.00512	23.91	0.00439	0.00485	26.09
1,00	0,00607	0.00743	16,11	0,00509	0.00564	25.16	0.00482	0.00534	27.46
1,05	0,00730	0.00815	16,91	0,00557	0.00619	26.42	0.00528	0.00586	28.84
1,10	0,00795	0.00890	17,72	0,00606	0.00676	27.68	0.00575	0.00640	30.21
1,15	0,00863	0.00968	18,52	0,00658	0.00735	28.94	0.00624	0.00697	31.58
1,20	0,00933	0.01050	19,33	0,00712	0.00797	30.20	0.00675	0.00756	32.96
1,25	0,01007	0.01135	20,13	0,00766	0.00862	31.46	0.00728	0.00817	34.33
1,30	0,10820	0.01223	20,94	0,00825	0.00929	32.71	0.00783	0.00880	35.70
1,35	0,01161	0.01314	21,74	0,00885	0.00998	33.97	0.00840	0.00946	37.08
1,40	0,01241	0.01409	22,55	0,00947	0.01070	35.23	0.00898	0.01014	38.45
1,45	0,01325	0.01506	23,35	0,01011	0.01144	36.49	0.00959	0.01064	39.82
1,50	0,01411	0.01607	24,16	0,01077	0.01221	37.75	0.01021	0.01157	41.20
1,55	0,01499	0.01711	24,96	0,01144	0.01300	39.01	0.01085	0.01232	42.57
1,60	0,01591	0.01819	25,77	0,01214	0.01382	40.26	0.01151	0.41349	43.94
1,65	0,01684	0.01929	26,57	0,01286	0.01466	41.52	0.01219	0.01389	45.32
1,70	0,01781	0.02043	27,38	0,01359	0.01552	42.78	0.01289	0.01471	46.69
1,75	0,01880	0.02160	28,18	0,01435	0.01641	44.04	0.01361	0.01555	48.06
1,80	0,01981	0.02261	28,99	0,01512	0.01732	45.30	0.01434	0.01642	49.44
1,85	0,02065	0.02404	29,86	0,01592	0.01826	46.55	0.01510	0.01731	50.81
1,90	0,02191	0.02531	30,6	0,01673	0.01923	47.81	0.01587	0.01822	52.18
1,95	0,02300	0.02661	31,41	0,01756	0.02021	49.07	0.01666	0.01916	53.56
2,00	0,02412	0.02794	32,21	0,01842	0.0212	50.33	0.01747	0.02011	54.93
2,05	0,02526	0.02930	33,02	0,1929	0.02226	51.59	0.01830	0.02110	56.34
2,10	0,02643	0.03070	33,82	0,02016	0.02332	52.85	0.01914	0.02210	57.68
2,15	0,02762	0.03212	34,63	0,02109	0.02441	54.10	0.02001	0.02313	59.05
2,20	0,02884	0.03358	35,43	0,02202	0.02552	55.36	0.02069	0.02416	60.42
2,25	0,03008	0.03548	36,24	0,02297	0.02665	56.62	0.02179	0.02526	61.79
2,30	0,03135	0.03660	37,04	0,02394	0.02781	57.88	0.02271	0.02635	63.17
2,35	0,03264	0.03816	37,85	0,02493	0.02899	59.14	0.02365	0.02747	64.54
2,40	0,03396	0.03975	38,65	0,02593	0.03020	60.40	0.02460	0.02862	65.91
2,45	0,03530	0.04137	39,46	0,02696	0.03143	61.65	0.02558	0.02979	67.29
2,50	0,03667	0.04302	40,26	0,02601	0.03266	62.91	0.02657	0.0309d	68.66

APPENDIX 2


CENTRIFUGAL PUMP
CHARACTERISTICS
NORBLOC 6 X 16 - 15
MBX 6 X 16 RI - 15
50 HZ
METRES
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m³/h
EFICIENCY
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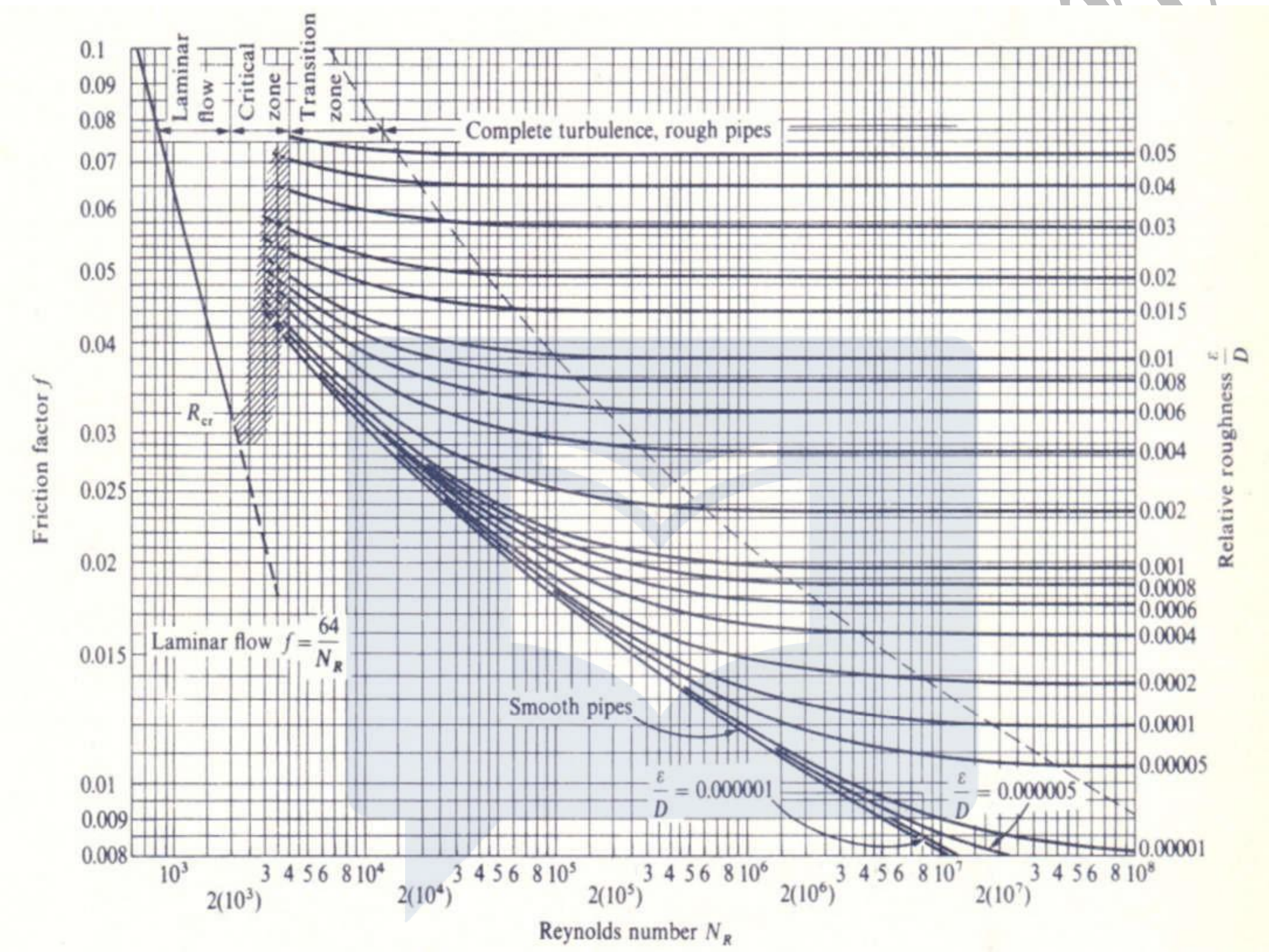
m³/h
GUINARD PUMPS

APPENDIX 3

MOODY CHART



APPENDIX 4

MINORS LOSSES EQUIVALENTS LENGHT (Le)	APPENDIX 4