CE 3372 WATER SYSTEMS DESIGN

PIPELINE HYDRAULICS EXAMPLES : PART 3

- A hydraulic system can be analysed as a set of linked components to make an otherwise complicated system easier to analyze.
- Idea is to break system into independent parts, analyze the parts then reassemble to answer questions about the whole system
- Continued example



- Analyze proposed system to determine anticipated behavior
 - Float valve fails at school
 - Outlet valve accidently left open
 - Pump operation under worst failure mode
 - Pump fails, time until system fails
 - Float valve limited
 - Oultet valve limited





• Upstream head = 1006.3 m

(pump working, supply tank stays full)

Downstream head = 992 m
 (pool elevation at schoolyard tank overflow)

- Float valve fails at school
- $Z_1 = 1006.3 \text{ m}$; $Z_2 = 992 \text{ m}$
- 2 bends, K =1.5 each
- 1 inlet K = 0.5
- Upstream valve K = 0.15
- Float valve K = 70
- Viscosity = 1.0 E-06sq.m/s
- Ks (HDPE) = 0.007mm 0.000007m

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••••	Not Secure — atomickitty,ddns.	6 0
M	Water Properties (SI) using Python	+
Machine Name : theodore-r Run Date : Tue Aug 11 14:: INPUT VALUES Temperature = 20.0 (degree LOOKUP VALUES Density = 998 (kg/m^3) Specific Weight = 9790 (N/ Dynamic Viscosity = 0.001 Kinematic Viscosity = 0.001 Vapor Pressure = 2340 (N/r	macbookpro.ttu.edu 54:11 2020 	Ē ā
M	Absolute Roughness Lookup using Python	+
Absolute Roughness Height Database Last Updated 10 A Machine name : atomickitty Run Date : Tue Aug 11 14:4 DATABASE QUERY Description = PVC and plas Absolute Roughness (millin Reference = adapted from h dynamics/major-head-loss-f	t (in millimeters) Lookup AUG 2020 //ddns.net /8:16 2020 VALUES stic pipe neters) = 0.007 tttps://www.nuclear-power.net/nuclear-engineer riction-loss/relative-roughness-of-pipe/	ring/fluid-

• Hydraulic Model

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Discharge Between Two Reservoirs (SI Units)



Pipeline connecting two reservoirs. Pool elevations are Z1 and Z2. Pipeline length is L, diameter is D, sand roughness height is ks. Pipeline can be analyzed with entrance and exit loss coefficients (Ki and Ke). Pipline can be analyzed with 2 fitting (Kf) loss coefficients. Calculator solves for flow rate in the pipeline.

Uses Jain equation to make initial flow estimate, then Newton's method to refine the estimate.

Detailed Explaination (Under Construction)

Pipeline Parameters
Pool Elevation (Z1):
1006.3
Pool Elevation (Z2):
992
Pipeline Length (L) :
Pipeline Diameter (D) :
0.127
Sand Roughness Height (ks) : 0.000007
Kinematic Viscosity (nu) :
1e-6
Gravitational Acceleration (g)
9.8
9.8

Fittings Parameters	\$
Inlet Loss (Ki):	
0.5	
Exit Loss (Ke) :	
70	
Fitting Loss (Kf) :	
0.15	
Fitting Loss (Kf) :	
3	

Use zero fitting values to ignore minor losses

M Discharge Between Two Reservoirs (SI units) (Update: 2020-0811)								
Machine Name : atomickitty.ddns.r. Run Date : Tue Aug 11 15:45:32 20 COMMAND TO RUN : /usr/bin/R: Return Code : 0	et 120 script 2QReser	voir.R						
INPUT VALUES			7					
Pool Elevation 1 (Z1) =	1006.3	meters	1					
Pool Elevation 2 (Z2) =	992.0	meters						
Pipeline Length (L) =	800.0	meters						
Pipeline Diameter (D) =	0.127	meters						
Sand Roughness Height (ks) =	7e-06	meethers						
Kinematic Viscosity (nu) =	1e-06	meters^2/second						
Gravitational Acceleration (g) =	9.8	meters/second^2						
Inlet Loss Coefficient (Ki) =	0.5	10						
Outlet Loss Coefficient (Ke) =	70.0	×.						
Fitting Loss Coefficient (Kf) =	0.15							
Fitting Loss Coefficient (Kf) =	3.0	6	30					
Ke L,p,k.	<u></u> *	T S						
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metter	**	and the second	7					
COMPUTED RESULT	4	авя длян — 8	-					
COMPUTED RESULT Discharge = Friction Factor =	0.01586375	8 m^3/sec						

 \sim 16 liters/second

Q

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Outlet valve left open

• Treat as hole in tank



Pump Requirements

- Float Valve Fails: Q = 16 LPS
- Outlet Valve Left Open: Q = 8 LPS
- Pipe Fails: Q = 24 LPS
- Thus a pump that produces
 - 1006.3 975 = 29.3 meters of head
 - 24 LPS discharge should be suitable
 - Example catalog listing next slide

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Charles and a strain of the state of the sta	Du	scharge Between Two Res	ervoirs (SI units) (Update: 202	20-08111	
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Sand Roughness Height (ks) =	7e-06	meethers			
Kinematic Viscosity (nu) =	1e-06	meters^2/second			
Gravitational Acceleration (g) =	9.8	meters/second^2			
Inlet Loss Coefficient (Ki) =	0.5				
Outlet Loss Coefficient (Ke) =	70.0	1 K			
Fitting Loss Coefficient (Kf) =	0.15	1			
Fitting Loss Coefficient (Kf) =	3.0				
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Friction Factor =	0.016679	88			
EGL Slope =	0.017875	m/m			
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Pump Requirements

- Float Valve Fails: Q = 16 LPS
- Outlet Valve Left Open: Q = 8 LPS
- Pipe Fails: Q = 24 LPS
- Thus a pump that produces
 - 1006.3 975 = 29.3 meters of head
 - 24 LPS discharge should be suitable
 - E.g. Kirloskar KLS 1537 specified for 100mm pipe, so will need reducer/ expander

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	Repla Easy r CED C free Morel Approxim PUMP MODEL K08-314+ K03-318+ K03-325+ K03-325+ K03-325+ K03-325+ K03-325+ K03-325+ K03-325+ K03-326+ K03-330+ K03-330+ K03-1030+ K03-1030+ K03-1030+ K03-1030+ K03-1030+	um vibrati ceable we maintenar soating ci hygienic & ate perfo kW HP 22 3.0 22 3.0 22 3.0 22 3.0 22 3.0 2.2 3.0 3.7 5.0 5.5 7.5 5.5 7.5 5.6 7.5 7.5 10.0 11.19 15.0	ensiduring parts considuring parts considered and spatial potable for mance PIPE SIZ (mm) SUC DEI 80 80 80 85 50 40 80 80 80 80 80 85 100 100 80 85 100 100	running and hence i res available mponents i cliniking wa LOAD CURRENT (in AMPS) 5.5 5.5 5.5 5.5 8.85 8.85 8.85 8.85 14.5 19.5 19.5 19.5 29.0	RATED voltage voltage (voltage (voltage voltag	6 19.0	8 175 13.2 22.7	10 15.5 12.3 21.6	Ra He Ca Pro 12 13.2 11.4 8.8 20.4 27.0 32.0 21.0	Gi ange sad apacio wer 14 9.0 10.4 19.0 10.4 19.0 14.9 25.5 31.0 20.6 36.0	ty Ratir TOT. 16 HAR 9.1 7.9 17.3 14.2 23.8 18.9 29.8 20.4 35.5	Mg AL H 18 GE II 7.4 7.5 4.7 15.4 13.5 21.7 18.0 28.5 20.0 35.0	EAD 20 N LIT 12.6 19.7 17.2 27.0 35.0	5-64 32-2. 2.2 ki S IN 22 RES 6.3 4.4 10.0 11.6 17.1 16.2 25.2 19.0 34.0	Metr 1 LP W-7.3 PEF 5.6 4.2 10.3 13.8 15.2 23.4 18.6 33.0 0	7 com es S S 5 kW 7 RES 26 8 SEC 4.7 4.0 8.8 14.0 20.9 18.0 32.0	(3.0) 28 3.2 3.8 6.4 12.4 17.9 17.2 31.0	30 3.5 10.1 13.2 28.0	0.0 H	110n 11P) 34 2.7	36 2.1 13.4 6.0
	Repla Easy r CED C free Morel Approxim PUMP MODEL K05-314+ K03-318+ K03-318+ K03-328+ K03-328+ K03-328+ K03-520 K03-627+ K03-627+ K03-627+ K03-627- K03-627- K03-627- <t< td=""><td>um vibralite ceable we anitemara nyglenic & ate perfo POWER RATING 22 3.0 22 3.0 22 3.0 22 3.0 22 3.0 2.2 3.7 5.0 5.5 7.5 5.5 7.5 7.5 10.4 11.19 15.3</td><td>ens during parts learning parts learning parts learning parts set iron cc potable for mance PIPE SIZ (mm) SUC DEI 80 80 80 85 50 40 80 85 50 40 80 85 50 40 80 65 50 40 80 65 80 65 80 80 80 80 80 80 80 80 80 80 80 80 80</td><td>running and hence i res availability mponents i drinking wat LOAD CURRENT (in AMPS) 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.</td><td>Comparing and the second secon</td><td>6 19.0</td><td>8 17.5 13.2 22.7 28</td><td>10 15.5 12.3 21.6</td><td>Ra He Ca Pro 12 13.2 11.4 8.8 20.4 27.0 32.0 21.0 32.0 21.0</td><td>Gi ange ad apaci ower 14 9.0 10.4 10.4 19.0 10.4 10.4 10.4 10.4 10.4 10.4 10.4 10</td><td>TOT 16 HAR 9.1 7.9 17.3 14.2 23.8 18.9 29.8 20.4 35.5 44</td><td>Mg AL H 18 GE II 7.4 7.5 4.7 15.4 13.5 21.7 18.0 28.5 20.0 35.0 48</td><td>EAD 20 4.5 13.2 12.6 19.7 17.2 27.0 52</td><td>5-64 32-2. 2.2 ki S IN 22 RES 6.3 4.4 10.0 11.6 17.1 16.2 25.2 19.0 34.0 56</td><td>Metr 1 LP W-7.1 24 PEF 5.5 4.2 10.3 13.8 15.2 23.4 18.6 33.0 60</td><td>Com Com CRES S S S S S K W CRES 26 3 S S S S S S S S S S S S S S</td><td>(3.0) 28 3.2 3.8 6.4 12.4 17.9 17.9 31.0 60</td><td>30 3.5 10.1 13.2 28.0</td><td>0.0 H 32 3.1</td><td>110n 11P) 34 2.7</td><td>36 2.1 13.4 6.0</td></t<>	um vibralite ceable we anitemara nyglenic & ate perfo POWER RATING 22 3.0 22 3.0 22 3.0 22 3.0 22 3.0 2.2 3.7 5.0 5.5 7.5 5.5 7.5 7.5 10.4 11.19 15.3	ens during parts learning parts learning parts learning parts set iron cc potable for mance PIPE SIZ (mm) SUC DEI 80 80 80 85 50 40 80 85 50 40 80 85 50 40 80 65 50 40 80 65 80 65 80 80 80 80 80 80 80 80 80 80 80 80 80	running and hence i res availability mponents i drinking wat LOAD CURRENT (in AMPS) 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.	Comparing and the second secon	6 19.0	8 17.5 13.2 22.7 28	10 15.5 12.3 21.6	Ra He Ca Pro 12 13.2 11.4 8.8 20.4 27.0 32.0 21.0 32.0 21.0	Gi ange ad apaci ower 14 9.0 10.4 10.4 19.0 10.4 10.4 10.4 10.4 10.4 10.4 10.4 10	TOT 16 HAR 9.1 7.9 17.3 14.2 23.8 18.9 29.8 20.4 35.5 44	Mg AL H 18 GE II 7.4 7.5 4.7 15.4 13.5 21.7 18.0 28.5 20.0 35.0 48	EAD 20 4.5 13.2 12.6 19.7 17.2 27.0 52	5-64 32-2. 2.2 ki S IN 22 RES 6.3 4.4 10.0 11.6 17.1 16.2 25.2 19.0 34.0 56	Metr 1 LP W-7.1 24 PEF 5.5 4.2 10.3 13.8 15.2 23.4 18.6 33.0 60	Com Com CRES S S S S S K W CRES 26 3 S S S S S S S S S S S S S S	(3.0) 28 3.2 3.8 6.4 12.4 17.9 17.9 31.0 60	30 3.5 10.1 13.2 28.0	0.0 H 32 3.1	110n 11P) 34 2.7	36 2.1 13.4 6.0
	Repla Easy 7 CED C free More 1	um vibrati coating ci coating ci	ons during particular control of the second spectral of the second spectral potable for the second spectral of the second spectral SUC DEL 80 80 80 80 80 80 80 80 80 80 80 80 100 100 100 100 100 100 100 100 100 100 100	running and hence i res availability mponents i drinking wa LOAD CURRENT (in AMPS) 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.	angerifie enongerifie itiy enongerifie wolffact 415 416 415	a rust	8 17.5 13.2 22.7 28 7.8	10 15.5 12.3 21.6 32 7.0	Rs He Ca Po 12 13.2 11.4 8.8 20.4 27.0 32.0 21.0 32.0 21.0 36 5.8	Gi ange sad apaciower 14 9.0 10.4 19.0 10.4 19.0 14.9 25.5 31.0 20.6 36.0 4.0 4.0	ty Ratir TOT 16 HAR 9.1 7.8 17.3 14.2 23.8 18.9 29.8 20.4 35.5 44	ning a ng AL H 18 GE II 7.4 7.5 4.7 15.4 13.5 20.0 35.0 48 2.1	EAD 20 N LIT 12.6 19.7 13.2 12.6 19.7 17.2 27.0 19.5 35.0 52	5-64 32-2.2 ki S IN 22 RES 6.3 4.4 10.0 11.6 17.1 16.2 25.2 19.0 34.0 56	Metro MET 24 PEF 5.6 4.2 10.3 13.8 15.2 23.4 18.6 33.0 60	7 com es S S S k W RES 26 8 SEC 4.7 4.0 8.8 14.0 20.9 18.0 320 64	(3.0) 28 3.2 3.8 5.4 12.4 17.9 17.9 17.9 5.4	30 3.5 10.1 13.2 28.0 :	0.0 H 32 3.1	110n 11P) 34 2.7	36 2.1 13.4 6.0
	Repla Easy r CED C free Morel Approxim PUMP MOB-314+ K08-314+ K08-314+ K08-314+ K08-318+ K08-325+ K08-422+ K08-422+ K08-1030+ K08-1030+ K08-1030+ K08-1030+ K08-530+ K08-530+ K08-530+ K08-550+ K08-560+ K08-560+ K08-560+ K08-560+ K08-560+	um ubrati ceable we anti-enar coating ci ate performer kw HP 22 3.0 22 3.0 2.2 3.0 2.2 3.0 3.7 5.0 3.7 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0	ons during particular and gaparticle and spinor potable for spotable for support of the spinor support of the	running and hence i res availability mponents i drinking wa LOAD CURRENT (in AMPS) 5.5 5.5 5.5 5.5 5.5 8.85 14.5 14.5 19.5 29.0 9.0 9.0 9.0 9.0	angerlife RATED vol.TAGI (VOLTS) 415	5 rust 6 19.0 24	8 17.5 13.2 22.7 28 7.8 10.9	10 15.5 12.3 21.6 32 7.0 9.3	Rs He Ca Pc 12 13.2 11.4 8.8 20.4 27.0 32.0 21.0 32.0 21.0 36 5.8 4.3 8.2	Gange sad apaciower 14 9.0 10.4 8.4 19.0 10.4 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0	ty Ratir TOT 16 HAR 9.1 7.9 17.3 14.2 23.8 18.9 25.8 20.4 35.5 44 3.2	ning a ng AL H 18 GE II 7,4 7,5 4,7 16,4 13,5 21,7 18,0 28,5 20,0 35,0 48 2,1	EAD 20 N LIT 12.6 19.7 17.2 27.0 19.5 36.0 52	5-64 32-2.2 ki S IN 22 RES 6.3 4.4 10.0 11.6 17.1 16.2 25.2 19.0 34.0 56	Metro MET 24 PEF 5.6 4.2 10.3 13.8 15.2 23.4 18.6 33.0 60	rRES 26 1 SEC 4.7 4.0 20.9 14.0 20.9 18.0 32.0 64	(3.0) 28 3.2 3.8 6.4 17.9 17.9 31.0 6.1	30 3.5 10.1 13.2 26.0 ;	32 3.1	110n 11P) 34 2.7	36 21 13.4 6.0
	Repla Easy r CED C free Morel I Approxim PUMP MODEL K08-314+ K03-314+ K03-314+ K03-314+ K03-328+	um vibrati maintenar coating ci cable we maintenar cable we realized and kw HP 22 8.0 22 8.0 22 8.0 22 8.0 22 8.0 22 8.0 22 8.0 22 8.0 3.7 5.0 5.5 7.5 16.4 3.7 5.0 3.7 5.0 5.5 7.5 5.7 5.7 5.7 5.7 5.7 5.7 5.7 5.7 5.7 5.7	ens during parta aning parta and spinor potable for mance PIPE SIZ SUC DEI 80 80 85 50 40 80 80 85 100 100 100 100 100 100 100 100 100 100 100	running and hence i res available mponents i cdrinking wa LOAD CURRENT (in AMPS) 5.5 5.5 5.5 5.5 5.5 8.85 8.85 14.5 19.5 19.5 29.0 9.0 9.0 14.5	RATED voltadis voltadis 415 415 415 415 415 415 415 415 415 415 415 415 415 415 415 390 380 415 415 390 380 415 415 380 381 415 383	E rust 6 19.0	8 17.5 13.2 22.7 28 7.8 10.2	10 15.5 12.3 21.6 32 7.0 9.3 8.4	Ra He Ca Pc 12 13.2 11.4 8.8 20.4 27.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21	Gange ead apacia wer 14 9.0 10.4 8.4 19.0 10.4 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0	ty Ratir TOT 16 HAR 9.1 7.9 17.3 14.2 23.8 18.9 29.8 20.4 35.5 44 3.2 6.5	ning 2 ng AL H 18 GE II 7.4 7.5 4.7 16.4 13.5 20.0 35.0 48 2.1 5.6	EAD 20 12.6 13.2 12.6 19.7 17.2 27.0 19.5 35.0 52 4.2	5-64 32-2.2 ki S IN 22 RES 6.3 4.4 10.0 11.6 17.1 16.2 25.2 19.0 34.0 56	Metro MET 24 PEF 5.5 4.2 10.3 13.8 15.2 23.4 18.6 33.0 60	rRES 26 1 SEC 4.7 4.0 8.8 14.0 20.9 18.0 320 64	(3.0) 2.8 3.2 3.8 6.4 12.4 17.9 17.	30 3.5 10.1 13.2 28.0 :	32 3.1	100 1P) 34 2.7	36 2.1 13.4 6.0
	Repla - Repla - CED C - Free - Morel Approxim PUMP MODEL K05-314+ K05-314+ K05-318+ K05-328+ K05-328+ K05-427+ K05-328+ K05-428+ K05-1537 K05-384+ K05-384+ K05-362+ K05-368+	um ubrati maintenar ceatle we maintenar ceatle we maintenar ceatle we realized we kw HP 22 30 22 30 22 30 22 30 22 30 37 50 55 75 56 75 56 75 56 75 56 75 56 75 56 75 56 75 56 75 57 5 57	ons during parts and parts potable for potable for source and spiral potable for source and spiral potable for source and spiral source an	running and hence i res available mponents i LOAD CURRENT (in AMPS) 5.5 5.5 5.5 8.85 8.85 8.85 8.85 14.5 14.5 19.5 29.0 9.0 9.0 14.5 14.5 19.5	ATED VOLTAGION 415 415 415 415 415 415 415 415 415 415 415 415 415 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380	24 10.7	8 17.5 13.2 22.7 28 7.8 10.2 12.4	10 15.5 12.3 21.6 32 7.0 9.3 8.4 11.9	Ra He Ca Po 12 13.2 11.4 8.8 20.4 27.0 21.0 21.0 21.0 21.0 36 5.8 4.3 8.2 7.9 11.3	Gange ange ad apaci ower 14 9.0 10.4 19.0 20.6 36.0 20.6 36.0 40 4.0 3.8 6.5 7.2 10.5	TOT. 16 HAR 9.1 7.9 17.3 14.2 23.8 14.2 23.8 29.8 20.4 3.5 44 3.2 5.5 9.4	AL H 18 GE II 7.4 7.5 4.7 15.4 7.5 21.7 15.0 28.5 20.0 35.0 48 2.1 5.6 8.0	EAD 20 N LIT 6.9 4.5 13.2 12.6 13.2 13.5 13.5 13.5 13.5 13.5 13.5 13.5 13.5	5-64 32-2.2 ki S IN 22 RES 6.3 4.4 10.0 11.6 17.1 16.2 25.2 19.0 34.0 56	Metri MET 24 PEF 5.6 4.2 10.3 13.8 15.2 23.4 18.6 33.0 60	rRES 26 1 SEC 4.7 4.0 20.9 18.0 32.0 64	(3.0) 28 COND 3.2 3.8 5.6 12.4 17.9	30 3.5 10.1 13.2 28.0	0.0 H	110n 11P) 34 2.7	36 21 13.4 6.0
	Repla - Repla - CED C - Morel -	um vibrati scoating vi ate performant RATING RATIN	ons during parts and parts in on co- potable for mance PIPE SIZ (mm) SUC DEI 80 60 60 50 40 80 65 50 100 100 100 80 65 50 100 100 100 80 65 50 100 100 100 80 65 50 100 100 100	running and hencel res availability mponents i drinking wat LOAD CURRENT (in AMPS) 5.5 5.5 5.5 5.5 5.5 5.5 5.5 5.5 8.85 8.85 8.85 8.85 8.85 8.85 8.85 14.5 19.5 9.0 14.5 19.5 19.5	ATED VOLTAGION 415 415 415 415 415 415 415 415 415 415 415 415 415 415 380 <td>24 10.7 12.8</td> <td>8 175 132 22.7 28 7.8 10.2 12.4</td> <td>10 15.5 12.3 21.6 32 7.0 9.3 8.4 11.9</td> <td>Ra He Ca Po 12 13.2 11.4 8.8 20.4 27.0 21.0 21.0 21.0 36 5.8 4.3 8.2 7.9 11.3</td> <td>Gi ange ad apaci ower 14 9.0 10.4 8.4 19.0 14.9 25.5 31.0 20.6 36.0 40 4.0 3.8 6.5 7.2 10.5 7.3</td> <td>TOT. 16 HAR 9.1 7.9 17.3 14.2 23.8 18.9 29.8 20.4 35.5 44 3.2 6.5 9.4 7.1</td> <td>AL H 18 GE II 7.4 7.5 4.7 15.4 13.5 20.0 35.0 48 2.1 5.6 8.0 6.7</td> <td>eAD 20 N LIT 6.9 4.5 13.2 12.6 19.7 17.2 27.0 19.5 35.0 52 4.2 5.8 6.3</td> <td>5-64 32-2. 2.2 k S IN 22 RES 6.3 4.4 10.0 11.6 17.1 16.2 25.2 19.0 34.0 5.8</td> <td>Metri MET 24 PEF 5.6 4.2 10.3 13.8 15.2 23.4 18.6 33.0 60</td> <td>7 com es S S 5 kW RES 26 1 SEC 4.7 4.0 8.8 14.0 20.9 18.0 32 c 64</td> <td>(3.0) 28 0 ND 3.2 3.8 6.4 17.9 17.2 31.0 6.7</td> <td>30 3.5 10.1 13.2 28.0 ;</td> <td>0.0 H</td> <td>110n 11P) 34 14.5</td> <td>36 2.1 13.4 6.0</td>	24 10.7 12.8	8 175 132 22.7 28 7.8 10.2 12.4	10 15.5 12.3 21.6 32 7.0 9.3 8.4 11.9	Ra He Ca Po 12 13.2 11.4 8.8 20.4 27.0 21.0 21.0 21.0 36 5.8 4.3 8.2 7.9 11.3	Gi ange ad apaci ower 14 9.0 10.4 8.4 19.0 14.9 25.5 31.0 20.6 36.0 40 4.0 3.8 6.5 7.2 10.5 7.3	TOT. 16 HAR 9.1 7.9 17.3 14.2 23.8 18.9 29.8 20.4 35.5 44 3.2 6.5 9.4 7.1	AL H 18 GE II 7.4 7.5 4.7 15.4 13.5 20.0 35.0 48 2.1 5.6 8.0 6.7	eAD 20 N LIT 6.9 4.5 13.2 12.6 19.7 17.2 27.0 19.5 35.0 52 4.2 5.8 6.3	5-64 32-2. 2.2 k S IN 22 RES 6.3 4.4 10.0 11.6 17.1 16.2 25.2 19.0 34.0 5.8	Metri MET 24 PEF 5.6 4.2 10.3 13.8 15.2 23.4 18.6 33.0 60	7 com es S S 5 kW RES 26 1 SEC 4.7 4.0 8.8 14.0 20.9 18.0 32 c 64	(3.0) 28 0 ND 3.2 3.8 6.4 17.9 17.2 31.0 6.7	30 3.5 10.1 13.2 28.0 ;	0.0 H	110n 11P) 34 14.5	36 2.1 13.4 6.0

ormance applicable to liquid of specific gravity 1 and viscosity a Models are available in Metro Series with Rated Voltace as 416

Thus a pump that produces

- 1006.3 975 = 29.3 meters of head
- 24 LPS discharge should be suitable
- E.g. Kirloskar KLS 1537 specified for 100mm pipe, so will need reducer/ expander

TABLE 25.13 1	able of Local Loss Coefficients
Use the equation $h_v = k v^{v/2} g$ unless otherwise indicate	ed. Energy loss E, equals b, head loss in foot
Perpendicular square entrance: k = 0.50 if edge is sharp	Check values: Swing type $k = 2.5$ when fully open Ball type $k = 70.0$ Lift type $k = 2.0$
Perpendicular rounded entrance: $\frac{1}{2} \frac{R/d}{k} = \frac{ 0.05 \ 0.1 \ 0.2 \ 0.3 \ 0.4 }{k = 0.25 \ 0.17 \ 0.08 \ 0.05 \ 0.04 }$	Angle valve: k = 5.0 if fully open
Additional loss due to skewed entrance: $k = 0.505 + 0.303 \sin \alpha + 0.226 \sin^2 \alpha$	Segment gate in rectangular conduit: $k = 0.3 + 1.3 [(1/s)]^2$ where $n = \phi_1 \phi_0 = the rate of opening with reserve to be or even to be one of the set of the set$
Strainer bucket: k = 10 with foot valve k = 5.5 without foot valve	Silice gate in rectangular conduit: $\frac{1}{1}$, $\frac{1}{1}$, $k = 0.3 + 1.9 [(1/a) - n]^2$ where $n = h/H$.
Standard tee, entrance to minor line: r_{ij} $k = 1.8$ Contusor outline	Sudden expansion: $h \rightarrow = = h E_t = (1 - \frac{v_t}{v_t})^2 \frac{v_t^2}{2g} \text{ or } E_t = (\frac{v_t}{v_2} - 1)^2 \frac{v_t^2}{2g}$
$-\Sigma >: \frac{d D = 0.5 0.6 0.8 0.9 }{k = 5.5 4 2.55 1.1 }$	Sudden contraction: $a_1^{j} = \frac{1}{1} \frac{a_1}{k}, \frac{(dD)^2}{k} = 0.01 (0.1) \frac{0.2}{0.2} \frac{0.4}{0.33} \frac{0.6}{0.25} \frac{0.8}{0.15}$ USE V. is Charlen 19.2 0.3
Exit from pipe into reservoir: $\rightarrow c = \frac{1}{2}$ $k = 1.0$	$Diffusor:E_{t} = k(v_{t}^{2} - v_{z}^{2})e^{t}$

4 of 36 + 80% **Product Catalogue** KIRI OSKAR Material of Construction Features Designed for underwater applications. No need of Standard Suppl priming and foot valve Impeller Cast Iron Deliver Easy installation-Foundation and installation platform **Delivery Casing** : Cast Iron or pump house not required Motor Body : Cast Iron Can withstand wide voltage fluctuations from 200-440 Shaft Stainless Steel Volts Water shower arrangement for out of water Applications applications Designed to prevent overloading and motor burning Submerged pump in Wells, Sumps and Water tanks Dynamically balanced rotating parts to ensure Gardening and sprinklers / conventional irrigation minimum vibrations during running Replaceable wearing parts and hence longer life Range Easy maintenance and spares availability CED coating cast iron components long life & rust Head : 6-64 metres : 32-2.1 LPS free Capacity More hygienic & potable for drinking water. : 2.2 kW-7.5 kW (3.0 HP-10.0 HP) Power Rating Approximate performance RATED PUMP POWER PIPE SIZE LOAD CURRENT VOLTAGE TOTAL HEADS IN METRES MODEL RATING (mm) (in AMPS) 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 **W HP SUC DEL** DISCHARGE IN LITRES PER SECOND KOS-314+ 2.2 3.0 80 en. 5.5 415 19.0 17.5 15.5 13.2 9.0 KOS-318- 22 30 30 RR. 55 415 132 123 114 104 51 74 KOS-325+ 2.2 3.0 8.8 8.4 7.9 7.5 6.9 6.3 5.6 4.7 3.2 50 5.5 415 4.7 4.5 4.4 4.2 4.0 3.8 3.5 3.1 2.7 2.1 KOS-335+ 2.2 3.0 50 40 5.5 415 KOS-520+ 3.7 5.0 415 22 7 21 6 20.4 19.0 17.3 16.4 13.2 10.0 āň 8.85 KOS-527+ 3.7 5.0 14.9 14.2 13.5 12.6 11.6 10.3 8.8 6.4 65 8.85 415 27.0 25.5 23.8 21.7 19.7 17.1 13.8 KOS-822+ 5.5 7.5 100 14.5 390 100 18.9 18.0 17.2 16.2 15.2 14.0 12.4 10.1 KOS-830+ 5.5 7.5 390 65 14.5 32.0 31.0 29.8 28.5 27.0 25.2 23.4 20.9 17.9 13.2 KOS-1030+ 7.5 10.0 100 100 380 19.5 KOS-10404 7.5 10.0 80 65 380 21.0 20.6 20.4 20.0 19.5 19.0 18.6 18.0 19.5 45134 KOS-1537 11.19 15.0 100 100 36.0 35.5 35.0 35.0 34.0 33.0 32.0 61.0 28.0 24.0 29.0 415 24 28 32 36 40 44 48 52 56 60 64 KOS-538+ 3.7 5.0 65 50 9.0 415 78 70 58 40 KOS-550+ 37 50 160 40 9.0 415 43 38 32 21 KOS-844 KK 75 65 65 14.5 380 93 82 65 KOS-852+ 5.5 7.5 65 390 8.4 7.9 7.2 6.5 5.6 4.2 50 14.5 KOS-10504 7.5 10.0 65 65 19.5 128 124 119 113 105 94 80 58 390 KOS-10654 7.5 10.0 65 50 19.5 390 7.3 7.1 6.7 6.3 5.8 5.2 4.3 KOS-1555 11.19 15.0 80 65 29.0 415 19.5 19.2 18.5 18.0 17.0 15.5 13.8 9.0 KOS-1575 11.19 15.0 65 50 415 7.8 7.5 7.0 6.5 6.0 5.0 1.5 29.0 Note: Performance applicable to liquid of specific gravity 1 and viscosity as of water All Models are available in Metro Series with Rated Voltage as 415V. 4

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Thus a pump that produces

- 1006.3 975 = 29.3 meters of head
- 24 LPS discharge should be suitable
- E.g. Kirloskar KLS 1537 specified for 100mm pipe, so will need reducer/ expander

TABLE 25.13 1	able of Local Loss Coefficients
Use the equation $h_v = k v^v / 2g$ unless otherwise indicate	ed. Energy loss E, equals b, head loss in foot
Perpendicular square entrance: k = 0.50 if edge is sharp	Check values: Swing type $k = 2.5$ when fully open Ball type $k = 70.0$ Lift type $k = 2.0$
Perpendicular rounded entrance: $\frac{1}{2} \frac{R/d}{k} = \frac{ 0.05 \ 0.1 \ \ 0.2 \ \ 0.3 \ \ 0.4 \ }{k = 0.25 \ 0.17 \ 0.08 \ 0.05 \ 0.04 }$	Angle valve: k = 5.0 if fully open
Additional loss due to skewed entrance: $k = 0.505 + 0.303 \sin \alpha + 0.226 \sin^2 \alpha$	Segment gate in rectangular conduit: $k = 0.3 + 1.3 [(1/s)]^2$ where $n = \phi_1 \phi_0 = the rate of opening with reserve to be or even to be one of the set of the set$
Strainer bucket: k = 10 with foot valve k = 5.5 without foot valve	Silice gate in rectangular conduit: $\frac{1}{1}$, $\frac{1}{1}$, $k = 0.3 + 1.9 [(1/a) - n]^2$ where $n = h/H$.
Standard tee, entrance to minor line: r_{1} $k = 1.8$ Contusor outline	Sudden expansion: $h \rightarrow = = h E_t = (1 - \frac{v_t}{v_t})^2 \frac{v_t^2}{2g} \text{ or } E_t = (\frac{v_t}{v_2} - 1)^2 \frac{v_t^2}{2g}$
$-\Sigma >: \frac{d D = 0.5 0.6 0.8 0.9 }{k = 5.5 4 2.55 1.1 }$	Sudden contraction: $a_1^{j} = \frac{1}{1} \frac{a_1}{k}, \frac{(dD)^2}{k} = 0.01 (0.1) \frac{0.2}{0.2} \frac{0.4}{0.33} \frac{0.6}{0.25} \frac{0.8}{0.15}$ USE V. is Charlen 19.2 0.3
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Thus a pump that produces

- 1006.3 975 = 29.3 meters of head
- 24 LPS discharge should be suitable
- E.g. Kirloskar KLS 1537 specified for 100mm pipe, so will need reducer/ expander
- However when we analyze the pumping side, don't have the correct pump
 - Can only produce 7 LPS , because we forgot the pipe friction.
 - Options?
 - 2 in series



Machine Name : theodore-macbookpro.ttu.edu Run Date : Mon Sep 7 20:46:58 2020 COMMAND TO RUN : /usr/bin/Rscript 2QReservoirWithPump.R

Return Code : 0

INPUT VALUES	1.1.3.1			
Pool Elevation 1 (Z1) =	975.0	meters		
Pool Elevation 2 (Z2) =	1006.3	meters		
Pipeline Length (L) =	3200.0	meters		
Pipeline Diameter (D) =	0.127	meters		
Sand Roughness Height (ks) =	7e-06	meters		
Kinematic Viscosity (nu) =	1e-06	meters^2/second		
Gravitational Acceleration (g) =	9.8	meters/second^2		
Inlet Loss Coefficient (Ki) =	0.5	11		
Outlet Loss Coefficient (Ke) =	1.0	1		
Fitting Loss Coefficient (Kf) =	2.55	K		
Fitting Loss Coefficient (Kf) =	0.32	`	mmgs	ar pump
Pump Shutoff Head (Hp@Q_0) =	40.0	Discharge (Q_0)	0.0	
Pump Point One (Hp@Q_1) =	30.0	Discharge (Q_1)	0.028	
Pump Point Two (Hp@Q_2) =	14.0	Discharge (Q_2)	0.036	



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COMPUTED RESULT		
Discharge =	0.0076394	m^3/sec 🗲
Added Head =	40.35164	m
Friction Losses =	9.051641	m
Static Lift =	31.3	m
Pipeline Friction Factor =	0.01918692	
Fitted Pump Shutoff =	41.48688	m
Pump Constant =	-19452.23	m/Q^2

Thus a pump that produces

- 1006.3 975 = 29.3 meters of head
- 24 LPS discharge should be suitable
- E.g. Kirloskar KLS 1537 specified for 100mm pipe, so will need reducer/ expander
- However when we analyze the pumping side, don't have the correct pump
 - Can only produce 7 LPS, because we forgot the pipe friction.
 - Options?
 - 2 in series (Almost works)
 - Probably look for a bigger pump, but for grins, lets try 3 in series



Machine Name : theodore-macbookpro.ttu.edu Run Date : Mon Sep 7 20:53:15 2020 COMMAND TO RUN : /usr/bin/Rscript 2QReservoirWithPump.R

Return Code : 0

INPUT VALUES	1.1.1.1	1 a	
Pool Elevation 1 (Z1) =	975.0	meters	1
Pool Elevation 2 (Z2) =	1006.3	meters	
Pipeline Length (L) =	3200.0	meters	1
Pipeline Diameter (D) =	0.127	meters	
Sand Roughness Height (ks) =	7e-06	meters	1
Kinematic Viscosity (nu) =	1e-06	meters^2/second	
Gravitational Acceleration (g) =	9.8	meters/second^2	
Inlet Loss Coefficient (Ki) =	0.5	11	1
Outlet Loss Coefficient (Ke) =	1.0		
Fitting Loss Coefficient (Kf) =	2.55	77	1 di second
Fitting Loss Coefficient (Kf) =	0.32		
Pump Shutoff Head (Hp@Q_0) =	80.0	Discharge (Q_0)	0.0
Pump Point One (Hp@Q_1) =	60.0	Discharge (Q_1)	0.028
Pump Point Two (Hp@Q_2) =	28.0	Discharge (Q_2)	0.036
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COMPUTED RESULT	and the second sec	
Discharge -	0.01734215	m^3/sec
Added Head =	71.27324	m
Friction Losses =	39.97324	m
Static Lift =	31.3	m
Pipeline Friction Factor =	0.01641738	47 H
Fitted Pump Shutoff =	82.97376	m
Pump Constant =	-38904.47	m/Q^2



Thus a pump that produces

- 1006.3 975 = 29.3 meters of head
- 24 LPS discharge should be suitable
- E.g. Kirloskar KLS 1537 specified for 100mm pipe, so will need reducer/ expander
- However when we analyze the pumping side, don't have the correct pump
 - Can only produce 7 LPS , because we forgot the pipe friction.
 - Options?
 - 3 in series (essentially working)
 - But best look for a bigger pump

Machine Name : theodore-macbookpro.ttu.edu Run Date : Mon Sep 7 20:55:39 2020 COMMAND TO RUN : /usr/bin/Rscript 2QReservoirWithPump.R

Return Code : 0

INPUT VALUES	1 44	1 k	11
Pool Elevation 1 (Z1) =	975.0	meters	
Pool Elevation 2 (Z2) =	1006.3	meters	
Pipeline Length (L) =	3200.0	meters	
Pipeline Diameter (D) =	0.127	meters	
Sand Roughness Height (ks) =	7e-06	meters	
Kinematic Viscosity (nu) =	1e-06	meters^2/second	
Gravitational Acceleration (g) =	9.8	meters/second^2	
Inlet Loss Coefficient (Ki) =	0.5		1
Outlet Loss Coefficient (Ke) =	1.0		
Fitting Loss Coefficient (Kf) =	2.55	71	1 di second
Fitting Loss Coefficient (Kf) =	0.32		
Pump Shutoff Head (Hp@Q_0) =	120.0	Discharge (Q_0)	0.0
Pump Point One (Hp@Q_1) =	90.0	Discharge (Q_1)	0.028
Pump Point Two (Hp@Q_2) =	42.0	Discharge (Q_2)	0.036



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COMPUTED RESULT		- 111
Discharge =	0.02240409	m^3/sec
Added Head =	95.16888	m
Friction Losses =	63.86888	m
Static Lift =	31.3	m
Pipeline Friction Factor =	0.0157098	
Fitted Pump Shutoff =	124.4606	m
Pump Constant =	-58356.7	m/Q^2