The Dalles AWS Intake Trashrack Calcs

CENWP-ENC-HD

Head Differential Versus % Blockage + Vibration Analyses

Originally Prepared by:	SJS	6/19/2019
Updated:	SJS	4/3/2023
Checked by:	LLE	4/10/2023

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References:

Blevins (2001), Flow Induced Vibration, 2nd Ed.

Miller, D. S. 1990. Internal Flow Systems, 2nd Ed.

USACE (2015) TDA AWSBS Award Drawings

USACE (2018) JDA Powerhouse Trashrack Design, Vibration Analyses (AKL, CENWP-ENC-HD)

USACE (2023) The Dalles Auxilary Water Supply Backup Debris Management 90% EDR.

ϒ = unit weight of water = **62.4** ✓

Trashrack Dimensions

Bottom Elevation =	**104**	feet NGDG 29	✓
Minimum Forebay =	**155**	feet NGDG 29	✓
Ytr =Min Open Depth =	51	feet	✓
Btr = Opening Width =	**22.8**	feet	✓
100% Open Flow Area	1164.5	ft^2	✓
design flow =	**1600**	cfs	Maximum normal (per USACE (2023) EDR)

Assume for trashrack dimensions: ✓

CC Spacing (SPvb)=	**0.94**	inches	SK505 -as built	W15-W-2 1 1/2" x 3/16"	
Design Clearance =	**3/4**	inches	Span between vert. supports =	5.75	feet
	✓		Number of spaces =	73.5	
	✓		CL Spacing =	0.94	inches
	✓		Clearance =	0.75	inches (design)
	✓		Difference =	0.00	inches
	✓		Matches design clearance		

Trashrack Panel

hp = Height =	**6** feet		✓
Top and Bottom Support heights =	**10** inches =	0.833 feet	✓
Ytr = Submerged height of trashrack =		51 ft	✓
N = Number of panels stacked =	Ytr/hp =	8.5	✓
Number of submerged support blockages =		17	✓
sum Top & bottom support blockages		14.17 ft	✓
Reduced total open trashrack depth =		36.83 ft	✓
Revised Total Open trash rack area		841.0 ft^2	✓
Opening Height (Htr) =	4.33 feet	per panel	✓
Open Width (Btr) =	22.8 feet		✓
Total Panel Area (Ap) =	137 ft^2		✓
Panel Trashrack Area (Atr) =	98.9 ft^2		✓

	Design Flow (cfs)	Trashrack size Area ft^2	Average Velocity (ft/s)	
Max design Q	1,600	841	1.90	Max normal case

Maximum Normal Case						
TR Velocity (V) =	1.90	ft/s	normal case			✓
Velocity head (VH) = V^2/2g =	0.06	feet				✓
Main Vertical Bars	W15-W-2 1 1/2" x 3/16"					
T =	**3/16**	inches				✓
Depth =	**1 1/2**	inches				✓
No. of Vb (Nv) =	**294**		SK505 -as built			✓
CC Spacing (SPvb) =	0.94	inches				✓
Main Supports						
Span between =	**57**	inches =	4.75 feet	SK505 -as built		✓
Support height =	**10**	inches				✓
Number of =	**2**					✓
Minor round lateral bars						
No. of Lb (Nl) =	**27**		SK505 -as built			✓
Bar D =	**1/4**	inches	*(assumed from photos)*			✓
CC Spacing (SPl) =	**2**	inches	*Custom normal for manufacturer*			✓
Porosity (Pi) = (SPvb - T) * (SPl - D)						
Porosity (Pi) =		70%				✓

For 15-W-2 1 1/2 x 3/16 bars, the maximum safe uniform loading is
Max safe load based on 18,000 Psi steel stress (1/2 normal yield stress)

U =	**432**	lbs/ft^2			✓
DH max = maximum safe head differential = U/ϒ			ϒ =	62.4 lbs/ft^3	
DH max =	6.9	feet	Max design differential across trashrack		✓

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Head loss through bars

HL =VH * Kb ✓

Kb = Trashrack headloss coeff = f(Pi)

Trashrack Headloss Coefficients

Miller (1990), "Internal Flow Systems"; Figures 14.8 & 14.7

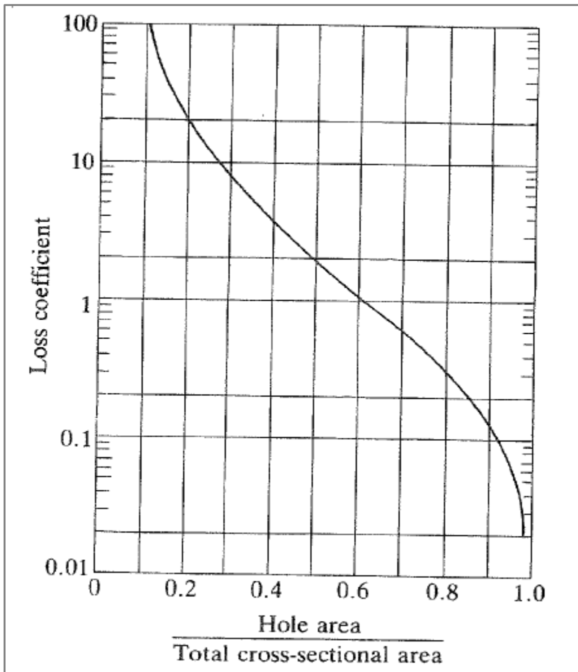

Fig. 14.7. Loss coefficients for round wire screens or nettin in holes)

Round Bars

Porosity	Kr	Log(Kr)/DP
0	10000	-19.79
0.1	105	-7.202
0.2	20	-4.26
0.3	7.5	-2.73
0.4	4	-3.01
0.5	2	-2.596
0.6	1.1	-2.632
0.7	0.6	-3.01
0.8	0.3	-4.771
0.9	0.1	-8.737
0.98	0.02	

example

P =	Kr =
0.55	1.48

✓

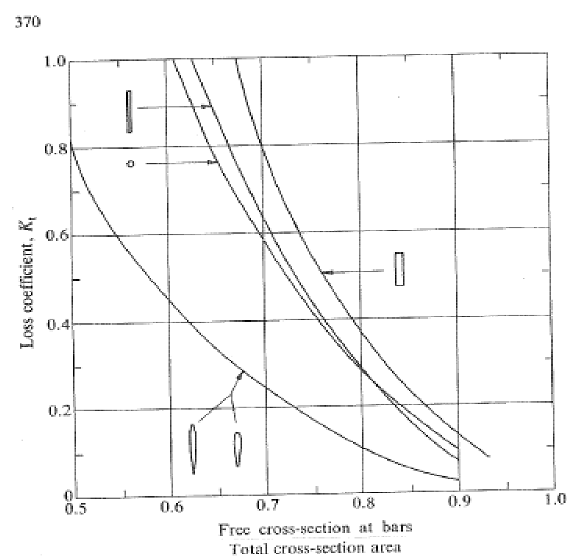

Fig. 14.8. Loss coefficients for trashracks

Flat Bars Miller Fig 14.8

Porosity	Kb	Log(Kr)/DP		Kb/Kr
0.7	0.8	-3.349		1.33
0.8	0.37	-4.543		1.23
0.9	0.13	-10.16		1.30
0.98	0.02		USE Kb/Kr =	**1.3**

✓

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Comparing flat bars versus round bars in Miller (1990) Figures 14.8 & 14.7

Kb ≈ **1.3** * Kr Kb for flat bars; Kr for round bars ✓

Look up Kr

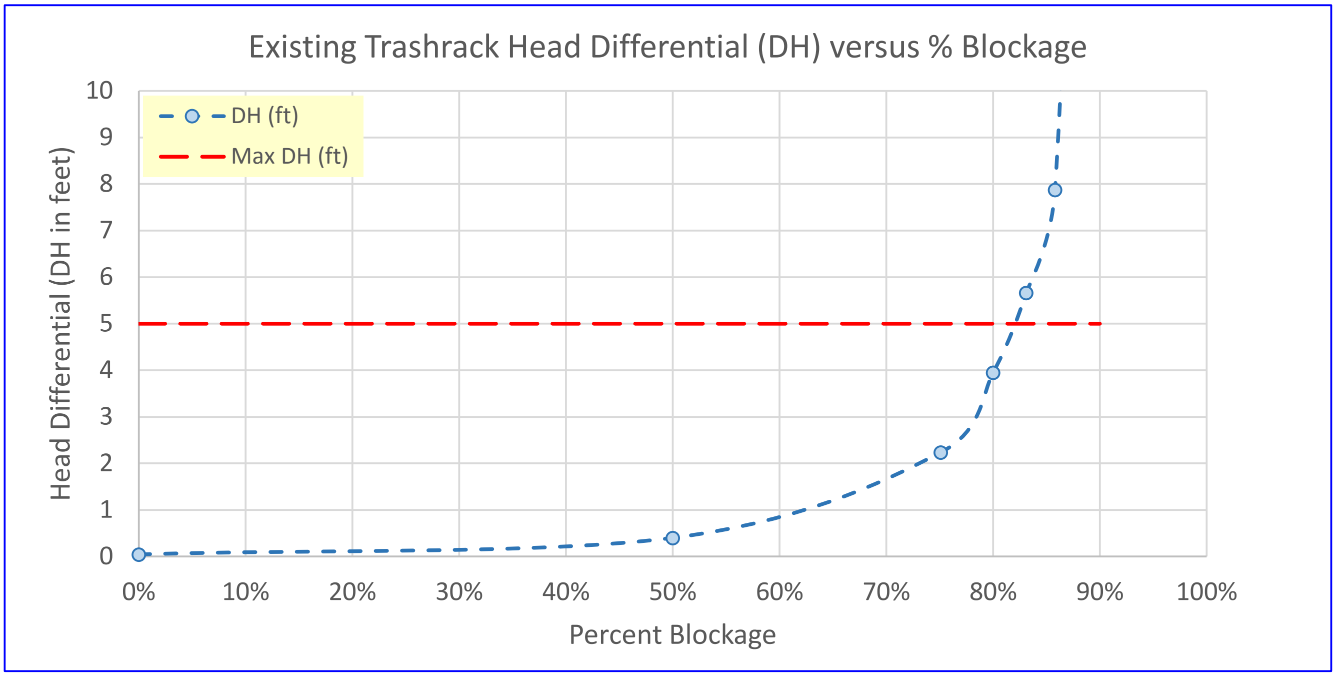
$$Kr = 10^{\left\{\log(Kr1)+(Pi-P1)*\frac{\log(Kr2)-\log(Kr1)}{P2-p1}\right\}}$$ ✓

Max Normal Case

Trashrack Headlosses as Function of Plugging Maximum Normal Case: 1600 cfs					
Bars Loss Coeff		Porosity	Kr	Kb	DH (ft)
Clean	0%	70%	0.60	0.8	0.0
plugged	50%	35%	5.47	7.1	0.4
plugged	75%	17%	30.60	39.8	2.2
plugged	80%	14%	54.0	70.3	3.9
plugged	83%	12%	77.5	100.7	5.7
plugged	86%	10%	107.7	140.1	7.9
plugged	90%	7%	411.5	534.9	30.1
Total Max DH at 80% plugging=					3.9

✓

✓



Estimated Head loss assuming bottom is blocked and all flow is from upper half

Assumed flow =	1600	cfs	✓
Outer Intake width =	23	feet	✓
inner Intake width =	12	feet	✓
Intake depth behind TR =	10	feet	✓
Down draft flow area =	175	ft2	✓
Ave. downdraft Velocity =	9.1	ft/s	✓
Velocity Head =	1.30	feet	✓
Abrupt turn headloss coeff =	1.1		✓
Estimated HL to intake =	2.9	feet	✓

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Vibrations Analyses of Trashrack

Water Prpoerties = ✓

Kin. Viscosity =	0.000015 ft/sec^2	Bar properties	density =	15.2 slugs/ft^3	
density =	1.94 slugs/ft^3		Mod of elasticity =	3.00E+07 lbs/in^2	✓

B = Trashrack width =	22.8 feet	Zicl = CL of Intake =	**116.5** ft	✓
Hft = Assummed height of flow = 2 *(Zicl - Ziv)		Ziv = Bottom of TR =	104 ft	✓
Aft = assume flow area of trashrack = B * Hft		Hft =	25 ft	✓
		Aft =	571 ft^2	✓

Maximum normaL flow =	1600 cfs			✓
Vbr = Average velocity through bars = Q/Aft/Pi		Pi = Porosity =	70%	✓
Vbr =	4.00 ft/s			✓
Max Velocity between bars =	4.0 ft/s			

Main Vert. Bars	d thickness	Lb length	L height	opening	CL spacing	Porosity	Bar aspect ratio (l/d)
(inches)	3/16	1 1/2	2.0	3/4	1	80%	8.0

✓

RE =	4.17E+03		✓
St = Strouhal No. =	**0.2** Blevins, fig 3.3 & 3.6	8: 1 aspect ratio	✓
fs= forcing frequency = St * U/d =	51.2 HZ		✓
λ = Boundary factor =	**3.142** pinned -pinned connections		✓
fn= natural frequency = (λ^2/(2 π L^2) * sqrt(E * I/m)			✓
I = intertia of the bars = d^3*Lb/12			✓

USACE (2018) established that a ratio of natural to forcing (fn/fs) frequencies ≥ 3 provides a sufficiently conservative vibration resistant design, given that the performance of the John Day Powerhouse trashracks, which have operated at fn/fs ≈ 2 for 50 years. ✓

Vibration Analysis of components

Main vertical bars — fn/fs ratio critera: fn/fs ≥ 3

inertia in^4	bar area in^2	ms Mass/ft slugs/ft	ma added mass	m combined mass	fn Hz	fn/fs		
0.0008	0.2813	0.0297	0.0238	0.0535	3203	62.5	OK	✓

Alternate vibration approach — criteria fs/fn < 40%

K	Wb lbs/ft^3	Wt lbs/ft^4	t in	l in	L ft	fn Hz	fs Hz	fs/fn
3.56	490	62.4	3/16	1 1/2	0.167	7259	55.3	0.01
St = 0.12 +0.012 *(l/t)=			0.216					OK
U =	4.00 ft/s							✓

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Lateral bars

Bars	d thickness	Lb length	L height	opening	CL spacing	Porosity	aspect ratio (l/d)
(inches)	1/4	1/4	1	3/4	1	75%	1.0

RE = 5.56E+03

St = Strouhal No. = **0.2** Blevins, fig 3.3 & 3.6 8: 1 aspect ratio

fs= forcing frequency = St * U/d = 38.4 HZ

λ = Boundary factor = **3.142** pinned-pinned connections

fn= natural frequency = (λ^2/(2 π L^2) * sqrt(E * I/m)

I1 = intertia of the bars = d^3*Lb/12 8 sepatate panel within wifth of TR

I2 = intertia of the lateral bars =Nb * lb2^3*d2/12

vibration analysis components

fn/fs ratio critera fn/fs ≥ 3

inertia in^4	bar area in^2	ms Mass/ft slugs/ft	ma added mass	m combined mass	fn Hz	fn/fs		
0.0003	0.0625	0.0066	0.0007	0.0073	24865	647	OK	✓

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