

LAMPIRAN 1 Perhitungan nilai Cd pada pipa ½ inch.

Percobaan	$\dot{V}_{\text{air}}$ (LPM)	$\dot{V}_{\text{air}}$ (m <sup>3</sup> /s)	$\Delta P_{\text{Rata-rata}}$ (N/m <sup>2</sup> )	$v$ (m/s)	Re	$A_2 \cdot (2/\rho_{\text{air}})^{0.5} (\Delta P)^{0.5}$	$(1 - (A_2/A_1)^2)^{0.5}$	$\dot{V}_{\text{air ideal}}$ (m <sup>3</sup> /s)	$\dot{V}_{\text{air aktual}}$ (m <sup>3</sup> /s)	Cd
1	1	1,667E-05	2260	0,064	1165,970	8,656E-05	0,988	8,764E-05	1,667E-05	0,190
2	1,5	2,500E-05	2540	0,096	1748,955	9,177E-05	0,988	9,291E-05	2,500E-05	0,269
3	2	3,333E-05	2720	0,128	2331,941	9,496E-05	0,988	9,615E-05	3,333E-05	0,347
4	2,5	4,167E-05	3060	0,160	2914,926	1,007E-04	0,988	1,020E-04	4,167E-05	0,409
5	3	5,000E-05	3570	0,192	3497,911	1,088E-04	0,988	1,102E-04	5,000E-05	0,454
6	3,5	5,833E-05	3910	0,224	4080,896	1,139E-04	0,988	1,153E-04	5,833E-05	0,506
7	4	6,667E-05	4420	0,256	4663,881	1,211E-04	0,988	1,226E-04	6,667E-05	0,544
8	4,5	7,500E-05	5030	0,288	5246,866	1,291E-04	0,988	1,307E-04	7,500E-05	0,574
9	5	8,333E-05	5660	0,320	5829,851	1,370E-04	0,988	1,387E-04	8,333E-05	0,601
10	5,5	9,167E-05	6320	0,352	6412,837	1,448E-04	0,988	1,466E-04	9,167E-05	0,625
11	6	1,000E-04	6960	0,384	6995,822	1,519E-04	0,988	1,538E-04	1,000E-04	0,650
12	6,5	1,083E-04	7730	0,416	7578,807	1,601E-04	0,988	1,621E-04	1,083E-04	0,668
13	7	1,167E-04	8620	0,448	8161,792	1,691E-04	0,988	1,712E-04	1,167E-04	0,682
14	7,5	1,250E-04	10000	0,480	8744,777	1,821E-04	0,988	1,844E-04	1,250E-04	0,678
15	8	1,333E-04	11010	0,513	9327,762	1,911E-04	0,988	1,934E-04	1,333E-04	0,689
16	8,5	1,417E-04	12380	0,545	9910,747	2,026E-04	0,988	2,051E-04	1,417E-04	0,691
17	9	1,500E-04	15430	0,577	10493,733	2,262E-04	0,988	2,290E-04	1,500E-04	0,655
18	9,5	1,583E-04	18490	0,609	11076,718	2,476E-04	0,988	2,507E-04	1,583E-04	0,632
19	10	1,667E-04	20370	0,641	11659,703	2,599E-04	0,988	2,631E-04	1,667E-04	0,633
20	10,5	1,750E-04	22840	0,673	12242,688	2,752E-04	0,988	2,786E-04	1,750E-04	0,628
21	11	1,833E-04	23212,93	0,705	12825,673	2,774E-04	0,988	2,809E-04	1,833E-04	0,653

LAMPIRAN 2 Perhitungan nilai Cd pada pipa ¾ inch.

Percobaan	$\dot{V}_{\text{air}}$ (LPM)	$\dot{V}_{\text{air}}$ (m <sup>3</sup> /s)	$\Delta P_{\text{Rata-rata}}$ (N/m <sup>2</sup> )	$v$ (m/s)	Re	$A_2 \cdot (2/\rho_{\text{air}})^{0.5} (\Delta P)^{0.5}$	$(1 - (A_2/A_1)^2)^{0.5}$	$\dot{V}_{\text{air ideal}}$ (m <sup>3</sup> /s)	$\dot{V}_{\text{air aktual}}$ (m <sup>3</sup> /s)	Cd
1	1	1,66667E-05	230	0,045	982,438	3,849E-05	0,988	3,896E-05	1,667E-05	0,428
2	1,5	0,000025	320	0,068	1473,657	4,540E-05	0,988	4,595E-05	2,500E-05	0,544
3	2	3,33333E-05	470	0,091	1964,876	5,502E-05	0,988	5,569E-05	3,333E-05	0,599
4	2,5	4,16667E-05	590	0,114	2456,095	6,164E-05	0,988	6,239E-05	4,167E-05	0,668
5	3	0,00005	720	0,136	2947,314	6,809E-05	0,988	6,893E-05	5,000E-05	0,725
6	3,5	5,83333E-05	970	0,159	3438,533	7,904E-05	0,988	8,000E-05	5,833E-05	0,729
7	4	6,66667E-05	1260	0,182	3929,752	9,008E-05	0,988	9,118E-05	6,667E-05	0,731
8	4,5	0,000075	1710	0,205	4420,971	1,049E-04	0,988	1,062E-04	7,500E-05	0,706
9	5	8,33333E-05	2160	0,227	4912,190	1,179E-04	0,988	1,194E-04	8,333E-05	0,698
10	5,5	9,16667E-05	2640	0,250	5403,409	1,304E-04	0,988	1,320E-04	9,167E-05	0,695
11	6	0,0001	3110	0,273	5894,628	1,415E-04	0,988	1,432E-04	1,000E-04	0,698
12	6,5	0,000108333	3780	0,296	6385,846	1,560E-04	0,988	1,579E-04	1,083E-04	0,686
13	7	0,000116667	4440	0,318	6877,065	1,691E-04	0,988	1,712E-04	1,167E-04	0,682
14	7,5	0,000125	5020	0,341	7368,284	1,798E-04	0,988	1,820E-04	1,250E-04	0,687
15	8	0,000133333	5840	0,364	7859,503	1,939E-04	0,988	1,963E-04	1,333E-04	0,679
16	8,5	0,000141667	6540	0,387	8350,722	2,052E-04	0,988	2,077E-04	1,417E-04	0,682
17	9	0,00015	7210	0,409	8841,941	2,155E-04	0,988	2,181E-04	1,500E-04	0,688
18	9,5	0,000158333	7890	0,432	9333,160	2,254E-04	0,988	2,282E-04	1,583E-04	0,694
19	10	0,000166667	8590	0,455	9824,379	2,352E-04	0,988	2,381E-04	1,667E-04	0,700
20	10,5	0,000175	10640	0,478	10315,598	2,618E-04	0,988	2,650E-04	1,750E-04	0,660
21	11	0,000183333	11700	0,500	10806,817	2,745E-04	0,988	2,778E-04	1,833E-04	0,660

LAMPIRAN 3 Hasil perhitungan  $\dot{V}_{orifice}$  pada pipa 1/2 inch.

Percobaan	$\dot{V}_{aktual}$ (LPM)	$\dot{V}_{aktual}$ (m <sup>3</sup> /s)	Re	$\dot{V}_{air\ ideal}$ (m <sup>3</sup> /s)	Cd (Persamaan regresi)	$\dot{V}_{orifice}$ (m <sup>3</sup> /s)	$\dot{V}_{orifice}$ (LPM)	$\Delta\dot{V}$ (LPM)
1	1	1,667E-05	1165,970	8,764E-05	2,295E-01	2,011E-05	1,207	0,171
2	1,5	2,500E-05	1748,955	9,291E-05	3,126E-01	2,904E-05	1,743	0,243
3	2	3,333E-05	2331,941	9,615E-05	3,716E-01	3,572E-05	2,143	0,143
4	2,5	4,167E-05	2914,926	1,020E-04	4,173E-01	4,256E-05	2,553	0,053
5	3	5,000E-05	3497,911	1,102E-04	4,547E-01	5,008E-05	3,005	0,005
6	3,5	5,833E-05	4080,896	1,153E-04	4,863E-01	5,606E-05	3,363	0,137
7	4	6,667E-05	4663,881	1,226E-04	5,137E-01	6,296E-05	3,777	0,223
8	4,5	7,500E-05	5246,866	1,307E-04	5,378E-01	7,032E-05	4,219	0,281
9	5	8,333E-05	5829,851	1,387E-04	5,594E-01	7,759E-05	4,655	0,345
10	5,5	9,167E-05	6412,837	1,466E-04	5,789E-01	8,485E-05	5,091	0,409
11	6	1,000E-04	6995,822	1,538E-04	5,968E-01	9,179E-05	5,507	0,493
12	6,5	1,083E-04	7578,807	1,621E-04	6,132E-01	9,939E-05	5,963	0,537
13	7	1,167E-04	8161,792	1,712E-04	6,284E-01	1,076E-04	6,453	0,547
14	7,5	1,250E-04	8744,777	1,844E-04	6,425E-01	1,185E-04	7,107	0,393
15	8	1,333E-04	9327,762	1,934E-04	6,558E-01	1,268E-04	7,611	0,389
16	8,5	1,417E-04	9910,747	2,051E-04	6,682E-01	1,371E-04	8,224	0,276
17	9	1,500E-04	10493,733	2,290E-04	6,799E-01	1,557E-04	9,342	0,342
18	9,5	1,583E-04	11076,718	2,507E-04	6,910E-01	1,732E-04	10,393	0,893
19	10	1,667E-04	11659,703	2,631E-04	7,015E-01	1,846E-04	11,075	1,075
20	10,5	1,750E-04	12242,688	2,786E-04	7,115E-01	1,982E-04	11,894	1,394
21	11	1,833E-04	12825,673	2,809E-04	7,210E-01	2,025E-04	12,151	1,151

LAMPIRAN 4 Hasil perhitungan  $\dot{V}_{orifice}$  pada pipa  $\frac{3}{4}$  inch.

Percobaan	$\dot{V}_{aktual}$ (LPM)	$\dot{V}_{aktual}$ ( $m^3/s$ )	Re	$\dot{V}_{air\ ideal}$ ( $m^3/s$ )	Cd (Persamaan regresi)	$\dot{V}_{orifice}$ ( $m^3/s$ )	$\dot{V}_{orifice}$ (LPM)	$\Delta\dot{V}$ (LPM)
1	1	1,667E-05	982,438	3,896E-05	0,540	2,103E-05	1,262	0,262
2	1,5	2,500E-05	1473,657	4,595E-05	0,572	2,628E-05	1,577	0,077
3	2	3,333E-05	1964,876	5,569E-05	0,601	3,347E-05	2,008	0,008
4	2,5	4,167E-05	2456,095	6,239E-05	0,627	3,914E-05	2,348	0,152
5	3	5,000E-05	2947,314	6,893E-05	0,651	4,485E-05	2,691	0,309
6	3,5	5,833E-05	3438,533	8,000E-05	0,671	5,369E-05	3,222	0,278
7	4	6,667E-05	3929,752	9,118E-05	0,689	6,280E-05	3,768	0,232
8	4,5	7,500E-05	4420,971	1,062E-04	0,703	7,472E-05	4,483	0,017
9	5	8,333E-05	4912,190	1,194E-04	0,715	8,538E-05	5,123	0,123
10	5,5	9,167E-05	5403,409	1,320E-04	0,724	9,557E-05	5,734	0,234
11	6	1,000E-04	5894,628	1,432E-04	0,730	1,046E-04	6,275	0,275
12	6,5	1,083E-04	6385,846	1,579E-04	0,733	1,158E-04	6,948	0,448
13	7	1,167E-04	6877,065	1,712E-04	0,733	1,255E-04	7,532	0,532
14	7,5	1,250E-04	7368,284	1,820E-04	0,731	1,330E-04	7,979	0,479
15	8	1,333E-04	7859,503	1,963E-04	0,725	1,423E-04	8,541	0,541
16	8,5	1,417E-04	8350,722	2,077E-04	0,717	1,489E-04	8,932	0,432
17	9	1,500E-04	8841,941	2,181E-04	0,705	1,538E-04	9,230	0,230
18	9,5	1,583E-04	9333,160	2,282E-04	0,691	1,577E-04	9,460	0,040
19	10	1,667E-04	9824,379	2,381E-04	0,674	1,604E-04	9,625	0,375
20	10,5	1,750E-04	10315,598	2,650E-04	0,654	1,732E-04	10,394	0,106
21	11	1,833E-04	10806,817	2,778E-04	0,631	1,753E-04	10,516	0,484

LAMPIRAN 5 Perbandingan hasil perhitungan pada ½ dan ¾ inch.

$\dot{V}_{\text{air}}$ (LPM)	$\dot{V}_{\text{air}}$ ( $\text{m}^3/\text{s}$ )	$\Delta P_{\text{Rata-rata 1}}$ ( $\text{N}/\text{m}^2$ )	$\Delta P_{\text{Rata-rata 2}}$ ( $\text{N}/\text{m}^2$ )	$Re_1$	$Re_2$	$v_1$ (m/s)	$v_2$ (m/s)	$\dot{V}_{\text{air ideal 1}}$ ( $\text{m}^3/\text{s}$ )	$\dot{V}_{\text{air ideal 2}}$ ( $\text{m}^3/\text{s}$ )	$Cd_1$	$Cd_2$
1	1,667E-05	2260	230	1165,970	982,438	0,064	0,045	8,764E-05	3,896E-05	0,190	0,428
1,5	2,500E-05	2540	320	1748,955	1473,657	0,096	0,068	9,291E-05	4,595E-05	0,269	0,544
2	3,333E-05	2720	470	2331,941	1964,876	0,128	0,091	9,615E-05	5,569E-05	0,347	0,599
2,5	4,167E-05	3060	590	2914,926	2456,095	0,160	0,114	1,020E-04	6,239E-05	0,409	0,668
3	5,000E-05	3570	720	3497,911	2947,314	0,192	0,136	1,102E-04	6,893E-05	0,454	0,725
3,5	5,833E-05	3910	970	4080,896	3438,533	0,224	0,159	1,153E-04	8,000E-05	0,506	0,729
4	6,667E-05	4420	1260	4663,881	3929,752	0,256	0,182	1,226E-04	9,118E-05	0,544	0,731
4,5	7,500E-05	5030	1710	5246,866	4420,971	0,288	0,205	1,307E-04	1,062E-04	0,574	0,706
5	8,333E-05	5660	2160	5829,851	4912,190	0,320	0,227	1,387E-04	1,194E-04	0,601	0,698
5,5	9,167E-05	6320	2640	6412,837	5403,409	0,352	0,250	1,466E-04	1,320E-04	0,625	0,695
6	1,000E-04	6960	3110	6995,822	5894,628	0,384	0,273	1,538E-04	1,432E-04	0,650	0,698
6,5	1,083E-04	7730	3780	7578,807	6385,846	0,416	0,296	1,621E-04	1,579E-04	0,668	0,686
7	1,167E-04	8620	4440	8161,792	6877,065	0,448	0,318	1,712E-04	1,712E-04	0,682	0,682
7,5	1,250E-04	10000	5020	8744,777	7368,284	0,480	0,341	1,844E-04	1,820E-04	0,678	0,687
8	1,333E-04	11010	5840	9327,762	7859,503	0,513	0,364	1,934E-04	1,963E-04	0,689	0,679
8,5	1,417E-04	12380	6540	9910,747	8350,722	0,545	0,387	2,051E-04	2,077E-04	0,691	0,682
9	1,500E-04	15430	7210	10493,733	8841,941	0,577	0,409	2,290E-04	2,181E-04	0,655	0,688
9,5	1,583E-04	18490	7890	11076,718	9333,160	0,609	0,432	2,507E-04	2,282E-04	0,632	0,694
10	1,667E-04	20370	8590	11659,703	9824,379	0,641	0,455	2,631E-04	2,381E-04	0,633	0,700
10,5	1,750E-04	22840	10640	12242,688	10315,598	0,673	0,478	2,786E-04	2,650E-04	0,628	0,660
11	1,833E-04	23212,93	11700	12825,673	10806,817	0,705	0,500	2,809E-04	2,778E-04	0,653	0,660

LAMPIRAN 6 Perhitungan interpolasi pada pipa ½ dan ¾ inch.

Re	$\Delta P_{\text{Rata-rata 1}}$ (N/m <sup>2</sup> )	$\Delta P_{\text{Rata-rata 2}}$ (N/m <sup>2</sup> )	$v_1$ (m/s)	$v_2$ (m/s)	$\dot{V}_{\text{air ideal 1}}$ (m <sup>3</sup> /s)	$\dot{V}_{\text{air ideal 2}}$ (m <sup>3</sup> /s)	Cd <sub>1</sub>	Cd <sub>2</sub>
1500	2420,430	328,044	0,082	0,069	9,066E-05	4,647E-05	0,235	0,541
2000	2617,511	478,580	0,110	0,093	9,431E-05	5,617E-05	0,302	0,594
2500	2818,013	601,619	0,137	0,116	9,783E-05	6,298E-05	0,365	0,663
3000	3134,424	746,814	0,165	0,139	1,032E-04	7,011E-05	0,415	0,725
3500	3571,218	1006,288	0,192	0,162	1,102E-04	8,140E-05	0,454	0,729
4000	3862,821	1324,354	0,220	0,185	1,146E-04	9,333E-05	0,499	0,735
4500	4276,636	1782,398	0,247	0,208	1,205E-04	1,083E-04	0,533	0,707
5000	4771,694	2245,805	0,275	0,231	1,273E-04	1,216E-04	0,561	0,699
5500	5303,548	2732,419	0,302	0,255	1,342E-04	1,342E-04	0,585	0,694
6000	5852,626	3253,723	0,330	0,278	1,410E-04	1,464E-04	0,608	0,701
6500	6415,688	3933,376	0,357	0,301	1,476E-04	1,610E-04	0,629	0,687
7000	6965,519	4585,153	0,385	0,324	1,539E-04	1,739E-04	0,650	0,680
7500	7625,913	5239,875	0,412	0,347	1,610E-04	1,858E-04	0,666	0,689
8000	8373,004	6040,211	0,440	0,370	1,686E-04	1,996E-04	0,678	0,678
8500	9420,581	6743,608	0,467	0,394	1,788E-04	2,109E-04	0,680	0,680
9000	10442,164	7428,802	0,495	0,417	1,883E-04	2,213E-04	0,683	0,686
9500	11414,754	8127,751	0,522	0,440	1,969E-04	2,315E-04	0,690	0,692
10000	12846,942	9322,917	0,549	0,463	2,088E-04	2,477E-04	0,685	0,714
10500	15462,897	11037,920	0,577	0,486	2,292E-04	2,698E-04	0,655	0,661

LAMPIRAN 7 Perbandingan hasil interpolasi  $\Delta P_{\text{Rata-rata}}$ .

Re	$\Delta P_{\text{Rata-rata 1}}$ (N/m <sup>2</sup> )	$\Delta P_{\text{Rata-rata 2}}$ (N/m <sup>2</sup> )	$\Delta P_{\text{Rata-rata 1}} - \Delta P_{\text{Rata-rata 2}}$ (N/m <sup>2</sup> )	$\Delta P_{\text{Rata-rata}}$ (%)
1500	2420,43003	328,044209	2092,385818	86,4469%
2000	2617,51145	478,580489	2138,930963	81,7162%
2500	2818,01315	601,619413	2216,393738	78,6509%
3000	3134,42367	746,81403	2387,609641	76,1738%
3500	3571,21841	1006,28832	2564,930091	71,8223%
4000	3862,82104	1324,35367	2538,46737	65,7154%
4500	4276,63551	1782,39788	2494,237626	58,3224%
5000	4771,69425	2245,80489	2525,889351	52,9349%
5500	5303,54773	2732,41902	2571,128703	48,4794%
6000	5852,62597	3253,7232	2598,902773	44,4058%
6500	6415,68789	3933,37625	2482,31164	38,6913%
7000	6965,51868	4585,15328	2380,365403	34,1736%
7500	7625,91288	5239,87504	2386,037833	31,2886%
8000	8373,00427	6040,21142	2332,792851	27,8609%
8500	9420,58148	6743,60787	2676,973612	28,4162%
9000	10442,1642	7428,80248	3013,361681	28,8576%
9500	11414,7543	8127,75106	3287,003236	28,7961%
10000	12846,9425	9322,91681	3524,02565	27,4309%
10500	15462,8971	11037,9202	4424,97689	28,6167%

LAMPIRAN 8 Perbandingan hasil interpolasi  $\dot{V}_{air\ ideal}$ .

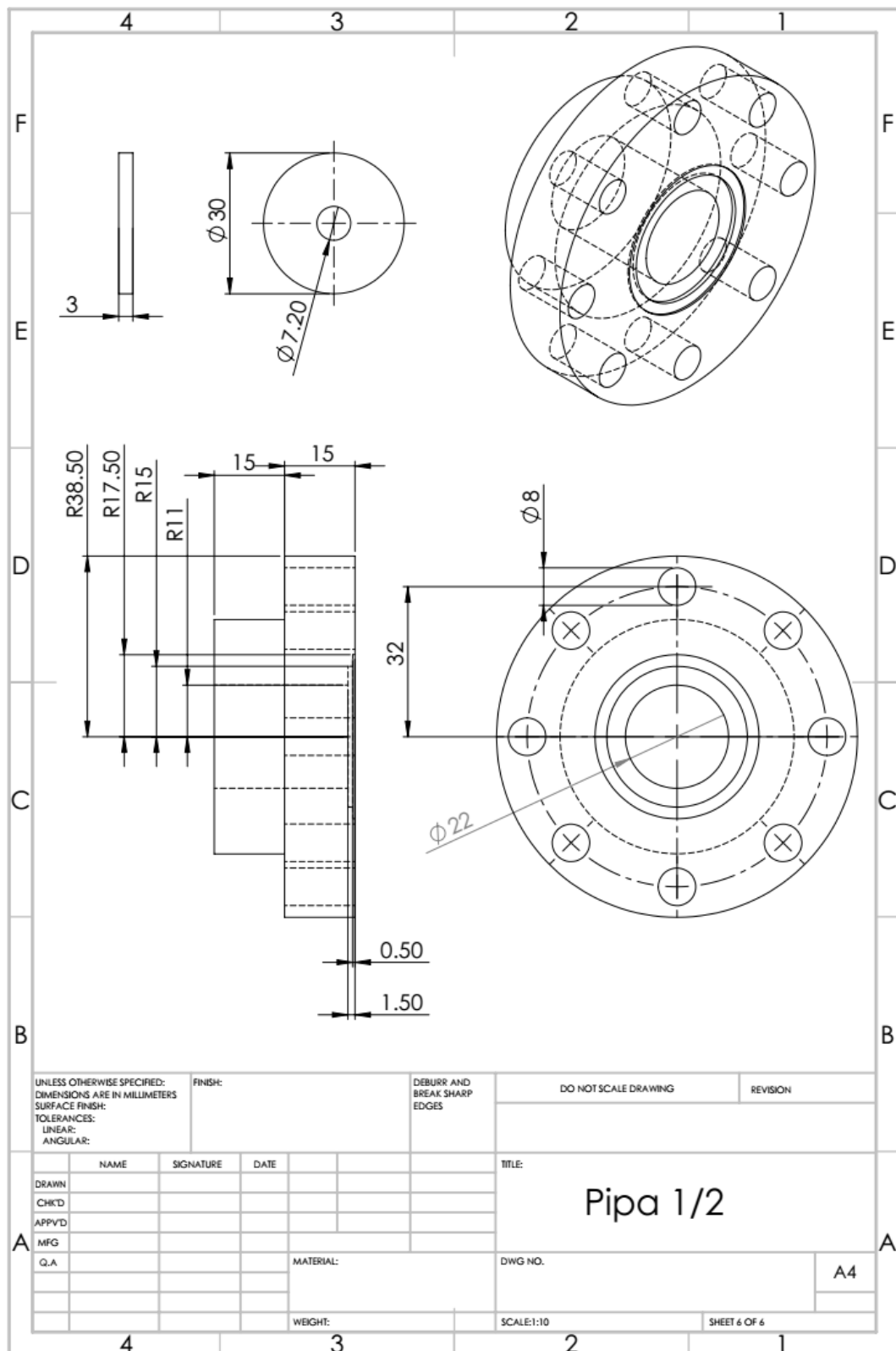
Re	$\dot{V}_{air\ ideal\ 1} (m^3/s)$	$\dot{V}_{air\ ideal\ 1} (m^3/s)$	$\dot{V}_{air\ ideal\ 1} - \dot{V}_{air\ ideal\ 2}$	$\Delta \dot{V}_{air\ ideal} \%$
1500	9,06612E-05	4,64725E-05	-4,41887E-05	48,7404%
2000	9,43053E-05	5,61676E-05	-3,81378E-05	40,4407%
2500	9,78291E-05	6,29774E-05	-3,48517E-05	35,6251%
3000	0,000103172	7,01135E-05	-3,3059E-05	32,0425%
3500	0,000110169	8,14005E-05	-2,8769E-05	26,1134%
4000	0,000114566	9,33309E-05	-2,12349E-05	18,5351%
4500	0,000120516	0,000108339	-1,21775E-05	10,1044%
5000	0,000127283	0,000121635	-5,64868E-06	4,4379%
5500	0,0001342	0,000134198	-1,69846E-09	0,0013%
6000	0,000140991	0,000146398	5,40767E-06	3,8355%
6500	0,000147642	0,000161003	1,33613E-05	9,0498%
7000	0,00015386	0,000173873	2,00126E-05	13,0070%
7500	0,000160966	0,000185833	2,48668E-05	15,4485%
8000	0,000168643	0,000199569	3,09261E-05	18,3382%
8500	0,000178816	0,000210886	3,20705E-05	17,9349%
9000	0,000188333	0,000221348	3,30151E-05	17,5302%
9500	0,000196892	0,000231531	3,46388E-05	17,5928%
10000	0,000208779	0,000247687	3,89076E-05	18,6358%
10500	0,000229234	0,000269799	4,05652E-05	17,6960%



## LAMPIRAN 9 Perbandingan hasil interpolasi Cd.

Re	Cd <sub>1</sub>	Cd <sub>2</sub>	Cd <sub>2</sub> - Cd <sub>1</sub>	ΔCd (%)
1500	0,235	0,541	0,306	56,50%
2000	0,302	0,594	0,291	49,04%
2500	0,365	0,663	0,298	44,99%
3000	0,415	0,725	0,310	42,73%
3500	0,454	0,729	0,275	37,70%
4000	0,499	0,735	0,236	32,11%
4500	0,533	0,707	0,174	24,61%
5000	0,561	0,699	0,138	19,70%
5500	0,585	0,694	0,108	15,62%
6000	0,608	0,701	0,093	13,22%
6500	0,629	0,687	0,058	8,42%
7000	0,650	0,680	0,030	4,41%
7500	0,666	0,689	0,023	3,33%
8000	0,678	0,678	0,001	0,08%
8500	0,680	0,680	0,001	0,10%
9000	0,683	0,686	0,003	0,40%
9500	0,690	0,692	0,002	0,32%
10000	0,685	0,714	0,029	4,07%
10500	0,655	0,661	0,006	0,90%

LAMPIRAN 10 Desain *flange* dan plat orifice pipa pipa 1/2 inch.



LAMPIRAN 11 Desain *flange* dan plat orifice pipa pipa 3/4 inch.

