

APPENDIX

A: The Geometrical Relationships and Reynolds Numbers

1. The Geometrical Relationships for Stratified Flow

All dimensionless quantities are expressed as a function of $\tilde{h}_L = h_L / d$.

Dimensionless wetted perimeter of liquid:

$$\tilde{S}_L = \pi - \cos^{-1}(2\tilde{h}_L - 1) \quad (\text{A-1})$$

Dimensionless wetted perimeter of gas:

$$\tilde{S}_G = \pi - \tilde{S}_L \quad (\text{A-2})$$

Dimensionless interfacial perimeter:

$$\tilde{S}_I = \sqrt{1 - (2\tilde{h}_L - 1)^2} \quad (\text{A-3})$$

Dimensionless pipe cross sectional area occupied by gas:

$$\tilde{A}_G = \frac{1}{4}(\tilde{S}_G + (2\tilde{h}_L - 1)\tilde{S}_I) \quad (\text{A-4})$$

Dimensionless pipe cross sectional area occupied by liquid:

$$\tilde{A}_L = \frac{1}{4}(\pi - 4\tilde{A}_G) \quad (\text{A-5})$$

2. Reynolds Numbers

Reynolds number of gas phase:

$$N_{\text{Re}G} = \frac{v_G d_G \rho_G}{\mu_G} \quad (\text{A-6})$$

Reynolds number of liquid phase:

$$N_{ReL} = \frac{v_L d_L \rho_L}{\mu_L} \quad (A-7)$$

Reynolds number of gas-liquid mixture:

$$N_{ReM} = \frac{v_M \rho_M d}{\mu_M} \quad (A-8)$$

B: Liquid Film Thickness Model of Paz for Annular Flow

A simple mass balance on the bottom film of the pipe yields:

$$l(D_B - E_B) + \Gamma \cos \theta = 0 \quad (B-1)$$

where D_B and E_B are the deposition rate and the entrainment rate at the bottom of the pipe, respectively, and Γ is the drainage flow rate into the bottom layer. A mass balance on the core gives

$$lE_B + 3lE_T = lD_B + 3lD_T = 4lD \quad (B-2)$$

As can be seen, Eq. (B-2) is carried out for equilibrium conditions, where the total deposition and entrainment are equal. The drainage flow rate Γ is calculated assuming full developed falling under laminar flow as given by Wallis¹⁾:

$$\Gamma = \frac{2g\rho_L(\rho_L - \rho_G)h_F^2}{3\mu_L} \quad (B-3)$$

To calculate the entrainment rate, Whalley and Hewitt²⁾ suggested correlating the experimental results in the form of $E\sigma/\tau_l\mu_L$ versus $\tau_l h_F/\sigma$. Their proposed correlation shows that for large

values of $\tau_l h_F / \sigma$, the dimensionless entrainment $E\sigma / \tau_l \mu_L$ approaches a constant value of about 5.

$$\frac{E\sigma}{\tau_l \mu_L} \approx 5 \quad (\text{B-4})$$

Paz³⁾ used the correlation of Wallis¹⁾ for calculation of the interfacial shear stress. The superficial gas velocity approximates the gas velocity in the core, since the film thickness is small.

$$\tau_l = \frac{0.005(1 + 300\tilde{h}_F)\rho_C v_{SG}^2}{2} \quad (\text{B-5})$$

where ρ_C is the mixture density in the gas core which is given by

$$\rho_C = H_C \rho_L + (1 - H_C) \rho_G \quad (\text{B-6})$$

The liquid holdup in the gas core, H_C , is related to liquid entrainment fraction, FE , as follows:

$$H_C = \frac{v_{SL} FE}{v_{SG} + v_{SL} FE} \quad (\text{B-7})$$

Substituting Eqs. (B-2) through (B-7) into Eq. (B-1),

$$l \left(\frac{E_B + 3E_T}{4} - E_B \right) + \frac{2g\rho_L(\rho_L - \rho_G)\tilde{h}_{FT}^3}{3\mu_L} \cos \theta = 0 \quad (\text{B-8})$$

If Eqs. (B-4) and (B-5) are substituted into Eq. (B-8), it becomes as

$$\begin{aligned}
& \frac{5\mu_L 0.005(1+300\tilde{h}_{FB})\rho_C v_{SG}^2 l}{8\sigma} + \frac{15\mu_L 0.005(1+300\tilde{h}_{FT})\rho_C v_{SG}^2 l}{8\sigma} \\
& - \frac{5\mu_L 0.005(1+300\tilde{h}_{FB})\rho_C v_{SG}^2 l}{2\sigma} + \frac{2g\rho_L(\rho_L - \rho_G)h_{FT}^3}{3\mu_L} = 0
\end{aligned} \tag{B-9}$$

Multiplying with μ_L/d^3 and rearranging, Eq. (B-9) yields:

$$3\tilde{h}_{FT} - N(\tilde{h}_{FB} - \tilde{h}_{FT}) = 0 \tag{B-10}$$

where the dimensionless group N is given by

$$N = \frac{4.22\rho_C\mu_L^2v_{SG}^2}{g\sigma\rho_L(\rho_L - \rho_G)d^2\cos\theta} \tag{B-11}$$

APPENDIX

C: Experimental Data

Table C-1 Experimental Data for 0° Inclined Flow at Low Pressure, 592 kPa (6 kgf/cm²A)

Trace Name	Q ₁	Q ₂	P1-01	P1-02	P1-03	dP1-01	dP1-02	dP1-03	HI-05	TI-1	PI-C-02	dP1-01	dP1-02	dP1-03	Pink1	Posit	Flow Pattern
Unit	Nm/h	m/h	kgf/cm ²	kgf/cm ²	kgf/cm ²	mmH ₂ O	mmH ₂ O	mmH ₂ O	%		kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ² A	kgf/cm ² A	
Test No. L001	349.682	5.002	5.021	4.980	5.003	-50.765	91.488	34.755	33.617	27.886	5.008	0.003	0.005	0.001	6.023	6.016	SR
L002	349.451	10.003	5.044	5.009	5.027	-16.771	141.190	58.059	32.600	33.367	5.006	0.006	0.009	0.003	6.057	6.038	SL
L003	349.747	18.015	5.045	5.003	5.017	63.826	249.941	81.339	37.724	36.978	4.969	0.014	0.020	0.005	6.058	6.027	SL
L004	343.569	35.027	5.125	5.083	5.086	244.163	543.986	199.286	47.764	24.948	4.900	0.034	0.052	0.018	6.150	6.103	SL
L005	345.398	65.022	5.093	5.005	4.983	693.819	1255.324	462.379	58.716	25.875	4.640	0.079	0.123	0.045	6.117	5.999	SL
L006	348.993	109.465	5.258	5.070	4.991	1692.116	2824.637	1030.116	69.720	25.452	4.070	0.179	0.280	0.102	6.282	6.008	SL
L007	349.347	179.996	5.457	5.017	4.802	4300.506	6682.847	2382.236	79.825	24.781	2.850	0.430	0.666	0.237	6.481	5.819	DB
L008	518.640	5.003	5.023	4.983	5.007	-50.096	84.259	25.018	22.318	29.790	5.005	0.003	0.004	0.000	6.025	6.020	SR
L009	537.527	10.019	5.051	5.005	5.025	5.937	165.291	51.644	26.455	33.849	5.009	0.008	0.011	0.002	6.061	6.035	SL
L010	519.051	18.005	5.063	5.016	5.031	109.524	312.629	95.829	31.281	37.380	4.966	0.018	0.026	0.007	6.075	6.041	SL
L011	518.607	34.925	5.140	5.085	5.085	338.460	671.927	215.683	42.265	29.091	4.910	0.044	0.064	0.020	6.164	6.101	SL
L012	515.134	65.039	5.109	4.997	4.958	892.539	1539.026	529.896	48.391	25.228	4.590	0.099	0.152	0.052	6.131	5.981	SL
L013	517.578	109.709	5.254	5.024	4.927	2159.948	3394.877	1128.188	60.541	30.930	3.960	0.225	0.337	0.113	6.282	5.946	SL
L014	518.143	181.149	5.731	5.213	4.966	5018.691	7737.011	2624.184	71.817	30.801	2.500	0.510	0.771	0.262	6.759	5.986	DB
L015	796.565	4.989	5.033	5.022	5.035	-33.780	104.280	33.045	17.509	10.064	5.000	0.004	0.006	0.001	6.061	6.055	SR
L016	788.209	10.013	5.040	4.985	5.001	46.085	227.168	69.908	20.825	35.664	4.967	0.012	0.017	0.004	6.049	6.011	SL
L017	798.240	18.004	5.021	4.967	4.978	184.574	425.093	128.376	25.578	37.586	4.888	0.026	0.038	0.010	6.034	5.988	SL
L018	803.922	34.888	5.148	5.081	5.070	511.412	907.541	289.534	32.906	26.050	4.800	0.060	0.088	0.029	6.177	6.089	SL
L019	794.032	65.043	5.302	5.161	5.108	1191.924	1971.088	675.533	40.629	29.696	4.520	0.129	0.195	0.066	6.324	6.131	SL
L020	794.186	110.391	5.410	5.113	4.984	2737.157	4293.077	1447.665	50.264	30.978	3.690	0.284	0.427	0.143	6.432	6.007	SL
L021	787.443	179.737	6.316	5.745	5.466	5526.054	8566.373	2588.163	64.782	30.855	2.500	0.561	0.854	0.296	7.345	6.485	DB
L022	1199.267	5.001	5.025	4.989	5.005	21.689	199.116	78.185	12.193	30.376	4.969	0.010	0.015	0.005	6.034	6.015	SR
L023	1190.586	9.996	5.042	4.993	5.004	123.269	330.852	115.617	15.443	35.772	4.931	0.020	0.030	0.008	6.052	6.014	F
L024	1205.230	17.991	5.083	5.005	5.005	316.201	644.312	218.144	19.903	37.278	4.851	0.039	0.059	0.019	6.096	6.015	F
L025	1201.604	34.974	5.200	5.105	5.075	795.154	1371.137	468.893	25.477	27.662	4.690	0.088	0.135	0.047	6.228	6.095	SL
L026	1214.339	64.937	5.319	5.116	5.028	1805.246	2951.396	1034.346	31.355	26.713	4.200	0.190	0.293	0.102	6.341	6.051	SL
L027	1213.453	109.081	5.523	5.126	4.944	3750.343	5834.288	1980.831	38.518	31.330	3.120	0.385	0.581	0.197	6.545	5.967	F
L028	1186.848	177.547	7.202	6.563	6.237	6165.594	9666.994	3427.232	54.926	30.796	2.500	0.625	0.964	0.343	8.230	7.257	DB
L029	1780.737	5.004	5.079	5.032	5.042	10.945	345.898	132.346	8.626	32.036	4.968	0.018	0.029	0.010	6.088	6.052	SR
L030	1805.579	10.014	5.063	4.998	4.997	280.612	606.511	218.096	11.391	36.217	4.852	0.036	0.055	0.019	6.073	6.008	A
L031	1798.947	18.000	5.075	4.973	4.963	548.144	1009.449	354.189	15.706	36.396	4.696	0.062	0.096	0.033	6.088	5.973	A
L032	1790.599	35.081	5.178	5.004	4.947	1272.399	2186.105	811.957	19.181	37.297	4.342	0.135	0.214	0.079	6.183	5.958	F
L033	1791.495	65.172	5.332	5.010	4.868	2773.504	4578.060	1700.798	22.812	40.088	3.561	0.285	0.453	0.168	6.338	5.880	F
L034	1772.186	109.825	6.163	5.671	5.429	4679.571	7361.363	2580.416	29.988	31.670	2.780	0.478	0.734	0.257	7.185	6.452	F
L035	1786.265	181.100	8.439	7.707	7.310	7100.160	11304.848	4144.689	44.301	30.737	2.740	0.719	1.128	0.414	9.468	8.330	DB

Table C-2 Experimental Data for 1° Inclined Flow at Low Pressure, 592 kPa (6 kgf/cm²A)

Trace Name	Q ₁	Q ₂	P1-01	P1-02	P1-03	dP1-01	dP1-02	dP1-03	HI-05	TI-1	PI-C-02	dP1-01	dP1-02	dP1-03	Pink	Posit	Flow Pattern
Unit	Nm/h	m/h	kgf/cm ²	kgf/cm ²	kgf/cm ²	mmH ₂ O	mmH ₂ O	mmH ₂ O	%		kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ² A	kgf/cm ² A	
Test No. L101	349.732	5.004	5.024	5.001	5.031	-117.104	-99.525	-70.524	28.762	28.030	5.006	0.009	0.016	0.008	6.044	6.027	SL
L102	349.208	10.003	5.011	4.990	5.019	-79.995	-2.134	-35.178	38.283	32.107	4.970	0.012	0.025	0.011	6.040	6.010	SL
L103	349.551	18.005	5.013	4.984	5.005	89.965	96.809	7.072	42.173	29.567	4.930	0.019	0.034	0.014	6.041	6.003	SL
L104	348.383	34.956	5.087	5.055	5.057	408.446	421.373	-71.766	47.238	26.616	4.880	0.015	0.029	0.004	6.118	6.052	SL
L105	348.132	63.814	5.118	5.041	5.018	774.482	1117.663	261.032	57.270	27.677	4.648	0.051	0.139	0.088	6.149	6.013	SL
L106	348.067	110.933	5.206	5.018	4.934	1885.408	2838.992	870.238	66.951	29.015	4.066	0.163	0.311	0.149	6.257	5.929	SL
L107	346.644	180.312	5.447	4.977	4.763	5267.209	6999.349	1647.364	77.049	25.844	2.720	0.447	0.729	0.282	6.475	5.755	DB
L108	518.901	5.003	5.025	5.003	5.036	-124.202	-108.821	-80.576	26.351	29.258	5.010	0.008	0.015	0.007	6.044	6.031	SL
L109	519.188	9.997	5.066	5.034	5.058	-82.506	-29.454	-52.064	30.428	34.144	5.012	0.012	0.022	0.009	6.090	6.066	SL
L110	518.931	18.001	5.039	5.007	5.032	126.646	124.242	-4.184	33.636	31.072	4.934	0.023	0.037	0.013	6.067	6.031	SL
L111	517.106	34.885	5.132	5.089	5.089	525.902	531.600	-80.726	39.708	30.891	4.865	0.027	0.080	0.053	6.162	6.084	SL
L112	516.141	63.675	5.186	5.086	5.057	1114.305	1403.627	201.081	47.485	31.836	4.985	0.085	0.168	0.082	6.217	6.082	SL
L113	516.111	110.177	5.283	5.057	4.968	2263.888	3288.808	845.694	59.647	33.035	3.931	0.210	0.357	0.146	6.314	5.963	SL
L114	518.692	180.571	5.834	5.300	5.062	6008.629	7861.583	1765.781	70.620	26.624	2.630	0.522	0.815	0.294	6.861	6.054	DB
L115	798.771	5.003	5.046	5.012	5.045	-145.962	-119.191	-73.238	23.021	29.439	5.010	0.006	0.014	0.007	6.066	6.041	SR
L116	796.782	9.973	5.025	4.998	5.026	-58.501	9.688	-43.004	22.308	34.731	4.965	0.015	0.026	0.010	6.048	6.024	SL
L117	798.515	18.009	5.027	4.989	5.014	186.722	216.248	20.831	27.019	32.025	4.883	0.029	0.046	0.016	6.055	6.012	SL
L118	796.264	35.005	5.083	5.023	5.019	842.308	756.049	-174.754	32.166	31.900	4.729	0.058	0.103	0.044	6.114	6.014	SL
L119	796.277	64.599	5.240	5.108	5.070	1521.881	1815.253	200.923	41.006	32.755	4.471	0.126	0.209	0.082	6.270	6.065	SL
L120	797.981	107.901	5.248	4.955	4.842	3094.783	4165.232	977.741	49.967	33.129	3.511	0.284	0.444	0.159	6.278	5.837	SL
L121	793.209	178.980	6.344	5.760	5.486	6999.349	8664.411	1990.551	62.514	26.987	2.540	0.581	0.895	0.317	7.371	6.478	DB
L122	1200.378	5.004	5.033	5.011	5.041	-105.701	-59.197	-68.582	13.740	26.012	4.970	0.010	0.019	0.007	6.057	6.039	SR
L123	1198.235	10.017	5.042	5.009	5.034	11.986	115.668	-7.033	16.348	34.523	4.929	0.022	0.037	0.014	6.066	6.032	SL
L124	1199.247	18.007	5.047	4.995	5.014	256.640	421.596	107.219	21.400	31.743	4.811	0.040	0.067	0.024	6.075	6.012	F
L125	1198.253	34.985	5.093	4.992	4.975	780.148	1221.329	37.806	25.291	35.483	4.578	0.090	0.147	0.054	6.122	5.968	F
L126	1203.448	63.064	5.204	4.995	4.925	1848.104	2808.831	908.294	31.395	37.043	4.074	0.197	0.306	0.107	6.229	5.919	SL
L127	1190.833	109.743	5.410	4.985	4.821	3908.991	5894.208	1900.084	38.850	35.098	2.860	0.394	0.614	0.215	6.422	5.806	F
L128	1191.737	179.699	7.298	6.644	6.330	6159.329	9629.093	3427.747	51.760	36.573	2.672	0.619	0.988	0.368	8.305	7.315	DB
L129	1197.238	5.006	5.080	5.018	5.042	-14.312	87.099	-15.523	8.973	29.022	4.929	0.019	0.024	0.013	6.074	6.040	SR
L130	1804.222	10.006	5.063	5.016	5.032	155.521	349.230	79.482	11.728	34.252	4.853	0.036	0.050	0.022	6.086	6.030	A
L131	1799.074	18.007	5.077	5.005	5.032	477.778	782.919	242.311	15.273	31.549	4.696	0.040	0.103	0.041	6.107	5.995	A
L132	1790.298	34.999	5.128	4.984	4.996	1201.120	1953.199	684.256	19.422	34.729	4.304	0.132	0.220	0.085	6.158	5.990	F
L133	1791.083	65.195	5.287	4.993	4.862	2713.101	4291.739	1542.483	23.228	37.131	3.526	0.284	0.454	0.171	6.317	5.856	F
L134	1795.938	110.383	6.235	5.725	5.495	4754.142	7340.500	2524.342	30.514	33.889	2.856	0.479	0.799	0.277	7.247	6.484	F
L135	1777.488	179.279	8.398	7.668	7.249	6904.294	10957.966	4021.895	41.542	37.250	2.841	0.694	1.120	0.427	9.404	8.280	DB

APPENDIX

Table C-3 Experimental Data for 3° Inclined Flow at Low Pressure, 592 kPa (6 kgf/cm²A)

Trace Name	Q _i	Q _e	P1-01	P1-02	P1-03	dP1-01	dP1-02	dP1-03	HI-05	TI-1	PI-C-002	dP1-01	dP1-02	dP1-03	P1 inlet	P1 exit	Flow Pattern
Unit	Nm/h	m/h	kgf/cm ²	kgf/cm ²	kgf/cm ²	mmH ₂ O	mmH ₂ O	mmH ₂ O	%		kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ² A	kgf/cm ² A	
Test No. L301	350.018	5.038	4.973	4.991	5.030	-13.186	-90.649	-683.910	30.715	21.040	4.932	0.022	0.047	0.026	5.976	5.975	SL
L302	350.294	9.992	4.992	5.000	5.034	240.762	-273.087	-588.184	38.183	30.245	4.930	0.041	0.069	0.032	5.980	5.965	SL
L303	349.573	18.016	4.992	4.978	5.017	350.913	-174.259	-633.549	44.505	34.188	4.893	0.027	0.074	0.048	5.993	5.951	SL
L304	347.647	34.933	5.113	5.072	5.109	143.790	110.001	-226.734	51.467	36.994	4.893	0.065	0.098	0.036	6.116	6.043	SL
L305	340.864	65.141	5.139	5.069	5.075	533.715	863.784	173.057	61.129	30.246	4.667	0.084	0.176	0.098	6.134	5.995	SL
L306	342.306	109.112	5.241	5.067	5.010	1737.083	2518.176	624.548	72.680	30.543	4.136	0.204	0.341	0.143	6.236	5.931	SL
L307	343.629	178.130	5.518	5.093	4.890	4568.083	6455.462	1790.661	82.332	28.199	2.932	0.487	0.734	0.249	6.499	5.815	DB
L308	519.530	5.001	4.975	4.992	5.032	-17.137	-661.745	-760.220	25.885	25.322	4.931	0.022	0.041	0.019	5.978	5.977	SL
L309	519.332	10.011	4.996	5.004	5.041	221.331	-290.268	-583.585	30.216	31.363	4.931	0.039	0.067	0.033	5.984	5.972	SL
L310	519.334	18.025	5.019	5.002	5.038	368.277	-158.632	-621.877	35.491	33.128	4.895	0.029	0.075	0.049	6.019	5.972	SL
L311	515.175	34.921	5.131	5.083	5.118	252.263	198.296	-259.517	43.717	36.587	4.846	0.076	0.107	0.033	6.134	6.052	SL
L312	514.928	64.937	5.216	5.133	5.132	753.917	1076.443	146.833	53.021	30.412	4.610	0.106	0.197	0.095	6.211	6.052	SL
L313	514.587	109.717	5.244	5.028	4.959	2165.713	3080.171	745.457	63.967	30.079	3.871	0.247	0.394	0.155	6.239	5.879	SL
L314	515.787	179.869	5.699	5.192	4.959	5405.488	7565.522	2025.009	74.901	28.766	2.495	0.571	0.845	0.276	6.680	5.884	DB
L315	790.465	5.038	4.983	4.997	5.043	-57.470	-761.110	-829.919	20.396	25.287	4.932	0.018	0.030	0.012	5.988	5.987	SR
L316	799.229	10.009	5.001	5.008	5.050	206.637	-374.805	-678.940	22.457	32.699	4.930	0.038	0.069	0.023	5.989	5.981	SL
L317	800.041	18.021	5.020	4.993	5.027	312.632	-329.615	-785.049	28.954	34.477	4.856	0.048	0.063	0.013	6.008	5.958	SL
L318	784.556	34.929	5.179	5.117	5.149	386.694	364.611	-239.081	36.024	36.151	4.811	0.089	0.124	0.035	6.182	6.083	SL
L319	799.951	64.868	5.178	5.069	5.045	1126.494	1530.527	247.875	43.395	30.346	4.372	0.143	0.242	0.106	6.173	5.966	SL
L320	795.330	109.754	5.379	5.116	5.014	2804.848	3892.391	997.609	53.689	26.298	3.614	0.311	0.477	0.174	6.340	5.999	SL
L321	804.778	179.557	6.377	5.821	5.554	5877.521	8368.074	2325.362	67.007	29.226	2.529	0.618	0.925	0.307	7.358	6.479	DB
L322	1194.986	5.004	4.995	5.004	5.056	-361.898	-555.859	-289.462	12.591	28.860	4.930	0.016	0.034	0.015	6.000	5.992	SR
L323	118.566	10.001	4.983	4.979	5.025	-229.804	-353.239	-224.631	16.061	28.640	4.851	0.029	0.054	0.022	5.987	5.962	SL
L324	118.456	17.978	5.022	4.998	5.030	-39.715	63.208	-35.731	19.826	24.281	4.774	0.048	0.096	0.041	6.027	5.967	F
L325	1204.314	35.016	5.113	5.009	5.014	528.718	810.374	218.919	25.404	37.296	4.576	0.110	0.173	0.062	6.139	5.975	F
L326	1193.548	64.976	5.223	5.018	4.970	1577.119	2416.497	748.779	31.275	39.790	4.074	0.215	0.333	0.115	6.249	5.931	SL
L327	1195.246	109.772	5.415	4.993	4.852	3711.807	5996.859	1779.044	39.479	38.640	2.784	0.428	0.651	0.218	6.441	5.812	F
L328	1163.822	180.669	7.211	6.581	6.280	9976.356	9938.078	3337.918	57.839	32.691	2.404	0.655	1.031	0.374	8.216	7.213	DB
L329	1804.661	5.012	4.987	4.989	5.042	-293.097	-488.498	-263.423	9.585	24.692	4.853	0.023	0.041	0.018	5.991	5.979	SR
L330	1797.171	10.017	4.994	4.980	5.018	-146.226	-35.459	-97.192	11.434	27.509	4.773	0.038	0.081	0.035	5.999	5.954	A
L331	1792.062	17.991	5.083	5.006	5.024	172.283	403.746	76.860	14.977	27.982	4.655	0.069	0.130	0.052	6.057	5.960	A
L332	1798.313	34.996	5.120	4.990	4.970	1501.263	1513.910	-96.918	20.646	35.657	4.265	0.142	0.243	0.102	6.121	5.904	F
L333	1802.298	64.981	5.322	5.033	4.927	2418.992	3908.652	1386.077	23.449	40.283	3.525	0.299	0.482	0.179	6.348	5.887	F
L334	1790.024	109.663	6.227	5.733	5.535	4437.680	6870.399	2324.251	31.487	39.176	2.837	0.501	0.779	0.273	7.253	6.496	F
L335	1796.853	178.989	8.382	7.675	7.318	6704.489	10765.000	3916.581	47.318	32.693	2.797	0.728	1.161	0.432	9.386	8.251	DB

**Table C-4 Experimental Data of Liquid Single-Phase Flow
for Each Inclined Flow at Low Pressure**

Trace Name	Q _i	Q _e	P1-01	P1-02	P1-03	dP1-01	dP1-02	dP1-03	HI-05	TI-1	PI-C-002	dP1-01	dP1-02	dP1-03	Pipe Roughness
Unit	Nm/h	m/h	kgf/cm ²	kgf/cm ²	kgf/cm ²	mmH ₂ O	mmH ₂ O	mmH ₂ O	V		kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ²	m (Absolute)
Test No. L50	0.000	181.780	4.183	3.857	3.718	2823.251	4590.281	1652.946	3.388	41.474	2.532	0.292	0.456	0.164	8.49219E-05
L51	0.005	180.105	4.126	3.823	3.686	2685.495	4442.888	1654.714	2.972	38.108	2.504	0.272	0.469	0.190	8.08833E-05
L53	0.000	180.399	5.325	5.039	4.894	2487.175	4278.736	1525.304	2.852	34.505	3.702	0.233	0.514	0.266	7.3609E-05

APPENDIX

Table C-5 Experimental Data for 0° Inclined Flow at High Pressure, 2060 kPa (21 kgf/cm²A)

Trace Name	Q _t	Q _s	P1-01	P1-02	P1-03	dP1-01	dP1-02	dP1-03	HT-05	T1-1	PIC-02	dP1-01	dP1-02	dP1-03	P1 inlet	P1 exit	Flow Pattern
Unit	Nm/h	m/h	kgf/cm ²	kgf/cm ²	kgf/cm ²	mmH ₂ O	mmH ₂ O	mmH ₂ O	%		kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ² A	kgf/cm ² A	
Test No. H001	59.889	1.397	20.029	19.966	20.012	-79.562	63.570	9.861	33.064	44.264	20.106	-0.0011	-0.0007	-0.0016	21.026	20.960	SS
H002	59.885	2.496	20.124	20.056	20.114	-80.077	58.874	-20.260	48.351	33.527	20.165	-0.0011	-0.0012	-0.0046	21.122	21.019	SS
H003	59.821	4.996	20.150	20.077	20.134	-79.867	63.621	2.475	65.374	31.407	20.185	-0.0011	-0.0007	-0.0024	21.147	21.039	SW-SR
H004	59.791	9.944	19.836	19.772	19.820	-55.792	90.748	33.517	72.390	31.035	19.893	0.0013	0.0020	0.0008	20.833	20.748	SL
H005	59.848	17.973	19.986	19.922	19.967	-38.704	139.403	69.721	84.625	41.968	20.043	0.0030	0.0068	0.0044	20.984	20.897	FB
H006	59.862	34.935	19.996	19.926	19.961	24.087	245.113	107.420	94.833	44.117	20.013	0.0093	0.0174	0.0081	20.993	20.867	FB
H007	59.808	64.921	20.105	20.009	20.026	251.212	637.007	268.574	96.975	45.110	19.973	0.0320	0.0566	0.0243	21.103	20.828	FB
H008	59.732	109.163	19.848	19.703	19.674	814.350	1621.735	691.325	96.170	33.745	19.318	0.0883	0.1551	0.0665	20.845	20.173	In-DB
H009	59.723	180.125	19.853	19.578	19.448	2149.463	3974.483	1706.159	98.179	36.324	18.439	0.2218	0.3903	0.1680	20.851	19.294	DB
H010	90.287	1.396	19.847	19.787	19.827	-78.101	68.538	35.773	32.175	32.414	19.942	-0.0009	-0.0002	0.0010	20.845	20.796	SS
H011	96.322	2.496	19.841	19.780	19.817	-77.961	69.574	34.473	44.775	33.087	19.944	-0.0009	-0.0001	0.0008	20.839	20.799	SS
H012	95.800	4.996	19.938	19.876	19.913	-73.580	77.916	37.385	53.080	33.412	20.047	-0.0005	0.0007	0.0011	20.936	20.901	SW-SR
H013	105.219	9.960	19.832	19.768	19.799	-62.196	99.311	45.542	61.130	32.477	19.937	0.0007	0.0028	0.0020	20.829	20.791	SL
H014	99.586	17.954	19.856	19.790	19.824	-40.838	140.705	64.524	76.737	39.185	19.940	0.0028	0.0070	0.0038	20.854	20.794	SL
H015	99.172	34.923	19.935	19.861	19.888	26.722	255.615	111.100	85.885	43.045	19.982	0.0096	0.0185	0.0085	20.932	20.836	FB
H016	98.182	64.632	20.094	19.997	20.008	251.728	641.153	269.321	92.226	44.863	19.986	0.0321	0.0570	0.0243	21.092	20.840	FB
H017	95.429	109.833	20.081	19.930	19.900	803.807	1603.155	680.201	95.608	45.614	19.584	0.0873	0.1532	0.0654	21.078	20.438	In-DB
H018	89.656	179.932	20.321	20.026	19.918	2154.242	3978.151	1696.056	98.077	43.352	18.835	0.2223	0.3907	0.1670	21.178	19.690	DB
H019	138.449	1.398	19.909	19.850	19.910	-89.828	57.257	30.775	31.299	34.646	19.972	-0.0021	-0.0014	0.0005	20.906	20.826	SS
H020	138.554	2.499	19.861	19.803	19.860	-87.122	60.152	32.304	43.788	34.524	19.933	-0.0018	-0.0011	0.0005	20.859	20.787	SW-SR
H021	138.446	4.994	19.936	19.871	19.928	-83.140	66.325	25.052	47.883	30.152	19.981	-0.0014	-0.0005	-0.0001	20.934	20.836	SW-SR
H022	138.210	9.967	19.892	19.830	19.879	-67.516	95.843	52.351	58.236	32.303	19.966	0.0001	0.0025	0.0026	20.889	20.820	SL
H023	138.306	17.944	19.844	19.783	19.825	-48.466	130.614	65.656	74.463	39.803	19.922	0.0021	0.0060	0.0040	20.842	20.776	SL
H024	138.517	34.942	19.920	19.854	19.880	20.684	251.713	111.458	86.296	42.576	19.946	0.0090	0.0181	0.0085	20.918	20.800	SL
H025	138.066	64.929	20.106	20.014	20.040	244.103	633.996	266.067	91.830	44.076	19.963	0.0313	0.0563	0.0240	21.103	20.817	FB
H026	136.929	109.933	20.528	20.379	20.369	807.955	1612.390	654.801	95.140	44.070	19.987	0.0877	0.1541	0.0629	21.526	20.841	In-DB
H027	138.187	179.785	20.230	19.939	19.825	2177.198	4002.084	1707.904	96.116	44.339	18.771	0.2246	0.3931	0.1682	21.625	19.625	DB
H028	234.787	1.397	19.951	19.876	19.942	-88.438	54.488	27.584	30.381	25.491	19.972	-0.0019	-0.0017	0.0002	20.948	20.826	SW-SR
H029	231.000	2.497	19.947	19.875	19.941	-86.904	59.600	30.709	36.373	25.521	19.976	-0.0018	-0.0012	0.0005	20.944	20.830	SW-SR
H030	229.167	4.998	19.933	19.860	19.925	-78.300	74.924	40.422	42.493	25.687	19.960	-0.0009	0.0004	0.0014	20.930	20.814	SW-SR
H031	228.352	9.960	19.869	19.800	19.861	-62.822	105.748	57.269	54.838	33.990	19.901	0.0006	0.0035	0.0031	20.867	20.755	SL
H032	228.874	17.963	19.881	19.813	19.849	-42.063	141.343	72.482	86.768	38.100	19.903	0.0027	0.0070	0.0046	20.879	20.758	SL
H033	228.073	34.948	19.993	19.918	19.966	30.458	272.351	128.843	78.135	42.041	19.968	0.0099	0.0201	0.0103	20.991	20.823	SL
H034	227.296	64.832	20.180	20.081	20.112	267.447	675.397	292.774	87.232	43.034	19.994	0.0336	0.0604	0.0267	21.177	20.848	SL
H035	228.439	109.820	20.211	20.055	20.041	854.400	1689.611	718.606	92.249	43.832	19.646	0.0923	0.1619	0.0693	21.209	20.500	In-DB
H036	227.987	179.694	21.164	20.868	20.755	2233.389	4075.596	1720.137	93.964	44.108	19.674	0.2302	0.4005	0.1694	22.162	20.528	DB
H037	347.706	1.396	19.911	19.844	19.895	-82.247	64.353	35.454	25.590	31.069	19.986	-0.0013	-0.0007	0.0009	20.908	20.840	SW-SR
H038	348.133	2.496	19.909	19.846	19.896	-78.035	71.195	38.302	29.414	31.216	19.983	-0.0009	0.0000	0.0012	20.907	20.837	SW-SR
H039	347.864	4.997	19.931	19.866	19.915	-68.900	89.124	47.650	38.115	31.389	20.000	0.0000	0.0018	0.0022	20.928	20.855	SW-SR
H040	348.424	9.963	19.873	19.806	19.855	-56.668	110.998	53.699	53.146	30.802	19.932	0.0012	0.0040	0.0028	20.870	20.786	SL
H041	348.051	17.922	19.934	19.862	19.911	-37.065	147.165	66.205	59.250	35.038	19.964	0.0032	0.0076	0.0040	20.931	20.818	SL
H042	347.849	34.942	20.017	19.938	19.981	-45.997	296.355	133.747	73.716	41.645	19.979	0.0115	0.0225	0.0108	21.015	20.834	SL
H043	347.373	64.910	20.185	20.081	20.107	308.817	741.528	318.563	82.226	42.867	19.983	0.0378	0.0671	0.0293	21.183	20.837	SL
H044	339.015	109.810	20.598	20.433	20.417	896.100	1761.758	748.744	88.587	43.572	19.981	0.0965	0.1691	0.0723	21.966	20.836	In-DB
H045	339.984	179.933	20.579	20.268	20.152	2339.552	4222.207	1759.456	91.640	43.555	19.002	0.2409	0.4151	0.1733	21.577	19.856	DB
H046	517.176	1.396	19.885	19.829	19.870	-69.935	78.762	39.081	18.123	33.570	19.989	0.0010	0.0023	0.0014	20.883	20.844	SW-SR
H047	516.569	2.496	19.884	19.821	19.856	-63.667	89.180	42.167	24.533	32.665	19.989	0.0017	0.0033	0.0017	20.881	20.843	SW-SR
H048	517.930	4.998	19.883	19.816	19.851	-58.766	103.811	48.923	35.284	32.950	19.977	0.0022	0.0048	0.0024	20.881	20.832	SW-SR
H049	520.288	9.977	19.898	19.833	19.869	-50.931	117.979	50.140	45.857	32.822	19.974	0.0029	0.0062	0.0025	20.895	20.828	SL
H050	517.679	17.964	19.931	19.861	19.895	-23.494	164.063	71.555	52.191	34.916	19.985	0.0057	0.0108	0.0046	20.928	20.840	SL
H051	517.255	34.951	20.004	19.924	19.951	77.184	341.528	147.214	63.671	38.878	19.985	0.0158	0.0285	0.0122	21.001	20.840	SL
H052	516.979	64.804	20.189	20.082	20.092	353.850	806.999	335.293	72.402	40.242	19.983	0.0434	0.0751	0.0310	21.196	20.837	SL
H053	516.468	109.849	20.197	20.025	19.981	993.121	1921.671	807.093	80.555	41.529	19.552	0.1074	0.1866	0.0782	21.184	20.407	In-DB
H054	515.059	179.988	20.814	20.492	20.346	2491.377	4465.531	1844.981	85.957	41.982	19.170	0.2572	0.4409	0.1820	21.811	20.024	DB
H055	799.088	1.396	19.871	19.805	19.842	-69.576	82.271	29.662	17.228	42.106	19.985	0.0011	0.0026	0.0004	20.869	20.839	SW-SR
H056	798.387	2.496	19.876	19.811	19.852	-64.524	89.869	30.732	24.294	42.223	19.985	0.0016	0.0034	0.0006	20.874	20.839	SW-SR
H057	796.939	4.999	19.891	19.825	19.867	-59.336	98.089	27.057	31.423	42.120	19.989	0.0021	0.0042	0.0002	20.888	20.843	SW-SR
H058	796.928	9.988	19.902	19.836	19.880	-53.566	112.147	33.232	40.670	38.614	19.996	0.0027	0.0056	0.0008	20.900	20.850	SL
H059	798.194	17.970	19.934	19.864	19.919	-18.208	175.696	43.212	43.744	37.269	19.988	0.0062	0.0120	0.0018	20.932	20.842	SL
H060	793.236	34.953	20.032	19.948	19.985	104.275	384.364	91.701	56.306	44.205	19.986	0.0185	0.0328	0.0066	21.030	20.	

APPENDIX

Table C-6 Experimental Data for 1° Inclined Flow at High Pressure, 2060 kPa (21 kgf/cm²A)

Trace Name	Q _g	Q _l	P1-01	P1-02	P1-03	dP1-01	dP1-02	dP1-03	HT-05	TI-1	PIC-02	dP1-01	dP1-02	dP1-03	P1inlet	P1exit	Flow Pattern
Unit	Nm/h	m/h	kgf/cm ²	kgf/cm ²	kgf/cm ²	mmH ₂ O	mmH ₂ O	mmH ₂ O	%		kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ² A	kgf/cm ² A	
Test No. H001	59.875	1.396	19.842	19.780	19.842	-92.238	49.548	35.935	90.194	26.554	19.869	0.015	0.032	0.017	20.859	20.830	FB
H002	59.883	2.496	19.930	19.857	19.912	-85.667	56.943	35.894	90.696	28.142	19.967	0.016	0.032	0.017	20.957	20.890	FB
H003	59.863	4.998	20.028	19.964	20.015	-79.950	65.558	37.897	92.900	29.639	20.084	0.016	0.033	0.017	21.044	20.993	FB
H004	59.902	9.967	20.032	19.970	20.015	-71.486	78.563	41.168	93.444	32.814	20.088	0.017	0.034	0.017	21.048	20.993	FB
H005	59.910	17.974	20.035	19.970	20.015	-51.088	110.905	53.228	94.740	38.890	20.080	0.019	0.038	0.018	21.051	20.993	FB
H006	59.891	34.942	20.065	19.993	20.031	13.785	232.305	104.787	96.817	42.941	20.082	0.026	0.050	0.024	21.081	21.009	FB
H007	59.894	64.948	20.192	20.097	20.113	247.379	632.277	264.090	97.636	43.896	20.053	0.049	0.090	0.039	21.208	21.091	In-DB
H008	59.875	109.736	20.451	20.301	20.281	792.710	1581.780	660.618	98.454	44.466	19.944	0.103	0.185	0.079	21.467	21.259	In-DB
H009	59.856	179.830	20.811	20.532	20.438	2083.776	3870.618	1680.581	99.211	44.520	19.406	0.233	0.414	0.178	21.828	21.416	DB
H010	100.646	1.397	20.059	19.994	20.052	-108.945	11.844	8.568	78.597	26.554	20.085	0.013	0.025	0.011	21.080	21.031	FB
H011	98.410	2.497	20.110	20.044	20.102	-112.260	12.780	-0.097	81.100	25.922	20.115	0.013	0.025	0.011	21.066	21.068	FB
H012	100.665	4.999	20.111	20.043	20.106	-108.614	17.288	-2.953	85.606	25.369	20.104	0.013	0.026	0.010	21.097	21.072	FB
H013	98.981	9.953	20.112	20.043	20.107	-98.006	39.467	22.262	83.600	29.367	20.103	0.014	0.028	0.013	21.098	21.073	FB
H014	100.525	17.946	20.122	20.053	20.114	-73.948	82.183	41.566	87.829	35.996	20.114	0.017	0.032	0.015	21.108	21.079	FB
H015	99.662	34.953	20.015	19.939	19.989	10.623	233.986	111.066	92.666	38.942	19.977	0.025	0.047	0.022	21.001	20.955	FB
H016	99.481	64.717	20.071	19.972	20.002	260.764	661.977	288.116	95.246	40.561	19.890	0.050	0.090	0.039	21.057	20.968	FB
H017	96.371	109.924	20.130	19.976	19.964	827.995	1631.934	688.885	97.562	41.274	19.568	0.107	0.187	0.079	21.116	20.930	In-DB
H018	88.491	180.009	20.382	20.104	19.996	2123.167	3931.646	1660.289	98.914	44.856	18.973	0.235	0.416	0.177	21.368	20.962	DB
H019	138.700	1.397	19.955	19.916	19.988	-117.328	-22.805	-47.806	72.519	41.299	20.019	0.012	0.024	0.008	20.972	20.966	SL
H020	139.444	2.497	19.941	19.896	19.960	-112.202	-15.240	-35.304	72.792	40.796	19.982	0.013	0.025	0.009	20.958	20.958	SL
H021	139.197	4.998	20.003	19.942	20.003	-105.958	1.710	-27.214	78.910	38.586	20.017	0.014	0.027	0.010	21.020	20.981	FB
H022	139.171	9.949	20.014	19.948	20.009	-95.545	29.271	-0.059	78.015	32.162	20.012	0.015	0.030	0.013	21.030	20.967	FB
H023	139.004	17.961	19.894	19.832	19.875	-67.710	91.485	42.062	80.450	39.612	19.942	0.015	0.031	0.016	20.885	20.854	FB
H024	138.554	34.953	19.983	19.912	19.950	17.696	242.870	106.172	87.017	42.853	19.992	0.023	0.046	0.022	20.975	20.929	FB
H025	138.673	64.843	20.127	20.033	20.054	251.299	643.999	271.558	92.567	43.971	19.984	0.047	0.086	0.039	21.119	21.033	FB
H026	137.061	109.691	20.292	20.140	20.122	814.647	1610.605	670.820	95.477	45.008	19.765	0.103	0.182	0.079	21.284	21.101	In-DB
H027	141.749	180.118	20.405	20.121	20.013	2166.231	3984.888	1686.814	97.163	44.962	18.967	0.238	0.420	0.180	21.396	20.992	DB
H028	228.762	1.396	19.965	19.901	19.967	-134.014	-34.234	-16.880	62.985	33.300	19.968	0.011	0.021	0.009	20.951	20.933	SL
H029	228.967	2.497	19.972	19.908	19.974	-130.887	-26.968	-13.923	64.035	34.605	19.973	0.011	0.021	0.009	20.958	20.939	SL
H030	228.914	4.998	19.968	19.903	19.969	-124.630	-14.442	-8.354	67.634	36.063	19.972	0.012	0.023	0.010	20.954	20.934	SL
H031	228.600	10.089	19.988	19.920	19.984	-108.677	12.413	3.521	70.769	36.838	19.981	0.013	0.025	0.011	20.974	20.949	SL
H032	228.196	17.943	20.013	19.941	20.002	-76.736	68.485	23.732	76.529	38.363	19.994	0.016	0.031	0.013	20.999	20.967	SL
H033	228.437	34.951	20.004	19.923	19.975	16.772	238.733	96.813	83.092	38.295	19.934	0.026	0.048	0.020	20.990	20.941	SL
H034	228.919	64.947	19.200	19.097	19.131	274.672	680.390	277.282	89.015	39.586	18.958	0.052	0.092	0.038	20.886	20.897	SL
H035	230.600	109.814	20.213	20.049	20.087	873.529	1705.187	711.846	93.301	40.838	19.594	0.112	0.194	0.082	21.199	21.002	In-DB
H036	229.393	179.855	20.535	20.228	20.115	2283.765	4130.397	1723.552	97.162	41.061	18.978	0.253	0.437	0.183	21.521	21.081	DB
H037	347.339	1.396	20.056	20.000	20.058	-129.169	-32.965	-13.320	52.390	31.120	20.112	0.010	0.018	0.008	21.042	21.028	SL
H038	348.144	2.496	20.032	19.974	20.031	-125.304	-24.556	-9.661	52.383	30.797	20.086	0.010	0.019	0.009	21.017	21.001	SL
H039	347.798	4.998	20.057	20.001	20.054	-120.030	-10.774	-4.267	58.926	31.445	20.109	0.011	0.020	0.009	21.043	21.024	SL
H040	348.009	9.934	20.057	19.999	20.051	-101.600	21.867	9.622	59.289	30.941	20.107	0.013	0.023	0.011	21.042	21.021	SL
H041	348.149	17.967	20.070	20.008	20.057	-68.429	79.880	34.710	64.244	40.528	20.103	0.016	0.029	0.013	21.055	21.027	SL
H042	347.810	34.937	20.128	20.054	20.095	42.540	274.305	117.606	73.258	44.728	20.105	0.027	0.049	0.021	21.113	21.065	SL
H043	347.737	64.908	20.177	20.076	20.101	299.378	708.382	290.335	82.847	45.790	19.980	0.053	0.092	0.039	21.146	21.071	SL
H044	347.501	109.786	20.261	20.100	20.078	907.313	1767.929	740.456	88.243	46.167	19.658	0.113	0.198	0.084	21.246	21.049	In-DB
H045	348.985	180.198	20.337	20.028	19.908	2367.382	4233.334	1723.400	93.033	44.845	18.753	0.259	0.445	0.182	21.323	20.878	DB
H046	517.333	1.397	20.061	20.000	20.066	-152.068	-70.800	-29.170	39.088	26.448	20.100	0.007	0.015	0.008	21.041	21.027	SL
H047	517.349	2.496	20.071	20.010	20.073	-145.853	-59.277	-24.045	43.048	26.371	20.113	0.008	0.016	0.009	21.051	21.035	SL
H048	518.303	4.998	20.063	20.002	20.064	-140.182	-44.736	-18.113	49.330	26.553	20.102	0.008	0.018	0.009	21.043	21.025	SL
H049	517.401	9.921	20.067	20.004	20.062	-118.654	-7.105	-2.853	53.281	28.570	20.104	0.010	0.021	0.011	21.047	21.023	SL
H050	517.503	17.957	20.088	20.020	20.074	-78.107	65.564	26.460	56.470	33.916	20.101	0.014	0.029	0.014	21.068	21.036	SL
H051	517.448	34.952	20.088	19.976	20.021	40.283	274.795	113.710	66.345	38.823	19.984	0.026	0.050	0.022	21.088	20.983	SL
H052	517.439	64.967	20.258	20.147	20.172	335.162	780.525	332.821	76.686	39.882	19.990	0.056	0.100	0.043	21.238	21.133	SL
H053	517.702	109.969	20.422	20.243	20.221	1002.877	1933.119	806.460	85.831	40.534	19.689	0.122	0.215	0.092	21.402	21.182	In-DB
H054	516.757	180.109	20.449	20.138	20.013	2526.863	4503.134	1854.422	89.416	40.816	18.729	0.275	0.472	0.196	21.449	20.974	DB
H055	795.912	1.396	20.035	19.970	20.045	-168.328	-104.439	-54.922	30.884	31.091	20.027	0.005	0.012	0.006	21.015	21.006	SL
H056	796.677	2.497	20.030	19.963	20.036	-160.349	-91.725	-49.193	33.925	32.971	20.019	0.006	0.013	0.006	21.010	20.997	SL
H057	799.458	4.998	20.032	19.966	20.035	-150.818	-72.917	-41.175	39.596	35.330	20.023	0.007	0.015	0.007	21.012	20.997	SL
H058	797.416	10.018	19.994	19.927	19.992	-126.935	-27.934	-19.604	45.452	37.116	19.982	0.009	0.019	0.009	20.974	20.954	SL
H059	795.926	17.885	20.014	19.942	20.004	-73.949	66.028	23.486	52.133	39.483	19.980	0.015	0.029	0.013	20.994	20.965	SL
H060	794.834	34.950	19.940	19.856	19.906	57.830	296.562	122.133	57.920	38.589	19.827	0.028	0.052	0.023	20.920	20.868	SL
H061	794.979	64.938	20.157	20.041	20.066	384.406	860.254	358.688	70.460	39.686	19.832	0.061	0.108	0.047	21.137	21.028	

APPENDIX

Table C-7 Experimental Data for 3° Inclined Flow at High Pressure, 2060 kPa (21 kgf/cm²A)

Trace Name	Q _e	Q _s	PI-01	PI-02	PI-03	dPI-01	dPI-02	dPI-03	HT-05	TI-1	PIC-02	dPI-01	dPI-02	dPI-03	PI inlet	PI exit	Flow Pattern
Unit	Nm/h	m/h	kgf/cm ²	kgf/cm ²	kgf/cm ²	mmH ₂ O	mmH ₂ O	mmH ₂ O	%		kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ² A	kgf/cm ² A	
Test No. HB01	59.823	1.396	20.082	20.027	20.036	-124.914	-24.536	439.656	89.474	34.60	20.058	0.044	0.075	0.024	21.100	21.030	FB
HB02	59.878	2.497	20.045	19.990	19.995	-124.213	-23.019	443.878	90.081	35.081	20.012	0.044	0.075	0.024	21.063	20.990	FB
HB03	59.939	4.998	20.053	19.995	19.999	-113.318	-5.540	448.362	91.876	35.499	20.028	0.046	0.077	0.025	21.071	20.994	FB
HB04	59.859	9.959	20.075	20.007	20.066	-103.781	22.290	117.824	92.086	22.250	19.989	0.047	0.078	0.031	21.085	21.013	FB
HB05	59.859	17.969	20.076	20.009	20.070	-83.935	60.970	131.504	94.02	28.829	19.983	0.049	0.082	0.032	21.087	21.017	FB
HB06	59.889	34.946	20.048	19.972	20.027	-1.342	207.297	191.122	96.514	31.356	19.964	0.057	0.097	0.038	21.059	20.974	FB
HB07	59.920	64.985	20.099	19.965	19.984	236.360	617.146	356.765	98.229	31.427	19.783	0.081	0.137	0.061	21.081	20.945	FB
HB08	59.830	109.671	20.135	19.984	19.961	810.128	1604.510	746.075	99.418	31.969	19.480	0.138	0.235	0.100	21.157	20.922	In-DB
HB09	59.664	180.045	20.281	19.991	19.865	2194.920	4023.874	1780.725	99.899	32.261	18.681	0.277	0.477	0.203	21.303	20.825	DB
HB10	98.790	1.397	20.080	20.024	20.030	-170.705	-115.925	489.223	79.748	28.907	20.038	0.040	0.066	0.029	21.088	21.025	FB
HB11	99.547	2.497	20.080	19.994	20.001	-167.075	-106.882	471.689	79.838	29.810	20.019	0.040	0.067	0.027	21.088	20.995	FB
HB12	99.595	4.999	20.049	19.994	19.999	-154.277	-78.667	467.851	83.760	32.518	20.022	0.041	0.069	0.027	21.067	20.994	FB
HB13	99.910	9.964	20.034	19.966	20.027	-141.280	-50.294	115.714	86.341	32.651	19.953	0.043	0.071	0.030	21.045	20.973	FB
HB14	101.506	17.961	20.005	19.934	19.990	-113.275	0.690	142.069	86.560	34.006	19.904	0.046	0.076	0.033	21.016	20.957	FB
HB15	99.717	34.941	20.028	19.948	19.996	-21.250	173.342	222.129	92.420	37.977	19.908	0.055	0.094	0.041	21.039	20.942	FB
HB16	98.740	64.911	20.080	19.987	20.009	234.641	617.381	311.960	96.044	31.738	19.804	0.081	0.137	0.056	21.102	20.970	In-DB
HB17	98.780	109.793	20.141	19.989	19.968	823.988	1618.424	735.147	97.613	32.064	19.477	0.140	0.237	0.098	21.163	20.929	In-DB
HB18	101.332	179.973	20.409	20.112	19.962	2176.730	3967.448	2219.099	99.088	39.950	18.853	0.275	0.474	0.202	21.426	20.957	DB
HB19	139.064	1.397	20.068	20.013	20.022	-197.058	-170.258	487.118	72.959	28.486	20.027	0.037	0.060	0.029	21.086	21.017	FB
HB20	139.180	2.498	20.068	20.012	20.022	-192.086	-157.449	473.128	73.795	28.609	20.023	0.038	0.061	0.027	21.086	21.017	FB
HB21	139.207	5.000	20.074	20.017	20.030	-177.927	-128.507	483.639	76.987	28.047	20.023	0.039	0.064	0.028	21.092	21.024	FB
HB22	136.289	9.953	20.032	19.970	19.998	-157.193	-86.299	412.255	80.597	31.805	19.985	0.040	0.067	0.022	21.044	20.982	FB
HB23	139.905	17.961	20.045	19.981	20.010	-122.161	-28.646	410.343	78.807	32.885	19.988	0.044	0.072	0.022	21.057	20.995	FB
HB24	139.865	34.945	20.144	20.069	20.087	-20.763	156.159	510.561	86.412	37.191	20.062	0.054	0.091	0.032	21.156	21.072	FB
HB25	138.792	64.966	20.135	20.038	20.026	231.432	607.270	811.065	92.037	41.100	19.914	0.080	0.138	0.061	21.153	21.021	In-DB
HB26	137.957	109.542	20.120	19.964	19.909	809.990	1591.830	1226.276	95.788	41.912	19.518	0.138	0.236	0.103	21.138	20.904	In-DB
HB27	140.367	180.031	20.436	20.137	19.986	2220.416	4026.393	2237.399	98.459	40.116	18.862	0.279	0.480	0.204	21.454	20.981	DB
HB28	230.241	1.396	20.077	19.952	19.989	-230.482	-145.800	184.711	63.084	26.075	19.987	0.034	0.059	0.035	21.016	20.941	SL
HB29	228.405	2.497	20.012	19.957	20.002	-221.029	-197.378	114.022	64.054	25.768	19.988	0.035	0.054	0.028	21.022	20.954	SL
HB30	228.352	4.999	20.015	19.960	20.006	-205.543	-190.311	107.209	64.788	26.099	19.987	0.037	0.055	0.027	21.025	20.957	SL
HB31	228.357	9.912	20.020	19.964	20.006	-185.243	-146.250	127.349	68.665	27.201	19.986	0.039	0.059	0.029	21.030	20.988	SL
HB32	228.372	17.991	20.040	19.980	20.018	-139.061	-63.876	174.034	70.565	34.099	19.991	0.043	0.068	0.034	21.050	20.970	FB
HB33	228.146	34.951	20.068	19.986	20.012	-19.422	158.112	287.028	79.374	38.655	19.982	0.055	0.090	0.045	21.067	20.964	FB
HB34	228.182	64.902	20.099	19.999	20.006	249.266	636.679	488.604	86.066	39.488	19.868	0.082	0.138	0.065	21.109	20.958	FB
HB35	227.972	109.697	20.294	20.134	20.094	852.605	1673.737	923.261	91.509	40.476	19.677	0.142	0.241	0.109	21.303	21.046	In-DB
HB36	227.036	179.801	20.316	20.015	19.872	2263.039	4093.688	1935.064	94.455	40.575	18.751	0.283	0.483	0.210	21.336	20.824	DB
HB37	349.141	1.397	20.013	19.966	19.916	-258.116	-303.203	1063.972	53.857	28.726	20.025	0.030	0.044	0.019	20.994	20.917	SL
HB38	348.040	2.496	20.016	19.968	19.917	-249.751	-279.522	1085.472	54.882	28.231	20.023	0.031	0.046	0.021	20.997	20.918	SL
HB39	348.019	4.998	20.025	19.975	19.924	-234.435	-245.976	1095.160	58.162	28.300	20.028	0.032	0.049	0.022	21.006	20.925	SL
HB40	348.251	9.940	19.992	19.940	19.885	-205.081	-193.757	1112.611	59.850	27.554	19.978	0.035	0.055	0.024	20.973	20.886	SL
HB41	348.397	17.960	20.024	19.967	19.907	-155.760	-101.713	1155.809	62.734	34.345	19.988	0.040	0.064	0.028	21.005	20.938	SL
HB42	348.514	34.938	20.043	19.976	19.903	-46.027	105.674	1251.539	73.381	40.040	19.953	0.051	0.085	0.038	21.024	20.904	SL
HB43	348.748	64.799	20.155	20.057	19.964	246.478	625.889	1449.946	80.817	40.563	19.908	0.080	0.137	0.057	21.135	20.964	SL
HB44	347.570	109.796	20.351	20.188	20.051	884.825	1727.841	916.207	87.918	41.419	19.709	0.144	0.247	0.104	21.332	21.052	In-DB
HB45	347.300	179.894	20.295	19.990	19.747	2340.012	4169.797	2927.071	91.461	41.642	18.698	0.290	0.491	0.205	21.276	20.748	DB
HB46	519.062	1.396	20.048	20.007	19.954	-305.600	-378.189	1062.021	45.135	40.342	20.067	0.025	0.036	0.019	21.029	20.955	SL
HB47	517.805	2.497	20.014	19.970	19.923	-298.463	-360.934	1027.009	45.888	40.277	20.022	0.026	0.038	0.015	20.994	20.924	SL
HB48	517.614	4.998	20.030	19.981	19.936	-275.625	-319.729	1043.950	50.393	40.081	20.027	0.028	0.042	0.017	21.011	20.937	SL
HB49	517.986	9.954	20.024	19.973	19.923	-240.935	-252.389	1070.173	54.920	33.200	20.016	0.031	0.049	0.019	21.005	20.924	SL
HB50	516.991	17.927	20.051	19.994	19.952	-184.132	-160.789	1119.374	54.634	36.280	20.023	0.037	0.058	0.024	21.032	20.953	SL
HB51	517.255	34.947	20.052	19.987	19.932	-64.810	63.234	1157.136	65.485	42.025	19.951	0.049	0.080	0.028	21.033	20.933	SL
HB52	517.132	64.947	20.232	20.130	20.051	254.946	625.148	1386.271	76.161	42.662	19.951	0.081	0.136	0.051	21.213	21.052	SL
HB53	517.178	109.894	20.200	20.029	19.901	990.688	1797.225	1890.536	83.729	43.250	19.481	0.149	0.254	0.101	21.181	20.902	In-DB
HB54	516.343	180.124	20.312	19.987	19.756	2472.505	4371.988	2924.297	88.925	43.085	18.569	0.303	0.511	0.205	21.293	20.756	DB
HB55	802.697	1.397	20.032	19.985	19.934	-351.703	-388.000	99.299	33.909	22.080	19.982	0.022	0.037	0.015	21.039	21.006	SL
HB56	798.804	2.496	20.042	19.995	19.940	-334.767	-414.436	142.333	37.163	22.108	19.988	0.024	0.034	0.011	21.049	21.020	SL
HB57	799.506	4.998	20.044	19.996	20.080	-311.894	-378.737	126.600	42.917	22.028	19.981	0.026	0.038	0.013	21.051	21.021	SL
HB58	798.265	9.942	20.061	20.009	20.091	-269.160	-300.043	91.919	46.038	23.378	19.986	0.030	0.046	0.016	21.068	21.033	SL
HB59	800.761	17.968	20.079	20.022	20.098	-206.558	-193.559	92.416	49.468	30.223	19.984	0.036	0.056	0.020	21.086	21.040	SL
HB60	793.491	34.935	20.065	19.994	20.060	-63.944	52.474	48.364	59.113	36.529	19.905	0.051	0.081	0.030	21.072	21.001	SL
HB61	795.286	64.666	20.096	19.993	20.033	282.957	664.833	303.645	69.641								

**Table C-8 Experimental Data of Liquid Single-Phase Flow
for Each Inclined Flow at High Pressure**

Trace Name	Q _g	Q _L	PI-01	PI-02	PI-03	dPI-01	dPI-02	dPI-03	HI-05	TI-1	PI-C-002	dPI-01	dPI-02	dPI-03	Pipe Roughness
Unit	Nm ³ /h	m ³ /h	kgf/cm ²	kgf/cm ²	kgf/cm ²	mmH ₂ O	mmH ₂ O	mmH ₂ O	V		kgf/cm ²	kgf/cm ²	kgf/cm ²	kgf/cm ²	m(Absolute)
Test No. HSI	-2.861	180.140	20.074	19.782	19.679	2121.906	3936.790	1696.304	3.714	37.830	18.540	0.221	0.390	0.168	1.43437E-05
HSI	1.304	180.092	20.244	19.975	19.871	2074.065	3864.262	1645.881	3.951	44.665	18.845	0.229	0.408	0.176	1.43473E-05
HS3	-0.017	180.080	19.460	19.166	19.056	2175.851	4014.199	1812.675	3.428	34.825	17.898	0.275	0.477	0.200	1.43481E-05

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